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Socio-economic development and land-use change: Analysis of rural housing land transition in the Transect of the Yangtse River, China

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Abstract

Rural housing land accounted for 67.3% of China's total construction land in 2000. While there are numerous studies analyzing the loss of arable land due to urban sprawl, less attention has been paid to the study of rural housing land in China. This paper develops a theoretical framework for rural housing land transition in China. It introduces a research method, which is using the spatial differentiation in regional development for compensating the deficiencies in time-series data, to analyze the rural housing land transition in the Transect of the Yangtse River (TYR). Detailed land-use data and socio-economic data from both research institutes and government departments were used to test the following hypothesis on rural housing land transition. We assume that rural housing in every region will undergo specific stages—the proportion of rural housing in the increase of total construction land will decline gradually with the development of the local economy, and the end of the transition corresponds to a new equilibrium between rural housing and other construction activities. Five regional types of rural housing land change were defined according to an aggregation index used to reflect landscape patterns. The outcomes indicated that the share of rural housing in the increase of total construction land declines gradually from the upper reaches to the lower reaches of the Yangtse River, i.e. from Ganzi–Yushu to Luzhou–Diqing, Enshi–Chongqing, Tongling–Yichang and to Shanghai–Chaohu. Each region is in a different phase of the rural housing land transition, which corresponds to a particular socio-economic developmental level. Finally, some policy implications were discussed by applying this research to land management issues. The authors argue that there are problems in the current rural housing land managerial system in China, and that the Central Government needs to define uniform regulations for rural housing according to regional socio-economic developmental level, physical conditions and rural housing land transition phase.

Keywords: Land-use and land-cover change; Rural housing land transition; Socio-economic development; Theoretical basis; The Transect of the Yangtse River; China

Introduction

Currently, issues related to land-use and land-cover change (LUCC) have attracted interest among a wide variety of researchers, ranging from those who are modelling the spatial and temporal patterns of land conversion, to those who try to understand the causes and consequences of land-use changes (Irwin and Geoghegan, 2001; Burgi et al., 2004). To some extent, LUCC is still a complex issue regarding its process, dynamic and driving forces (Lambin et al., 2003). Therefore, a single research approach does not suffice for a complete analysis of LUCC. Instead, a combination of multiple approaches is necessary for LUCC research (Verburg and Veldkamp, 2001; Cai, 2001; Long, 2003). More attention has been paid to LUCC in developing countries, especially in China (Lin and Ho, 2003; Hubacek and Sun, 2001). While there are numerous studies analyzing the loss of arable land in eastern and coastal China due to

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urban sprawl (Weng, 2002; Tan et al., 2005), the transformation of arable land into rural housing land has found much less attention.

In 2000, according to the statistical data from the Ministry of Land and Resources of China (MLRC), rural housing land[1] in China amounted to 16.5 Mha, which accounted for 67.3% of China's total construction land (this includes rural housing land and urban and other build-up land). Why do villagers in China's most densely populated and productive agricultural regions use so much of the scarce farmland to construct housing? And why has the Chinese government, which has legislated to conserve arable land so as to ensure national food security, been unable to control housing construction in the country side (Sargeson, 2002)? These open questions indicate that studying rural housing land will make a big contribution to the LUCC research in China, as well as providing some basis for stipulating policies in favor of rural land resources control. The aims of this paper are to develop a theoretical approach in an attempt to account for a specific land-use change process, viz. rural housing land transition in China, to explore a new integrated approach, and analyze the transition of rural housing land in the Transect of the Yangtse River (TYR) by presenting empirical evidences, and to practically apply the outcomes to land management issues.

