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Land-use Change and Socio-economic Driving Forces of Rural Settlement in China from 1996 to 2005

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Abstract: While urbanization has accelerated, the rural population in China has started decreasing in recent years. However, the expansion of rural settlement has not been sufficiently curbed. The questions of why this has happened and who has driven the land-use change (LUC) of rural settlement in China have aroused great interests among researchers. In this paper, it is suggested that population is not always a positive driving force for the LUC of rural settlement in China. Furthermore, socio-economic driving forces other than urbanization, population and industrialization are analyzed. On a national scale, the major driving forces are the per-capita rural housing area and the cultivated land area. On a regional scale, the main driving forces in the eastern China are the house-building capacity of rural households and the per-capita rural housing area; while in the central China, the main driving forces are rural housing investment, the proportion of primary industry employees in the rural working population, and the cultivated land area. For the western China, the main driving forces are rural register population and cultivated land area.

Keywords: land-use change (LUC); rural settlement; driving force; land institution; China

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1 Introduction

Land-use change (LUC) has been paid close attention in recent years, ranging from land use conversion and land use modeling, to driving forces analysis (Irwin and Geoghegan, 2001; Burgi *et al*., 2004; Long *et al*., 2007; Chou and Chang, 2008). So far, LUC remains a complex issue to some degree, involving many complicated processes and diversified driving forces (Lambin *et al*., 2001; Lambin *et al*., 2003; Foley *et al*., 2005; Rudel *et al*., 2005). Accurate understanding of the cause and effect of LUC depends on identifying both the socio-conomic and geo-bio-physical drivers exactly (Riebsame *et al*., 1994; Seto and Kaufmann, 2003; Taillefumier and Piegay, 2003; Mottet *et al*., 2006;). Compared to geo-bio-physical drivers, socio-economic driving forces are more important and much more difficult to identify in LUC, especially in a short time period (Krausmann *et al*., 2003). Although industrialization, urbanization and population have been recognized as crucial factors influencing LUC (Verburg *et al*., 1999; Chen *et al*., 2001; Veldkamp and Lambin, 2001; Tan *et al*., 2008; Long *et al*., 2009a; Garedew *et al*., 2012; Paulsen, 2012), they are still not sufficient enough to explain all important LUC, such as that of rural settlement in China.

With a large rural population, the area of rural settlement in China is vast and exceeds that of urban settlement (Long *et al*., 2012; Tian *et al*., 2012). Therefore, the LUC of rural settlement in China is particularly important for its significant effect on urbanization, intensive land use and agricultural land conservation. Presently, China is experiencing transitions in both urban

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and rural regions (Unger, 2002; Long *et al*., 2009b; Long *et al*., 2010; Zhao, 2012). Since the mid-1990s, urbanization has been greatly accelerated in China with a new round of market-oriented economic reforms and the flexible *hukou* system (household registration system) (Chen *et al*., 2011). This has enabled the release of a considerable number of people from rural areas, eventually leading to a decrease in the rural population. However, since the 1990s, rural settlement has continued to increase instead of decreasing. For example, a study using remote-sensing data showed that the area of rural settlement increased by 7.88×10^5 ha in the 1990s in China (Tian, 2003); from 1990 to 1995, the expansion occurred mainly in the south-east coastal zones; but from 1996 to 2000 the expansion was mainly in the west. Thus it is difficult to interpret the LUC of rural settlement in China in recent years by using only the driving forces of urbanization, population and industrialization.

There are several approaches to identifying the driving forces of LUC. The most common has been empirical analysis. Researchers have selected driving forces according to their knowledge and experiences, and discussed the potential relationship between driving forces and LUC (de Koning *et al*., 1999; Wood *et al*., 2004; Verburg *et al*., 2004; Li *et al*., 2005; Wang *et al*., 2008). When it comes to the driving force of policy, empirical analysis is particularly important, although it is usually difficult to analyze impact qualitatively. To recognize the drivers more accurately, some quantitative approaches were also used, such as correlation analysis (Liu *et al*., 2003; Long *et al*., 2007; Wang *et al*., 2008; Figueroa *et al*., 2009) and a logistic model (Serneels and Lambin, 2001; Fang *et al*., 2007; Lin *et al*., 2011). Correlation analysis usually needs sequential data over a long period of time to guarantee that the sample number is large enough to apply statistical analysis. But for China, long term land-use and socio-economic data are always insufficient due to the lack of related databases. The logistic model uses data at two time points in most cases but the data should also have spatial attributes. However, socio-economic data in China are usually aggregated in administrative units and are difficult to couple with data on LUC in space. These insufficiencies sometimes limit the accurate identification of the driving forces of LUC.

Nevertheless, the panel data model, which is widely utilized in econometrics, can incorporate observations on multiple phenomena over multiple time periods. This means that the panel data model can have both cross-sectional and time series dimensions (Hsiao, 2003; Baltagi, 2008). Thus, the panel data model can reveal dynamics that are difficult to detect by using only cross-sectional data or serial data. The ability to monitor multiple units over multiple time periods enables the panel data model to include very large numbers of observations. These advantages enable the quantitative study of the socio-economic dynamics of LUC in a short time period. Although the panel data model has been widely employed in many economic fields (Fischer *et al*., 2009; Bonnal, 2010; Sismeiro *et al*., 2012), few studies on LUC by using the panel data model to study have been found. Furthermore, in this limited literature (Seto and Kaufmann, 2003), no research focused on the driving forces of LUC for rural settlement.

