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Land-use changes and policy dimension driving forces in China: Present, trend and future

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ABSTRACT

China has extremely scarce land resources compared to the world average. There is an urgent need for studies of the current situation and the trends in land-use change and assessment of the performance of land policies in China. Assessment of land-use change has long been hindered by a lack of accurate and reliable data. This paper uses the data obtained from the national land surveys of 1996 and land-use change surveys from 1997 to 2008, to analyze changes in land use and the policy dimension driving forces related to the changes, especially cultivated land, forestry land, grassland, as well as developed land. The aim of this analysis will be to derive the physical, social and economical driving forces of those changes to grasp the trends in land-use change and the effects of land policies and to formulate strategies for the protection and sustainable use of agricultural land. The results indicate that, although the overall change in land use was not large, cultivated land was significantly reduced and developed land rapidly increased. A great deal of high quality cultivated land was changed to developed land and low quality cultivated land generated from unused land, which has resulted in a serious threat to food supplies in China. Predictions using the methods of linear extrapolation and a BP neural network indicate that it is impossible to keep to a target of 0.12 billion hectares of cultivated land in the future under the mode of economic development used between 1996 and 2008. The results also indicate that the implementation of the laws and regulations about controlling the developed land and preserving cultivated land had significant effects on changes in land use, especially cultivated land and developed land. The results suggest that the changes in land use are closely related to economic fluctuation and the enaction and implementation of these land policies had a little time lag for cultivated land protection. There is a pressing need for China to use its limited land resources more efficiently and effectively by enacting or re-enforcing the laws and regulations on land resources protection and economic development, not only for its own growing population, but also the world. Therefore, we must formulate strategies for the protection and sustainable use of agricultural land.

Introduction

Land is a precious resource. Over 21% of the world's population is living on cultivated land constituting only 7% of the total area available on the earth. Whereas total amount of land resources is great, land resources per capita is small in China. In addition, China's land resources are characterized with great spatial variation in natural quality, unbalance in the geographic distribution of population, land resources, and water resources in space. Available land resources as well as uncultivated arable land resources are lacking. China has extremely scarce land resources. The demand for cultivated land in China is greater than its availability. Several researchers have identified the problem of the widening gap between the growing population and the rapidly shrinking land resources (Orleans, 1991; Meyer and Turner, 1992; Crook, 1993; Wu and Guo, 1994; Yeh and Wu, 1996; Sun and Li, 1997; Yang and Li, 2000; Lin and Ho, 2003; Lichtenberg and Ding, 2008). Some have expressed serious concerns over China's ability to feed itself and the possible implications this may have for the world (Brown, 1995a,b; Smil, 1995; Ho, 2001; Erik and Cheng, 2008). With the persistent increase in population expected to occur over the next 20–30 years, together with ever increasing industrialization and urbanization, China now faces the dilemma of the rapidly growing consumption of its resources. Moreover, the severe land pollution and degradation that will accompany this growth will further result in a shortage of arable land resources (Gao et al., 1999; Li, 2000; Shi et al., 2000). The state of a country's land resources and environment can significantly affect the sustainable development of the

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economy (Ma and Cui, 1987; Chen and Peter, 2000; Lin, 2002; Ho and Lin, 2004). When the situation of land use has a negative impact on the sustainable development, the government should enact new or adjust the existing regulations and laws to strengthen effective management of land resources. Many researchers have attempted to analyze the effects of land policies qualitatively (Cai, 2003; Ding, 2003; Ho and Lin, 2004; Lin and Ho, 2005; Lichtenberg and Ding, 2008), but few analysis was based on accurate and reliable data.

Therefore, a better understanding of land resources and well-timed regulating and controlling of land use are crucial for sustainable development in China. We must have a clear picture of the current state of various land-use types and of the changes in land use that have occurred in the past. We need to be able to explain such changes and analyze the driving forces of land policies and predict land-use changes in the future.

Assessing land-use change requires accurate and reliable data. In line with this, the relevant Chinese authorities carried out large-scale national land surveys between 1984 and 1996 and have conducted land-use change surveys every year since 1996. The purpose of this paper is to use data obtained from the surveys to analyze the changes in China's land use and to assess the performance of China's land policies, especially in regard to cultivated land, forestry land, grassland and developed land. The aim of this analysis will be to derive the physical, social and economical driving forces of those changes to grasp the direction of the land-use change and to formulate strategies and policies for the protection and sustainable use of agricultural land.

The paper first discusses the data collection and methodologies used for the analysis. Following this, the results, analysis and discussion are presented. Finally, concluding remarks and recommendations are given.