Rural housing land transition in China: a theoretical basis and hypothesis

Theoretical basis

The most fundamental obstacle to progress in understanding and predicting human impacts on terrestrial ecosystems lies in the lack of a comprehensive and integrative theory of human–environment relationships, which can be applied to explain empirical observations and predict new results. The integrative character of LUCC research would require an understanding and modelling that incorporates the principles from such theories (Nunes and Augé, 1999). Although our understanding of LUCC has improved since early studies on deforestation by Myers (1980) and Mather (1990), it does appear that theoretical elaboration is underdeveloped (Irwin and Geoghegan, 2001). While it seems that LUCC research still remains under-theorized, applications making use of structural elements that specifically attempt to examine and explain these issues are few (Walker and Solecki, 2004). The discipline, in principle, that should be most able to meet the demands is geography (Grainger, 1995a). There is tremendous scope for this kind of study, which needs knowledge concerning physical geography as well as human geography.

Land use morphology is the overall pattern of actual land cover in a country or region at a given time, comprising the main types of land use. It will vary with socio-economic development. Land use transition refers to the changes in land-use morphology over time, and it usually corresponds to a particular socio-economic development phase (Grainger, 1995a). Land use transition, therefore, includes both temporal and spatial dimensions. Massey (1999) explored the possibility that there may be commonalities between physical geography and human geography in emerging ways of conceptualizing space, time and space–time. At present, the theorization of forest transition in both temporal and spatial dimensions is relatively mature (Grainger, 1995b; Mather, 1992; Mather and Needle, 1998; Mather, 2004).

Before 1978, traditional central planning economic policy had been carried out in China. At that time, the rural population in China had no choice but to work in collective farming (with weak incentives for work), and all members shared the output more-or-less equally. There was no obvious difference in the degree of development in the regional rural economy in China, despite the existing enormous regional diversity in climate, terrain, natural and human resources (Heilig, 2003; Arayama and Miyoshi, 2004). However, China has been experiencing rapid transitions since Deng XiaoPing launched economic reforms in 1978. The traditional central planning economy was changed into a market-based economy (a more laissez-faire/neo-liberal approach) and the primarily agricultural economy is being transformed into an urban, industrial economy. The early 1980s saw high growth in primary sector output in the wake of de-collectivization and the privatization of land-use rights under the ''household responsibility system'', which to a great extent stimulated rural economic growth at the early stages of China's transition (Heilig, 2003; Lin, 1992; Chow, 2002). Coastal China, with the advantages of location, was the initial area of reform and opening, which also has been one of the most developed areas. An important dimension of regional inequality in China has been the uneven rate of growth between the eastern provinces, and the central and western provinces (Kanbur and Zhang, 1999; World Bank, 2001). There is an obvious gradient of regional economic growth along the Yangtse River, which can be considered a miniature of regional disparity in China's economic development, and also a geographical as well as historical continuum, representing important development stages in China. Walker (2001) hypothesizes a two-stage sequence in the linkages between urban and rural sectors. This relationship, in turn, is mainly conditioned by the degree of development in the regional economy. The change

[1]Rural housing land refers to the land utilized by rural residents for dwelling and living, i.e. land for building house and other structures or affiliated facilities. According to China's farmers' living customs, which have been formulated for a long time, rural housing land usually includes: (1) land for dwelling and living, such as living house, kitchen, room for livestock (e.g., pigsty, sheepfold, stable and cowshed), warehouse, room for storing farm machinery, toilet; (2) surrounding afforested land, such as bamboo forest, forest tree, flower nursery; and (3) other land for service facilities of living, such as cellar, well, methane-generating pit (usually for lighting and cooking).

process of rural housing links closely with urban and rural sectors, and is affected by the degree of development in the regional economy. Accordingly, a Transect along the Yangtse River makes possible the study of rural housing land transition in China.

Understanding the change process of rural housing in China

In developing a broad conceptual framework for understanding the change of rural housing in China we need to pay analytical attention both to endogenous growth factors within a specific period and also to the corresponding management measures. In China, the growth of rural housing had been very slow before 1978. There were two reasons. On the one hand, it was the Chinese tradition to have three or four generations living in the same house (so called "*Si Shi Tong Tang*"), and owning one more house or yearning for capacious house had been considered as the source of capitalism (so called "*capitalism's tail*") and should have been eliminated before 1978. On the other hand, low income gained from working in collective farming made improving farmers' housing conditions almost impossible.