To enact policy that promotes intensive land use and strengthens agricultural land protection while accelerating urbanization and industrialization, decision makers must understand the factors that drive the expansion of rural settlement. Without a clear sense of the causes that lead to the expansion of rural settlement, policies will be ineffectual. Accordingly, we combine time series land-use data and socio-economic data to estimate the socio-economic driving forces of LUC of rural settlement in China by using econometric equations. Through this research, we want to answer the following questions: 1) How has rural settlement changed in China in recent years? 2) What are the key socio-economic driving forces of LUC for rural settlement in China, other than urbanization, population and industrialization? 3) Because the institutional system of China is different from most Western countries, does the specific land institutional arrangement affect the LUC of rural settlement in China?

2 A Theoretical Hypothesis of Land-use Change for Rural Settlement in China

Before 1978, rural housing grew slowly in China due to farmers′ insufficient wealth (Long *et al*., 2007), a limited rural population, and the problematic institution of land property and land market. There are no obvious differences in the regional development of rural settlement, except for the existing regional diversity in climate, terrain and population (Arayama and Miyoshi,

2004; Long *et al*., 2007). After 1978, with the implementation of economic reforms, the traditional planning economy was changed into a market-based economy. The LUC of rural settlement linked closely with this social and economic transformation. As a result, several waves of rural housing construction were triggered, resulting in the sharp expansion of rural settlement (Song *et al*., 2012). With continuous development of the economy and institutional reforms, China underwent several periods of transition in society and economy. Echoing these transitions, the LUC of rural settlement has remarkable staged features with different key driving forces after 1978. In this paper, we assume that the development of rural settlement can be divided into three stages.

In the first stage, rural settlement expanded obviously due to the increasing rural population and accumulative wealth. According to *A Theory of Human Motivation* by Maslow (1943), human motivations are generally divided into five levels i.e. physiological, safety, belongingness and love, esteem and self-actualization. Maslow′s theory can also be utilized to describe the needs of dwelling but the levels should be redivided. Because the levels of belongingness and love, and self-actualization are difficult to define when analyzing dwelling needs, a theory of dwelling needs was simplified to three levels: physiological needs, safety needs and esteem needs (Fig. 1). Physiological needs are the primary requirements for human survival. Possessing one′s own rural house, regardless of the quality and form, is a dream for farmers who had just become wealthy in China after the economic reform in 1978. Driven by physiological need, a great many rural houses will be built to satisfy the basic dwelling demand for an increasing population, inevitably resulting in the expansion of rural settlement.

In the second stage, the primary dwelling objective (possessing a rural house) is satisfied and the safety of the dwelling becomes the next objective that farmers pursue. After a period of wealth accumulation, farmers may renovate old houses to improve living conditions. Furthermore, with economic development, the industrial structure will also change. The importance of the non-agricultural industry will gradually exceed agriculture, generating numerous non-agricultural employment opportunities. The increase in non-agricultural employment opportunities will improve farmers′ income and result in rural-to-urban migration, significantly influencing the LUC of rural settlement. Farmers′ desire to dwell safely and comfortably, and the change of employment structure both have significant influences on the LUC of rural settlement at this stage.

In the third stage, farmers seek to satisfy the need for esteem. Specifically, they would like to live in big houses and increase the housing area if the conditions allow. Housing area can be increased either through expanding the rural settlement or increasing the floor-area ratio. Which approach is selected is mainly determined by the farmers′ house-building capacities. If farmers have adequate house-building capacities, lots of multi-storey houses will be built with a high floor-area ratio. Thus, the dwelling needs of esteem can be met by increasing floor-area ratio instead of expanding the rural settlement. In addition, with accelerated urbanization, the expansion of rural settlement can, ideally, be effectively curbed.

Since the foundation of the People′s Republic of China in 1949, and especially since the initiation of economic reform in 1978, the mainland of China has witnessed quick and fierce changes in the fields of economic development, population growth and institutional reform. However, for the broader territory and different physical geographic conditions, a regional disparity is

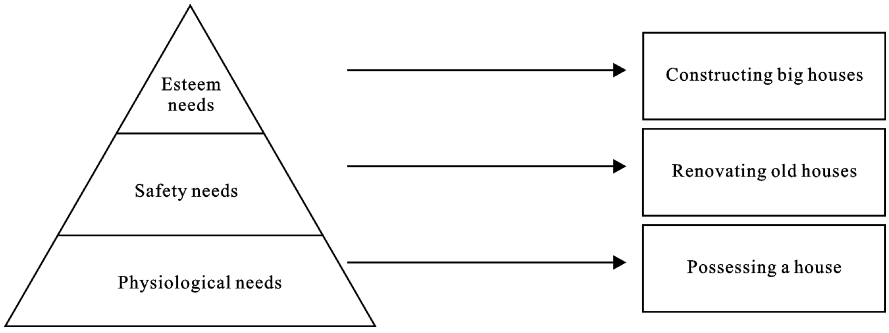

Fig. 1 An interpretation of dwelling needs of Chinese farmers

obvious in the eastern, central and western provinces of the mainland of China (Kanbur and Zhang, 1999). From the eastern provinces to the central and western provinces, there is an obvious gradient in economic and social development. Due to the lack of long-term data on rural settlement, the eastern China, the central China and the western China, which have an obvious development gradient, are thus taken as examples of different developmental stages of rural settlement. The conventional division of the three major regions of the mainland of China according to natural, economic and social development is shown in Fig. 2.