Data and methodologies used

Data collected

The data on land use at state, province and county levels in 1996 were obtained from the nation-wide land surveys carried out by the former China State Land Administration Bureau (CSLAB, 1996). The aim of the surveys was to gather data on the areas and locations of various land-use types and the land ownership in each county (Ma, 2000; Liu, 2000). A standardized land classification scheme, consisting of eight categories and forty-six sub-categories of land-use types, was adopted for the whole country. Aided by aerial photographs, field surveys and available maps, the surveys covered 2843 counties, 43,000 towns, 740,000 villages, 25,000 farms, and 400,000 administrative units. Most of the surveys were conducted during 1990–1995. However, the data were adjusted to a reference date of 31 October 1996, in a way similar to the national population census. The data on land-use changes in each of the years from 1997 to 2008 were obtained from the land-use change surveys conducted by the Ministry of Land and Resources. Since 2002, the land-use change surveys have adopted a new standardized land-use classification scheme, as shown in Table 1. The scheme is divided into 3 levels; the first level of three categories, includes agricultural land, developed land, and unused land and other land; the second level lists 15 categories of usage while the third level consists of 71 categories, the definition of each being self-explained by its level 2 categorization. Only the major level 3 categories are listed in Table 1. Field surveys were the primary method for obtaining information on land-use change. The data for a province were obtained from the results of all the counties under its jurisdiction, and the data for the whole country were then collated and published by the Ministry of Land and Resources as the "Comprehensive Statistics Annals of Land and Resources". The data on land-use changes at state, province and county levels in each of the years from 1997 to 2005 and the data at state and province levels in from 2006 to 2008 were collected in the study. The social and economic data at state and province levels, which were used for analysis in this study, came from each "China Statistics Yearbook" from 1996 to 2005 published by China State Statistics Bureau (CSSB, 1996–2005).

Methodologies used

Calculation of the yearly change rate of a land-use type

The change of a land-use type is the result of land conversion. It involves the conversion of one particular land-use type i to another type j and the conversion of land-use type i from type j. Although there are several models to describe the sources and trends of conversion among land-use types (Cai, 2001; Liu and He, 2002; Long et al., 2007, 2009), we preferred to use the real data obtained from the surveys of land-use types for this study. The transformation rate and the increasing rate for each land-use type were calculated as below.

The transformation rate of a land-use type is calculated as

$$TRL_i = \frac{LA(i,t_1) - ULA_i}{LA(i,t_1)} \times \frac{1}{t_2 - t_1} \times 100\%$$

where TRL_i is the transformation rate of land-use type i in a monitoring period from t_1 to t_2, and $(LA(i,t_1) - ULA_i)$ represents the area of land-use type i converted to other types in the period with $LA(i,t_1)$ being the area of type i at the beginning of the period and ULA_i being its unchanged area during the period.

The increasing rate IRL_i of land-use type i is expressed as

$$IRL_i = \frac{LA(i,t_2) - ULA_i}{LA(i,t_1)} \times \frac{1}{t_2 - t_1} \times 100\%$$

where $(LA(i,t_2) - ULA_i)$ represents the area of land-use type i converted from other land-use types, i.e., newly created land-use type i, in the monitoring period and $LA(i,t_2)$ is the area of land-use type i at the end of the monitoring period, and ULA_i is the same as above.

The change rate CRL_i of land-use type i is then

$$CRL_i = IRL_i - TRL_i$$

A positive CRL_i indicates the area of type i land-use was increasing, while negative indicates it was decreasing.

Multivariate statistical analysis

Multivariate statistical analysis was applied in the analysis of the changes in land use and national socio-economic characteristics concerning related policies using SPSS 11.1 software. Correlation coefficient and the regression model between the primary and secondary and tertiary industry (GDP) and the fixed assets investment and the area of developed land were analyzed. The correlation analysis between the indicators of land-use structure and the economic density (the primary and secondary and tertiary industry per mu) (1 mu is a Chinese imperial unit equal to 0.06667 hectare), the ratio of the primary industry, the secondary industry and the tertiary industry in the primary and secondary and tertiary industry using 31 provinces (cities) data were calculated. The above economic data were selected from the Statistics Yearbooks of the State Bureau of Statistics from 1999 to 2005.

Prediction of land-use change using the method of linear extrapolation

The method of linear extrapolation was used in this study to predict the cultivated land generated through land consolidation (Long et al., 2010), land reclamation and land development in 2010. The information used to make the prediction included the average areas of cultivated land generated according to the