With the implementing of market-based economy after 1978, many farmers were becoming affluent and they began to prefer multi-functional, more comfortable or spacious houses. The rural household model of "*Si Shi Tong Tang*" is no longer popular. Many young couples prefer to have their own housing. China still has a huge amount of rural population. According to the fifth national population census conducted in 2000, China's rural population was 827.8 million, or 63.9% of the total population. Rural housing has been expanding sharply. The social and demographic aspirations of families and the reconfiguration of rural households' economic activities are major stimuli of the rural house-building craze (Sargeson, 2002). Farmers prefer to build their houses in the valleys (instead of the hillside), and they prefer good location and settle close to roads and other available infrastructure, which contributed to the loss of agricultural land (Yang and Li, 2000; Xu, 2004). In order to conserve arable land, provincial regulations for rural housing were defined (Table 1), which are still unable to effectively control housing construction in rural area.

With the progress of urbanization, however, some village houses are vacant in China's developed rural areas (especially in eastern China), either because their owners have two or more houses or because they are rural–urban migrators and live permanently in urban areas, which resulted in a serious waste of land resources. The vacant rural housing land of rural–urban migrants in the suburb is usually changed to urban and other build-up land. A spot of vacant rural housing land of rural–urban migrants in rural area is often transferred to other farmers who may need it. If in a rural area there is a large amount of vacant rural housing land, it will be changed into cultivated land through carrying out a land consolidation project, which is financed by the Central Government of China.

Hypothesis

The relationship between land-use and social change is a dynamic process, which should be viewed in a long-term perspective both in historical and spatial dimensions (Haberl et al., 2001). At present, both rural development and urban development in China are in a transition period. On the one hand, we can observe the transformation of a traditional agricultural society into a modern industrial and urban society; on the other hand, the economy is changing from a traditional planned economy to a modern market system. However, there are obvious regional discrepancies in the process of social and economic transformation (Liu, 2000; Lin et al., 1998; Heilig, 2003). As is typical for a large and rapidly developing country, regional development is highly unbalanced (Li, 1999). Different regions have diverse developing advantages, but are also confronted with different development tasks (Cai, 1990, 1999; Li and Hou, 2001). They will be at different stages of development and, therefore, will be characterized by different types of land-use patterns (Chen and Wang, 2004; Li and Wang, 2000).

Land-use changes, while restricted by physical conditions, are mainly driven by socio-economic factors. They can be mainly characterized by the changes of cultivated land and construction land, which are tightly inter-related with human production activities (Long and Li, 2002). The expansion of construction land usually occurred at the cost of cultivated land. Usually, with socio-economic development, construction land will increase. Since China was founded in 1949 and experienced several campaigns that hampered the economic development, such as Great Leap Forward (1958–1960) and Cultural Revolution (1966–1975), the total amount of construction land has not changed much in recent decades. Therefore, we chose to analyze only the increase of construction land.

The proportion of rural housing in the increase of total construction land at regional level will have obvious differences, which are associated with the rural population ratio, socio-economic developmental level and ecological conditions. There is a high correlation between the amount of rural housing land and rural population in China (Tian, 2003). The underlying trends of population growth and socio-economic development are probably the most significant factors leading to rural housing land transition in China.

We assume that the proportion of rural housing land in the total construction land will decrease with the process of urbanization, which will lead to the rural–urban migration and the change from rural housing land to urban and other build-up land and, in the later phase of urbanization, the proportion will reach nearly a fixed value. Currently, the speed of urbanization in developed (eastern) areas of China is fast, and the share of rural housing in the increase of total construction land will decline; however, this share will increase in less-developed (western and central) areas of China, because of the low urbanization rate and dominating rural development. Accordingly, we assume that rural housing in every region will undergo specific stages—the