However, the development of rural settlement can not necessarily be accommodated within the law due to limitations in land-use policies and institutional factors. In China, the expansion of rural settlement often occupies a large expanse of precious cultivated land which may threaten food security. Therefore, the central government has implemented many policies to hinder the expansion of rural settlement on cultivated land. Furthermore, the imperfect institution of land property and market in rural areas could also influence the stage transition of rural settlement.

3 Methodology and Data Sources

3.1 Model of driving forces

The panel data model is applied to analyze driving forces of the LUC of rural settlement. The model can arrange data in spatial and temporal dimensions and effectively increase the number of samples through repeated observation of the same section. It also controls the individual differences (unobserved effect) by setting dummy variables in order to better integrate the observed values of different sections at multiple time periods (Seto and Kaufmann, 2003). In this way, the model improves the degree of freedom, reduces the co-linearity of the explanatory variables, and thus describes well the dynamicity in LUC. The model formula is:

$$y_{it} = \alpha_i + \beta_i x_{it} + u_i \quad (1)$$

where y_{it} is the value of the dependent variable on section i at time t (k × 1 order vector of the dependent variable); α_i is the intercept on section i; x_{it} is the value of the explanatory variable (driving forces) on section i at time t (k × 1 order vector of the independent variable); β_i is the k × 1 order coefficient vector on section i; μ_i is an error term on section i.

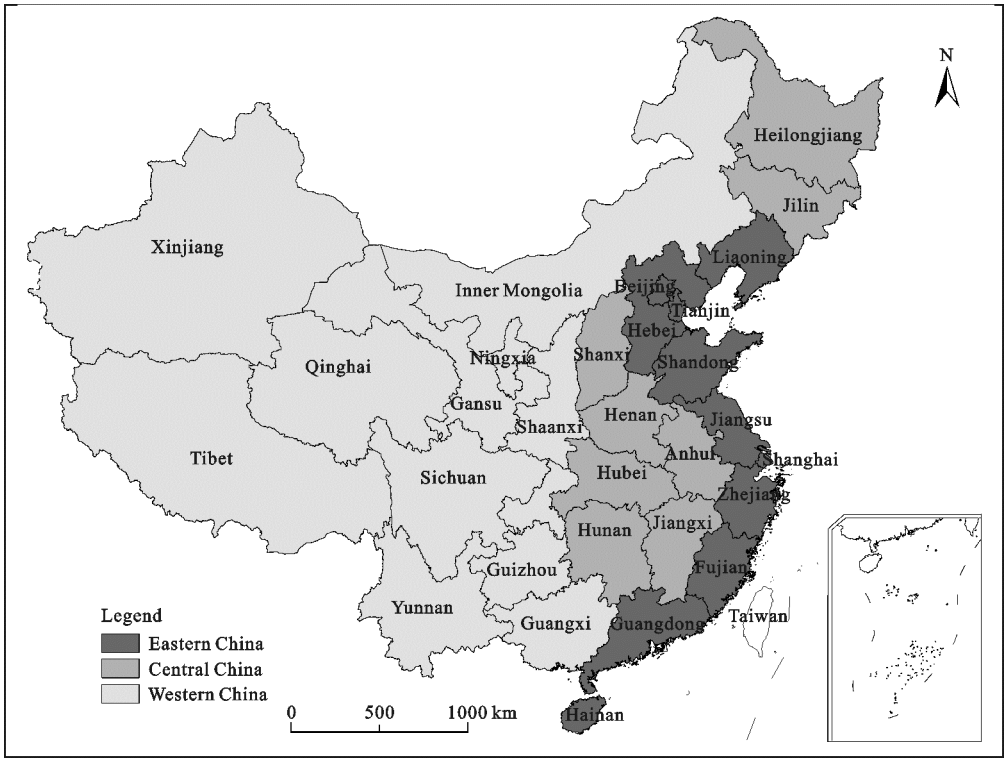

Fig. 2 Division of three major regions in China. Conventional division of three major regions does not include Chinese Taiwan, Hongkong and Macao

The software Stata 7.0 is applied to set the panel data model, and the fixed-effect estimator is chosen through the *F* statistic test and the Hausman test.

3.2 Selection of dependent variables and driving forces for model

The dependent variables of the panel data model are rural settlement area (y) at the provincial level from 1996 to 2005. The driving forces were selected in accordance with previous research and the theoretical hypothesis of the LUC of rural settlement. The spatial and temporal factors in LUC usually pertain to natural and social conditions, climate change, economic development and population. The impacts of natural conditions are mainly cumulative, and those of socio-economic factors are much more obvious on short-term spatial and temporal changes in LUC (Liu and Deng, 2010). Hence, this study chose the driving forces of economic development, social conditions, population and policy effects.

In China, there are two categories of rural demographic survey. The rural population covers all residents living outside of urban areas; the rural register population refers to rural residents who are registered in the native household registration agency. Land management departments usually review and approve the allocation of the land for house construction according to rural register population. Land used for house construction in village is the key component of rural settlement. Hence, this study selects the rural register population (x_1) as the driving factor for the LUC of rural settlement. Moreover, since the scale of rural settlement is closely related to the construction activities of local farmers, the rural housing investment (x_2) and house-building capacity of rural households (x_3) become economic factors. Here, house-building capacity of rural households is the ratio of farmers′ average net income to house-building cost. This indicator can evaluate the economic capacity of an individual farmer for house building. A higher value means a better capacity.

Changes in rural employment structure affect the amount of rural settlement; the improvement of housing conditions can also directly or indirectly alter the land use of rural settlement. Thus, the proportion of primary industry employees in rural working population (x_4) and the per-capita rural housing area (x_5) are chosen as the social factors. The policies having impacts on rural settlement always concern cultivated land protection, yet it is hard to quantify their effects. Nevertheless, the cultivated land area may be regarded as the result of the implementation of these policies and is much easier to calculate. Therefore, the cultivated land area (x_6) can serve as the policy factor driving the LUC in rural settlement.

3.3 Data sources

The Chinese government noticed the reality that China has lack of reliable land-use data in the 1990s. So they decided to carry out a national land use survey from 1990–1995. The earliest land-use data of rural settlement we can acquire originate from that survey. After 1996, the Chinese government implemented a renovating survey every year to update the land-use data. The latest updating data of rural settlement we can acquire were in 2005. The land-use survey data of rural settlement were sourced from the information center of the Ministry of Land and Resources of China (MLRC). Sequential data ranging from 1996 to 2005 for each province of China were used to analyze the driving forces of the LUC for rural settlement with the panel data model. For the lack of related land use survey in Chinese Taiwan, Hongkong and Macao, the dataset does not include these three regions. The statistics for the rural register population came from the *China Population and Employment Statistical Yearbook*s (1997–2006) (PESC, 1997–2006). The original data from the *China Statistical Yearbook*s (1997–2006) (NBSC, 1997–2006) covered the net per-capita income of farmers, rural private housing investment and cost, and the rural employment structure. The number of rural settlements was taken from the *China Rural Statistical Yearbook*s (1997–2006) (RSEID, 1997–2006). All the economic data were adjusted for inflation with the consumer price index (CPI).

4 Results and Discussion

4.1 Land-use change of rural settlement

From 1996 to 2005, the total area of rural settlement in the mainland of China increased from 1.64573×10^7 ha to 1.65748×10^7 ha, a slight increase of 0.71% (Table 1). From 1996 to 2001, the area registered a major expansion of 1.197×10^5 ha; from 2002 to 2005, it went down a little by 0.21×10^4 ha. Rural settlement scaled up in most provinces from 1996 to 2005, but the areas decreased in ten provinces, namely Henan, Tibet, Chong-

qing, Shandong, Shaanxi, Anhui, Jiangxi, Gansu, Hainan and Sichuan. In Henan and Tibet, the decrease was larger, at 3.60% and 3.24%, respectively (Table 1). In Gansu, Hainan and Sichuan, the decrease was as little as 0.33%, 0.06%, and 0.05%, respectively. Among the provinces with increased rural settlement, increases exceeding 7% occurred in Tianjin, Xinjiang, Shanghai and Qinghai. But in Jilin, Hunan and Liaoning, the increases were small. Above all, the provinces with rapid expansion were mostly located in the eastern China, apart from Xinjiang, Qinghai, Yunnan and Shanxi in the central and the western China. Most of the provinces with fast shrinkage were in the central and the western China. Only Shandong and Hainan in the eastern China witnessed a slight decrease in rural settlement.

In terms of the volume of changes, major shrinkage happened in Henan, Shandong and Anhui, particularly in Henan from 1996 to 2005. During this time the decreased area of rural settlement of Henan accounted for 49.72% of the total decreased area of rural settlement of the ten provinces (1.055×10^5 ha). The total increased area was 2.231×10^5 ha for 21 provinces, among which Xinjiang, Hubei and Shanxi together contributed 59.39%.

In the eastern China, the proportion of rural settlement increased from 32.47% to 32.74%; in the central China, the proportion increased from 29.68% to 29.85%; while, in the western China, it dropped from 37.85% to 37.41%. At the provincial level, Tianjin, Shanghai, Qinghai and Xinjiang all had a higher increase in the proportion of rural settlement (Fig. 3). On the contrary, provinces, such as Henan, Tibet, Chongqing, Shandong, Shaanxi, Anhui and Jiangxi experienced a rapid decrease. In general, the proportion of rural settlement maintained a rising trend in the southeastern coastal region and the northwest but a falling trend in the central China.

4.2 Driving forces for LUC of rural settlement

4.2.1 Regression results of panel data model

To identify the exact effects of various drivers in different regions, regional models have been established for the eastern, central and western China in addition to the national-scale model. The regression results show the significance of all models (Table 2). The fitness (R^2) is higher for the national and the eastern-region models, but lower for the central and western ones.

4.2.2 Population factors driving land-use change of rural settlement

At the national level, the rural register population had no significant impact on rural settlement area from 1996 to 2005. The negative coefficient of estimation also indicated the opposite changes of the population and the

Table 1 Change rate of rural settlement area in China from 1996 to 2005 (%)

Administrative units	1996–2001	2002–2005	1996–2005	Administrative units	1996–2001	2002–2005	1996–2005
Mainland of China	0.73	–0.01	0.71	Henan	–0.24	–3.37	–3.60
Beijing	1.52	–0.79	0.72	Hubei	–0.26	1.26	1.00
Tianjin	2.63	5.88	8.67	Hunan	0.31	0.06	0.37
Hebei	1.33	2.03	3.39	Guangdong	1.52	0.79	2.32
Shanxi	4.14	0.98	5.16	Guangxi	1.11	0.63	1.74
Inner Mongolia	0.02	0.95	0.97	Hainan	–0.01	–0.05	–0.06
Liaoning	–0.73	1.18	0.44	Chongqing	–0.97	–0.81	–1.78
Jilin	0.29	–0.09	0.20	Sichuan	0.06	–0.11	–0.05
Heilongjiang	0.46	0.32	0.79	Guizhou	1.01	0.82	1.83
Shanghai	0.19	7.49	7.69	Yunnan	2.96	1.58	4.59
Jiangsu	3.37	–0.90	2.44	Tibet	1.08	–4.27	–3.24
Zhejiang	1.02	1.39	2.42	Shaanxi	–0.81	–0.62	–1.42
Anhui	–0.51	–0.73	–1.24	Gansu	0.75	–1.07	–0.33
Fujian	3.07	0.75	3.84	Qinghai	1.34	5.99	7.41
Jiangxi	1.31	–2.36	–1.08	Ningxia	–0.62	1.22	0.59
Shandong	0.14	–1.66	–1.52	Xinjiang	3.55	4.17	7.87