Table 1
Some existing provincial regulations for rural housing in China

Province	Maximum area (m^2)	Explanatory note
Beijing (1991)	167	In suburb or other area with high population density and little cultivated land
	200	In other areas
Tianjin (1992)	133	In suburb
	167	In other areas where cultivated land per capita (CLpc) is less than 667 m^2
	200	In other areas where CLpc exceeds 667 m^2
Chongqing (1991)	20–25*	In suburb
	25–30*	In other areas
Heilongjiang (1987)	250	In suburb
	350	In other areas
Jilin (1994)	270	In suburb
	330	In other areas
Liaoning (1987)	300	A household with four or less people in the villages with 1333 m^2 or more CLpc
	400	A household with five or more people in the villages with 1333 m^2 or more CLpc
	200	A household with four or less people in the villages with CLpc less than 1333 m^2
	266	A household with five or more people in the villages with CLpc less than 1333 m^2
Hebei (1987)	133	In the villages with 667 m^2 or less CLpc
	167	In the villages with CLpc above 667 m^2
	233–467	In sandbar or mountainous regions
Henan (1991)	133	In suburb or in plain with CLpc less than 667 m^2
	167	In plain with 667 m^2 or more CLpc
	200	In hilly or mountainous regions
Shandong (1992)	133–167	In suburb
	133–200	In plain
	267	In hilly or mountainous regions
Jiangsu (1989)	133	In suburb or in villages with CLpc less than 667 m^2
	133–200	In the villages with CLpc between 667 and 1333 m^2
	200–267	In the villages with 1333 m^2 or more CLpc, or in hilly or mountainous regions
Hubei (1987)	140	If cultivated land may be occupied by housing construction activities
	200	If not
Anhui (1989)	160	In suburb
	220	In northern plain
	160	If cultivated land may be occupied by housing construction activities in hilly or mountainous regions
	300	If not
Jiangxi (1989)	130–180	If rural housing will be built on used housing land or idle land
	100–130	If cultivated land may be occupied by housing construction activities
Zhejiang (1994)	125	If cultivated land may be occupied by housing construction activities
	140	If not (the two numbers may be lowered according to the scale of household and local conditions)
Fujian (1989)	20*	Usually
	120	A household with more than six people
Guangdong (1991)	80	In plain
	120	In hilly regions
	150	In mountainous regions
Guangxi (1988)	22*	If cultivated land may be occupied by housing construction activities
	30*	If not
	160	Even a household with eight or more people if cultivated land may be occupied by housing construction activities
	250	Even a household with eight or more people if not
Shanxi (1989)	200	Usually
	133	In the villages with CLpc less than 667 m^2

Table 1 (*continued*)

Province	Maximum area (m^2)	Explanatory note
	267	In the villages with 2667 m^2 or more CLpc
Xinjiang (1989)		The maximum area is defined by County Government according to local conditions
Yunnan (1994)	20* (100)	In suburb (even a household with five or more people)
	30* (150)	In hilly or mountainous regions (even a household with five or more people)

Notes: Data are from corresponding provincial ordinances implementing land administration law of the People's Republic of China, and the digits in brackets behind different province names are the particular years from which the ordinances are valid.
The numbers with "*" mean maximum area per capita, and others without "*" mean maximum area per household.

proportion of rural housing in the increase of total construction land will decline gradually with the development of the local economy, and the end of the transition corresponds to a new equilibrium between rural housing and other construction activities.

Study area

In the Yangtse River Valley, we have identified a Transect in which the underlying gradient is the changing pattern of land-use. We can use this Transect as a coherent set of study sites to determine how land-use associated land-cover is changing as a result of social and environmental factors, and how these changes interacts with biophysical factors (Koch et al., 1995). Usually, land-use change is triggered by socio-economic factors (Heilig, 1997; Krausmann et al., 2003; Grainger, 2004). Therefore, the socio-economic developmental level was considered the most important factor to define our study area. The level of development is sharply declining from the East of the Yangtse Transect to the West.