Source: Land use survey data were acquired from the Information Center of Ministry of Land and Resources

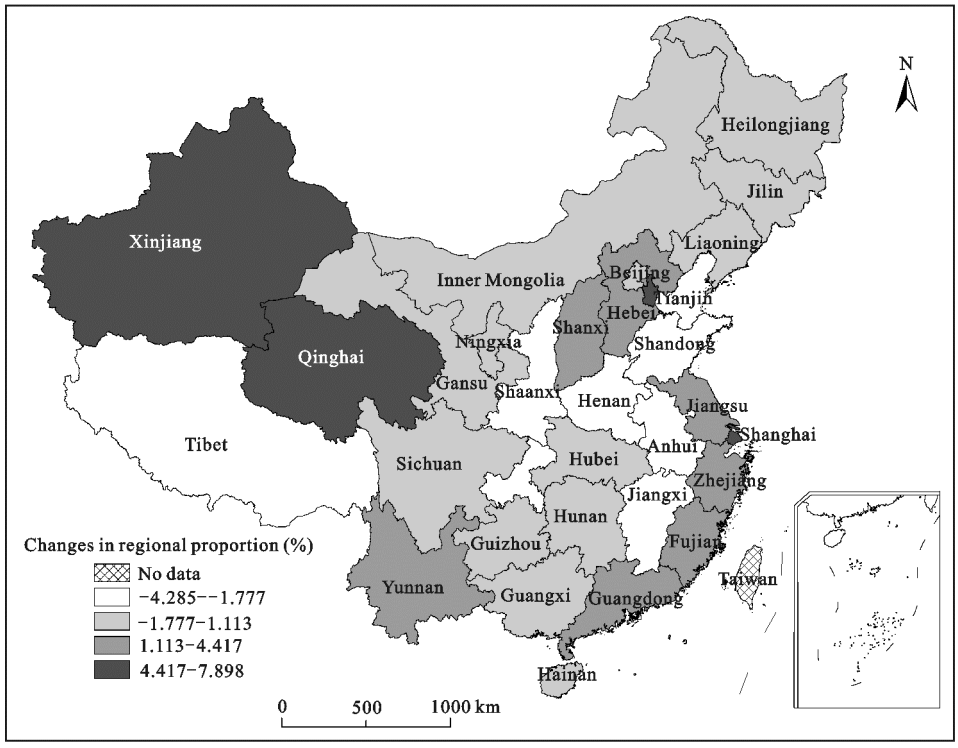

Fig. 3 Changes in proportion of rural settlement in different provinces in China from 1996 to 2005

Table 2 Regression results of panel data model

	Mainland of China		Eastern China		Central China		Western China	
	Coef.	$p>\|t\|$	Coef.	$p>\|t\|$	Coef.	$p>\|t\|$	Coef.	$p>\|t\|$
Ln (x_1)	–0.042	0.142	–0.078	0.015	–0.065	0.210	0.371***	0.005
Ln (x_2)	0.001	0.726	0.003	0.581	–0.011**	0.047	0.001	0.874
Ln (x_3)	–0.003	0.636	–0.020**	0.022	0.003	0.726	0.011	0.366
Ln (x_4)	0.028	0.327	0.030	0.321	0.066**	0.047	0.063	0.480
Ln (x_5)	0.047**	0.008	0.062***	0.001	–0.003	0.882	0.031	0.450
Ln (x_6)	–0.089***	0.005	–0.057	0.154	–0.345***	0.000	–0.160***	0.031
constant	4.266***	0.000	3.988***	0.000	6.758***	0.000	1.325	0.163
sigma_u	1.030		1.295		0.523		0.635	
sigma_e	0.019		0.016		0.009		0.024	
rho	1.000		1.000		1.000		0.999	
Number of observation	296		110		79		107	
R^2 (overall)	0.907		0.972		0.617		0.496	
Probably>F	0.000		0.000		0.003		0.001	

Notes: x_1, x_2, x_3, x_4, x_5 and x_6 are rural register population, rural housing investment, house-building capacity of rural households, proportion of primary industry employees in rural working population, per-capita rural housing area and cultivated land area, respectively; the dependent variables of the panel data model are rural settlement area; ** and *** present significant level at 5% and 1%, respectively; sigma_u is the random-intercept standard deviation; sigma_e is the residual standard deviation; and rho is the intraclass correlation.

land-use scale. For example, during that time span the national rate of change on rural settlement area was 0.71%, while the simultaneous change rate for the rural register population was –3.84% (Table 3). The rural demographic change had no significant impacts on rural settlement in the eastern and central China (though the opposite changes actually occurred in the eastern China). In contrast, rural settlement area had responded actively

to the growth of the rural register population (with an estimation coefficient of 0.371) (Table 2) in the western China, which greatly boosted the expansion. From 1996 to 2005, the rural register population increased by 1.46% in the western China, and rural settlement area there increased by 1.29% (Table 3).

Rural settlement area and rural register population naturally changed in the same direction in the western China but the opposite happened in the eastern China because of the restrictions on the property right and land market of rural settlement. After the foundation of the People′s Republic of China in 1949, the state initiated a nationwide rural land reform to deprive lords of land and distribute it to individual farm households. By 1953, the land reform was basically finished and new private land ownership (farm households) came into being. The land distributed to farmers was under private ownership and could be freely transacted or leased. However, this land property reform was only a temporary institutional fix (Lin and Ho, 2005) and soon changed again when the People′s Commune Movement began in 1956. The people′s commune was the highest administrative unit in rural areas of China during the period of 1958–1982 until it was replaced by township. The classification of people′s communes were divided in turn into communes, production brigades and production teams. In the People's Commune Movement, farmers were required to give their ownership of farmland and rural settlement land to the rural cooperative but they could use them freely. Then the rural collective-ownership land system was shaped, i.e. the rural cooperative had the land ownership, while famers acquired the land-use right (Ding, 2003; 2007). However, farmers could not transact, lease, or transfer rural settlement land privately. As for rural houses, farmers still had complete private ownership and could dispose of them freely during this period. Furthermore, before 1998 not only rural people but also urban people could apply for rural settlement land, or purchase rural houses. But in 1999, the new *Land Administration Law* (enacted in 1998 and implemented in 1999) (SCNPC, 1998) abolished the stipulation that urban people could build houses in rural settlements. In addition, the purchase of rural houses by urban people was also strictly forbidden. Then, the possibility that the urban population could acquire rural settlement land was completely eliminated (Cai, 2003).

In China, land ownership was divided into state-owned and rural collective-owned property according to the land location. After 1978, when the economic reform was implemented, China was forced to reform its land system in order to accommodate the development of a market economy and allocate land resources more efficiently (Ho and Lin, 2003). The use right of both urban and rural land was separated from ownership, that is, the ownership still belonged to the state or the rural collective but individuals, enterprises and organizations could acquire the use right, resulting in the formation of a land market in China (Hsing, 2006). The land market in China is divided into three ranks. The primary market is utilized by land owners to convey land-use rights among land users by using an allocation and conveyance approach. The secondary market is used to transfer land-use rights between different land users. The third market refers to the lease and mortgage of land-use rights, not changing the owner of the land-use right. Rural settlement land can be dispensed by rural collectives but the transfer of the use right is strictly limited (Ho and Lin, 2004). The members of a rural collective can use collective-owned land to build rural settlement legally, but conveyance, transfer or lease of the land-use right of rural settlement are forbidden. Rural settlement land can not enter the land markets freely except when changed from rural collective-owned land to state-owned land through land expropriation (Qian, 2008). Land expropriation refers to that the government expropriates land from the rural collective for the sake of public interests.

Table 3 Changes of rural register population and rural settlement area from 1996 to 2005

Region	Rural settlement area			Rural register population		
	1996 (10^2 km^2)	2005 (10^2 km^2)	Change rate (%)	1996 (10^4 person)	2005 (10^4 person)	Change rate (%)
China	1645.73	1657.48	0.71	90407.25	86935.34	–3.84
Eastern China	534.34	542.68	1.56	31770.48	28228.16	–11.15
Central China	622.87	620.00	–0.46	30996.19	30662.86	–1.08
Western China	488.52	494.81	1.29	27640.58	28044.32	1.46

Source: Land use survey data were acquired from the Information Center of Ministry of Land and Resources

When land was expropriated, the land ownership was changed from rural collective to the state. Governments will compensate the rural collectives and farmers for land expropriation according to certain stipulations of the laws.

This institutional shortage of land property and land market influenced the LUC of rural settlement deeply. Firstly, the limitation that only the rural registered population can apply and possess rural settlement land curbed the normal recycling of idle land in rural settlement. In recent years, with the acceleration of urbanization, massive rural people migrated to urban area. However, because of all kinds of causes, the land of rural settlement they used in rural area is idled. When the urban population was deprived of the right to purchase rural settlement land and rural houses, the recycling possibility of idled rural settlement land was reduced due to insufficient users. Under the current system of land market, it is completely forbidden for rural settlement land to enter the primary market. In the secondary market, the use-right transfer of rural settlement land is mostly limited to native villages. In the third market, the mortgage and lease of rural settlement land is almost prohibited by the law. Accordingly, if rural settlement land is idled, it can not be freely allocated through the market mechanism. Idle rural settlement land can not flow to other land-use types such as needed for industry, commerce and service. Therefore, much rural settlement land is idled due to urbanization but farmers have not the enthusiasm to dispose it due to limitations in land property and the market mechanism. Meanwhile, new rural settlement land keeps on expanding for the newly increased rural population. Therefore, the expansion of rural settlement has not been well controlled even in the context of depopulation in rural areas, especially in the eastern China.

4.2.3 Economic factors driving land-use change of rural settlement

Economic factors, house-building capacity of rural households and rural housing investment have no significant influences on the scale of rural settlement at the national level or in the western China. But house-building capacity of rural households plays a more important role in the eastern China, as does rural housing investment in the central China. Both have negative coefficients of estimation. In other words, raising the house-building capacity of rural households may curb the expansion of rural settlement, thanks to the native housing pattern. The more developed economy there permits rural households to build multi-storey houses with a high floor-area ratio. Improved house-building capacity of rural households can turn horizontal expansion into an increase in floor-area ratio. However, this mechanism and its effect have been weakened at the national level and in the central and western China.