Our study area, the TYR, is depicted in Fig. 1. It comprises an area of about 1.12 Mkm^2, containing 312 counties (or cities at county level), which belong to the following eleven provinces—Shanghai, Jiangsu, Anhui, Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Yunnan, Qinghai and Tibet (Long and Li, 2001). Along the Transect, there are several of the biggest cities in China—Shanghai (to the East), Nanjing (the capital of Jiangsu province), Wuhan (the capital of Hubei province) and Chongqing. TYR is about 3600 km in length, with an average width of 200 km or so and has an underlying gradient both in physical/environmental factors as well as in socio-economic factors (Fig. 2).

Materials and methods

Data source and processing

The analysis of land-use changes in TYR is based on two single land-cover (LC) maps at a 1:100,000 scale. These two maps were derived from two sets of historical Land-sat™ images, which were taken in 1986/1987 and 1999/2000, respectively, by the Institute of Geographic Sciences and Natural Resources Research and Institute of Remote Sensing Applications, the Chinese Academy of Sciences (Liu et al., 2003). There are six major LC types (cultivated land, forested land, grass land, water body, unused land and rural and urban settlements), and 25 sub-categories in the original LC datasets. For our in depth analysis of land-use changes in TYR, we reclassified the original LC types into eight common classes—paddy fields, dry land, forested land, grass land, water body, urban and other build-up land, rural housing land and unused land.

In addition, statistical land-use data in counties from 1987 to 2001 were used for analyzing land use transition. The data from 1987 to 1995 are from the corresponding yearbooks of former China's State Land Administration Bureau, and those from 1996 to 2001 are from MLRC. The socio-economic statistical data utilized in the analyzing process are from China's State Statistical Bureau (2000).

Methods

A land-use change matrix is obtained by using two reclassified LC maps representing the internal variations of LC in TYR between 1986/1987 and 1999/2000. We use the ESRI's ArcGIS spatial analyst module to identify the land-use change between the two periods. For each LC category i in the matrix, the change between the periods is calculated by the following equation:

$$CH_i = \left(\left(p_{i.} - p_{.i}\right)/p_{.i}\right) 100, \tag{1}$$

where CH_i is the change of LC in row i relative to the previous compared year, $p_{i.}$ is the row total of area for category i, and $p_{.i}$ is the column total of area for category i.

To explore the internal conversions between different LCs, which took place in two compared periods, we treat the change (decrease or increase) of a LC in a given year relative to the compared year as a result of several "loss or gain" conversions. Thus, for any type of "conversion loss to" or "conversion gain from", the percentage taken by this type in the total "loss or gain" conversion of a LC is calculated as

$$P_{loss(i),j} = ((p_{j,i} - p_{i,j})/(p_{i.} - p_{.i}))\ 100, \quad i \neq j,$$
$$P_{gain(i),j} = ((p_{i,j} - p_{j,i})/(p_{i.} - p_{.i}))\ 100, \quad i \neq j, \tag{2}$$

where $P_{loss(i),j}$ is the percentage taken by type j in the total "conversion loss" of category row i, $P_{gain(i),j}$ is the