Rural housing investment in the central China may not necessarily lead to expansion. It depends on how the money is spent. According to Qiao and Zhu (2008), the financial status of rural households in Henan (a province in the central China) has been improved in recent years, resulting in more frequent investment in house renovation. Particularly from 1996 to 2005, the renovation rate of the surveyed households was much higher than that of other time spans (Table 4). Among the seven selected time spans, the rates for 1996–2000 and 2001–2005 account for 50% of the total. As shown by the case study of Xiantao City in Hubei Province, located in the central China (Hu *et al*., 2007), nearly 3000 rural households have engaged in house construction in recent years, but most of them rebuilt the houses on the original sites.

The construction date and renovation cycle determine when to repair or renovate a house in the countryside,

Table 4 Changes in house renovation rates of surveyed rural households in Henan Province in past 30 years (%)

Renovation span	Qiangnan Village	Beisong Village	Shanghe Village	Songquan Village	Chenwan Village
Before 1980	0.00	0.90	3.67	0.82	2.52
1981–1985	4.20	0.00	5.50	2.46	0.84
1986–1990	7.56	7.21	8.26	1.64	3.36
1991–1995	6.72	6.31	4.59	4.92	6.72
1996–2000	12.61	15.32	11.93	7.38	4.20
2001–2005	8.40	15.32	5.50	8.20	6.72
2005–2007	5.88	7.21	1.83	10.66	0.00

Note: The renovation rate is the proportion of households that renovated houses in survey to total surveyed households. Qiao and Zhu, 2008

and the purpose of renovation is mainly to improve living conditions and expand the housing area in rural China. Generally, the renovation span lasts for about 10 to 20 years. From the beginning of reform until the mid-1980s, the income of Chinese farmers increased rapidly. As a result, the number of houses owned by them multiplied and formed the first wave of rural housing construction. The second wave was initiated when the farmers started to upgrade their old houses in the middle and late 1990s. Because most of the investment was in renovation, it did not lead to the occupation of more land but, to some degree, lessened the tension of land demands caused by the increasing population (as the floor area was increased) and thus curbed the expansion of rural settlement. Therefore, more rural housing investment in the central China may not necessarily mean a larger scale of rural settlement.

4.2.4 Social factors driving land-use change of rural settlement

In the eastern China and the nation as a whole, the per-capita rural housing area has an obvious positive effect on rural settlement area; in the central China, it is the proportion of primary industry employees in rural working population; while in the western China, the rural settlement is not sensitive to social factors at all (Table 2).

The socio-economic development in recent years raised the expectation of rural residents for better housing conditions. From 1996 to 2005, the per-capita rural housing area grew by 36.85% (Song *et al*., 2008). The rural register population began to drop in 2001, but the total housing area maintained its increasing trend in the countryside from 1996 to 2005, up by 31.59%, because of the rapid growth of the per-capita rural housing area in rural China. The expansion of the housing area can be realized by either enlarging the rural settlement or raising the floor-area ratio of existing houses. However, the annual growth rate of floor-area ratio in rural China was 1.94% (Table 5) from 1998 to 2005 (for the lack of floor area ratio data during 1996–1998, Song *et al*. (2008) only calculated the annual change rate during 1998–2005), much lower than that of total rural housing areas (3.51%). At the provincial level, the annual floor-area ratio growth rate was higher than that of the total housing area only in Hainan, Shandong, Hubei, Zhejiang, Jiangsu, Sichuan and the three municipalities under direct administration of the central government (Beijing, Shanghai and Tianjin). The floor-area ratio even decreased in the northwestern and southwestern provinces such as Qinghai, Gansu, Xinjiang, Tibet, Yunan and Ningxia. Nevertheless, the total housing area always demonstrated an increasing trend in these provinces. Thus the occupation of new housing area resulted in a larger scale of rural settlement in China as a whole.

In the central China, rural settlement is noticeably relevant to the per-capita rural housing area and the proportion of primary industry employees in rural working population (with a positive coefficient of estimation). In other words, a lower proportion of primary industry employees in rural working population may help restrain the scale of rural settlement. The central China represents one of the major regions of grain production. Yet in recent years, a large number of agricultural labor forces have been transferred to non-agricultural sectors because of the minimal benefits in grain production and other problems. The central China has become the main exporter of labor forces to the coastal areas. The demands for dwellings in the central China were then mitigated due to rural-to-urban migration. Parts of the dwelling demand were transferred from rural areas to urban areas, curbing the expansion of rural settlement. As a result, the scale of rural settlement is sensitive to the rural employment structure in the central China.

4.2.5 Policy factors driving land-use change of rural settlement

In the central and western China and at the national level, rural settlement area is closely related to the cultivated land area. Particularly in the central China, the coefficient of estimation reaches –0.345 (Table 2), which means that strict protection can reduce the loss of cultivated land and thus curb the expansion of rural settlement. Since they are always adjacent, 93.14% of the expanded residential areas come from cultivated land; the rest are from forests, grasslands, water areas and undeveloped lands (Tian, 2003). From the late 1980s to the late 1990s, China lost 3.24×10^4 ha of cultivated land, of which 10.30% were occupied by rural settlement (Tian and Qu, 2008). To protect cultivated land against growing urban and rural construction, the state issued the Regulation on the Protection of Basic Cultivated Land (SCNPC, 1998). In the administrative measures of the provinces, such as Tianjin, Hubei, Shanxi, Inner Mongolia, Liaoning, Jilin, Jiangsu, Shandong, Henan, Gansu and Xinjiang, the approval of rural set-