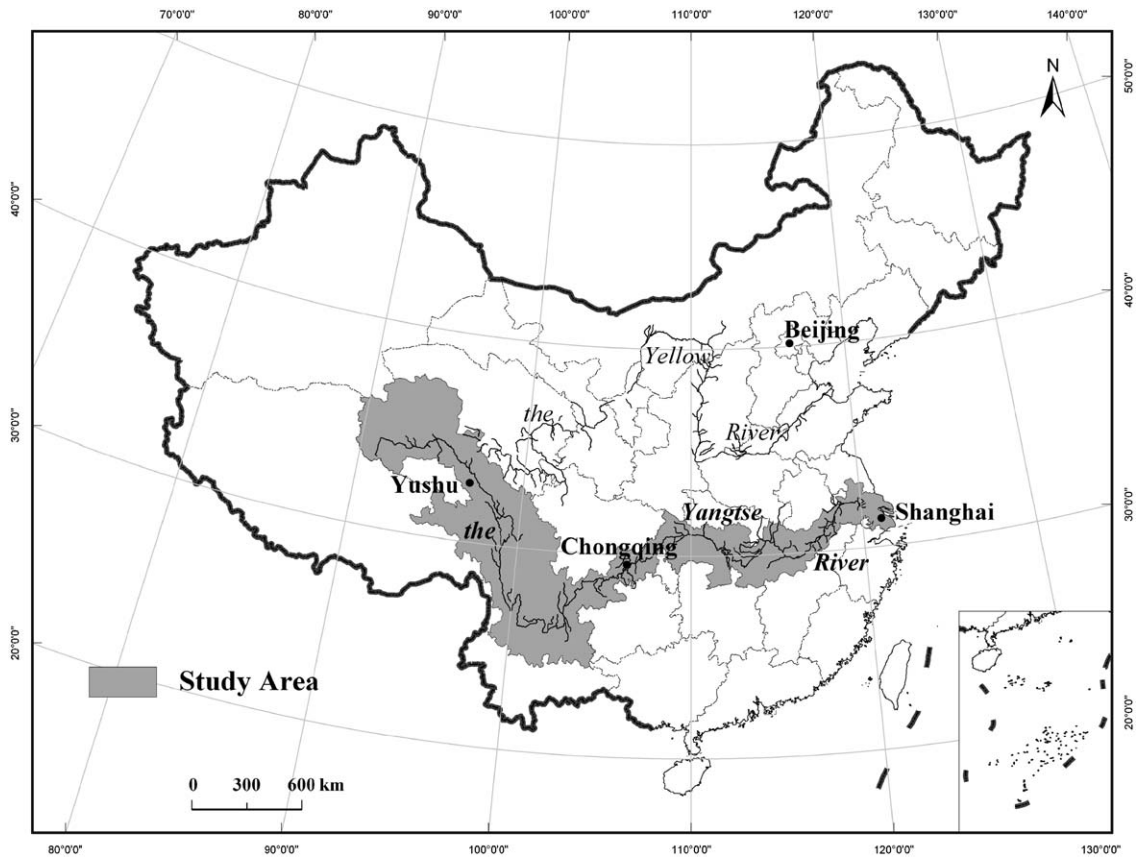

Fig. 1. Location of the study area (TYR).

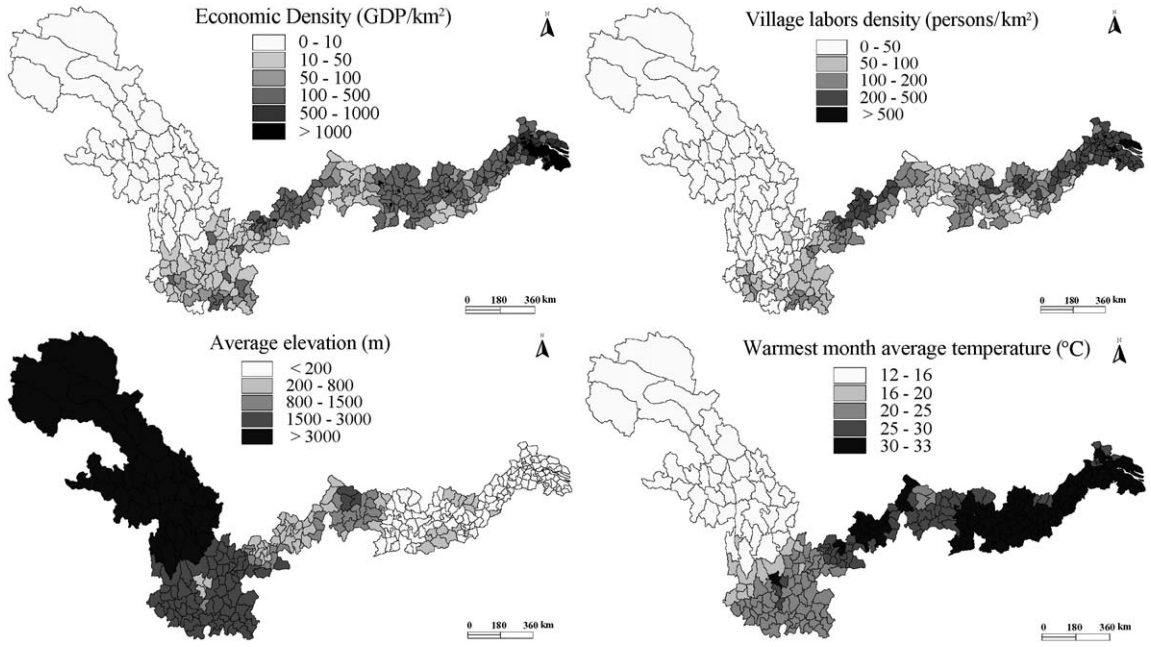

Fig. 2. Existing gradients of socio-economic factors and environmental factors in the study area. Economic density was calculated by dividing the gross domestic product (GDP) of each county by the total area of the county, and the unit of GDP is 10^4 RMB¥, exchange rate US$ to RMB¥: 1–8.3; data of socio-economic factors are from China's State Statistical Bureau (2000), and that of environmental factors are from IIASA.

percentage taken by type j in the total "conversion gain" of category row i, and $p_{i,j}$, $p_{j,i}$ is the individual entry in the matrix.

In order to regionalize the regional types of rural housing changes in study area, an aggregation index (AI) is calculated to reflect the characteristics of spatial pattern

of changed rural housing land in every prefecture. We take it as our base indicator of regionalization. The value of AI is between 0 and 100, and it is calculated by the following equation:[2]

$$AI = \left[\frac{g_{ii}}{\max - g_{ii}}\right] 100, \quad (3)$$

where g_{ii} is the number of like adjacencies (joins) between pixels of patch type (class) i based on the single-count method, and max-g_{ii} is the maximum number of like adjacencies (joins) between pixels of patch type (class) i based on the single-count method.

Although the lack of data concerning rural housing is one of the major reasons hampering rural housing studies (Tian et al., 2003), lack of explanatory theories may be another factor. Land use transitions are often studied with long time series statistics. Although global environmental data have grown in abundance in recent decades (Mather, 2005), time-series data for China are unreliable, because the statistical system was disrupted several times since 1949 by political and economic campaigns. However, China has a vast territory with obvious regional differentiation in the level of socio-economic development, which make it possible to apply a spatial comparative research method to study land use transition. This method is using the differentiation in regional development to compensate data deficiencies in the long time series, reflecting the change process of rural housing land.[3]

Results

Land-use changes in the study area

From Table 2 it can be seen that LC has shifted greatly over the period from 1986/1987 to 1999/2000 in TYR. In this period, paddy fields and dry land decreased by 2.8% and 0.9%, respectively. In contrast, rural housing land and urban and other build-up land increased by 15.9% and 45.7%, respectively, in 1999/2000. The change extent of other land-use types is relatively small.

In order to explore the internal conversions between different LCs, we calculated the percentages taken by corresponding types in loss or gain conversions by formula (2) utilizing the data in Table 2. For example, the percentage taken by paddy fields (PF) in the gain conversions of rural housing (RH) equals "(142.7−22.1)/(1082.9−934.7)", i.e. 81.4%. Table 3 illustrates the percentages taken by corresponding land-use classes in such loss or gain conversions in TYR from 1986/1987 to 1999/2000. From Table 3, it is clear that the decrease of paddy fields in 1999/2000 was mainly caused by the increase of urban and other build-up land (36.7%) and rural housing land (35.4%), and the shrinking of dry land was also mainly caused by these two with 52.6% and 21.1%, respectively. However, in terms of spread of rural housing land and urban and other build-up land in 1999/2000, almost all of these changes occurred at the expense of paddy fields and dry land, which account for 81.4% and 12.8% for rural housing land, and 66.6% and 25.3% for urban and other build-up land (Table 3).

To a large extent, land-use change in TYR from 1986/1987 to 1999/2000 was characterized by a serious conversion of paddy fields and dry land to rural housing land and urban and other build-up land.