Table 5 Change of rural housing area and floor-area ratio in China from 1996 to 2005

Administrative unit	Total rural housing area			Floor area ratio		
	1996 (10^7 m^2)	2005 (10^7 m^2)	Annual change rate (%)	1998	2005	Annual change rate (%)
China	196.09	258.04	3.51	0.236	0.268	1.94
Beijing	1.00	1.10	1.09	0.215	0.297	5.45
Tianjin	0.82	0.99	2.27	0.188	0.226	2.89
Hebei	11.38	14.23	2.78	0.234	0.272	2.32
Shanxi	4.05	5.51	4.03	0.169	0.183	1.18
Inner Mongolia	2.39	2.78	1.82	0.064	0.046	–4.02
Liaoning	4.47	5.42	2.35	0.132	0.147	1.62
Jilin	2.45	2.94	2.22	0.083	0.083	0.00
Heilongjiang	3.41	3.96	1.81	0.082	0.070	–2.09
Shanghai	1.69	1.20	–3.27	0.612	0.749	3.20
Jiangsu	15.11	15.86	0.55	0.326	0.418	4.03
Zhejiang	12.81	18.89	5.28	0.700	1.014	6.41
Anhui	9.67	13.91	4.87	0.200	0.241	2.93
Fujian	6.07	9.29	5.91	0.474	0.727	7.63
Jiangxi	7.53	11.02	5.14	0.336	0.451	4.89
Shandong	14.47	17.98	2.69	0.248	0.308	3.46
Henan	15.31	21.45	4.46	0.220	0.270	3.62
Hubei	11.24	12.97	1.71	0.290	0.340	2.78
Hunan	14.06	19.61	4.39	0.340	0.430	3.70
Guangdong	10.69	9.81	–0.91	0.400	0.400	0.00
Guangxi	7.45	11.43	5.93	0.340	0.390	1.94
Hainan	1.05	1.10	0.59	0.150	0.160	0.85
Chongqing	6.06	7.74	3.09	0.320	0.360	1.42
Sichuan	16.40	22.94	0.39	0.310	0.450	6.98
Guizhou	4.84	7.66	6.46	0.280	0.290	0.41
Yunnan	6.66	9.01	3.92	0.310	0.220	–4.09
Tibet	0.30	0.43	4.55	0.240	0.170	–3.95
Shaanxi	5.08	7.19	4.62	0.200	0.200	0.22
Gansu	2.81	3.73	3.62	0.140	0.060	–8.24
Qinghai	0.44	0.64	5.06	0.140	0.050	–9.46
Ningxia	0.59	0.79	3.72	0.100	0.080	–2.66
Xinjiang	1.73	2.37	4.16	0.060	0.030	–7.99

Source: Song *et al*., 2008

tlement should depend on the area of native cultivated land. Moreover, the policies which integrate urban and rural land use for construction especially guarantee the total cultivated land area against any reduction within their effective regions. These approaches have preserved the cultivated land and slowed down the expansion of rural settlement.

Some important land use policies, such as ′increasing vs. decreasing balance′, also have vital effects on the LUC of rural settlement in China. The key objective of ′increasing vs. decreasing balance′ policy is to achieve the balance between the increase in urban construction land and a decrease in rural settlement (Long *et al*., 2012). In the regions implementing ′increasing vs. decreasing balance′ policy, former rural settlements were usually reclaimed as agricultural land in order to support food security goals and guarantee that the total construction land was not increased. Thus through the implementation of ′increasing vs. decreasing balance′, the expansion of rural settlement could be effectively

curbed. But differences in the policy implementation of ′increasing vs. decreasing balance′ might affect the LUC of rural settlement in different provinces. For example, Shandong Province and Sichuan Province were selected as the first pilot provinces to implement the policy. Affected by this to some degree, the rural settlement in Shandong and Sichuan decreased by 1.52% and 0.05% respectively. Within those provinces that have still not implemented the ′increasing vs. decreasing balance′ policy till now, such as Xinjiang, Shanghai, Qinghai, Shanxi and Hubei, the rural settlements all increased significantly during 1996–2005.

5 Conclusions

Rural settlement area in China increased by 0.71% during 1996–2005, while simultaneously the rural population decreased by –3.84%. The LUC of rural settlement in China is difficult to interpret by using only the change of rural population. We established a theoretical hypothesis to explain the LUC of rural settlement, i.e. the LUC of rural settlement can be divided into three stages prompted by different drivers, e.g. rural register population, the per-capita rural housing area, the house-building capacity of rural households, rural housing investment, the proportion of primary industry employees in trural working population and cultivated land area.

The eastern, central and western China, which have an obvious development gradient, were used as examples to test the theoretical hypothesis. The LUC of rural settlement in the eastern, central and western China are in the third, secondary and primary stage, respectively. The LUC of the eastern China is sensitive to house-building capacity of rural households and the per-capita rural housing area, while that of the central China is sensitive to rural housing investment, the proportion of primary industry employees in rural working population and cultivated land area. Unlike the eastern and central China, rural register population plays a positive role in the LUC of rural settlement in the western China as well as cultivated land area. On a national scale, the per-capita rural housing area and the cultivated land area are the key driving forces of the LUC of rural settlement.

Rural population did not positively drive the LCU of rural settlement in the eastern and central China due to the problematic land property system. The restrictions in land transfer and a semi-opened land market left idle rural housing land unable to be reused, resulting in the insignificant effects of population on the LUC of rural settlement. Evolution of farmers′ dwelling needs combined with farmland conservation policies drove the LUC of rural settlement in China.

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