Regional types of rural housing land change

The rural housing land takes up nearly 65% of the construction land in the study area (Table 2). Rural housing land was identified from other construction land according to its special image characteristics, which include obvious geometrical shape, clear boundary and diversified configuration. Information about changes in rural housing land was derived from two reclassified maps from 1986/1987 and 1999/2000. The results demonstrated that changes in rural housing land were mostly gained from other land-use types (mainly in paddy fields), and only small areas of rural housing land were changed into other types of land (Table 2). The patches of new rural housing land are small and scattered. In order to reveal the changed spatial pattern and to identify regional types of change, the map data (vector format) were converted into raster format with a spatial resolution 1000×1000 m using ESRI's ArcGIS spatial analyst module.

AIs of 42 prefectures and five counties (with large area) in the source area of the Yangtse River were calculated by formula (3), and arranged in the sequence from the lower reaches to the upper reaches (Fig. 3). Through analyzing the changes in the AI and considering the continuity in territory, five regional types, from the lower reaches to the upper reaches, were defined as follows: Shanghai–Chaohu, Tongling–Yichang, Enshi–Chongqing, Luzhou–Diqing and Ganzi–Yushu. Fig. 4 is a gridded map illustrating the regional types of rural housing land change in the study area. It can be seen from Table 4 that there are obvious differences among these five regions in both physical and socio-economic aspects.

Analysis of rural housing land transition

It can be seen from Fig. 5 that the proportion of rural housing in the increase of total construction land declines gradually from the upper reaches to the lower reaches, i.e. from Ganzi–Yushu to Luzhou–Diqing, Enshi–Chongqing, Tongling–Yichang and to Shanghai–Chaohu. The proportion in developed areas is lower than that in developing areas, even less-developed areas, because of rapid urbanization. However, change of the curves in Fig. 5 is not only affected by a single factor of urbanization, but also

[2]McGarigal, K., Cushman, S.A., Neel, M.C., Ene, E., 2002. FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps.

[3]We assume that regions with lower levels of development represent the situation in earlier time periods, while more developed regions would represent more recent trends in land use transition.

Table 2
Land-use change matrix of each compared LC in 1986/1987 and 1999/2000, and changes in 1999/2000

LC in 1999/2000 (10^3 ha)	LC in 1986/1987 (10^3 ha)								Total	Changes in 1999/2000	
	PF	DL	FL	GL	WB	UB	RH	UL		10^3 ha	%[a]
PF	**11596.1**	154.0	46.9	25.4	51.4	5.9	22.1	1.3	11903.2	−340.2	−2.8
DL	182.6	**9021.2**	402.8	300.1	12.4	5.2	12.9	1.1	9938.1	−90.1	−0.9
FL	63.5	441.1	**28065.2**	3040.2	36.4	1.4	2.5	566.4	32216.7	−123.2	−0.4
GL	25.7	299.7	3207.7	**29513.1**	166.3	0.7	2.8	3395.9	36611.9	137.5	0.4
WB	99.7	23.2	35.0	101.7	**4461.1**	0.7	2.0	313.6	5037.1	−40.1	−0.8
UB	130.7	52.6	7.9	2.6	4.0	**394.3**	3.9	1.1	597.0	187.3	45.7
RH	142.7	31.8	10.3	4.7	2.2	0.9	**886.6**	3.7	1082.9	148.2	15.9
UL	2.4	4.7	564.2	3486.6	343.5	0.6	1.9	**10478.7**	14882.6	120.7	0.8
Total	12243.4	10028.2	32339.9	36474.4	5077.2	409.7	934.7	14761.9	112269.4		

Note: PF—paddy fields; DL—dry land; FL—forested land; GL—grass land; WB—water body; UB—urban and other build-up land; RH—rural housing land; UL—unused land.
[a]The percentages of changes were calculated by formula (1), e.g., that of PF equals "(11903.2–12243.4)/12243.4", i.e. −2.8%.

Table 3
Internal conversions between LCs from 1986/1987 to 1999/2000, and the percentages taken by corresponding types in such loss or gain conversions

LC	Type (1)	Percent (%)	Type (2)	Percent (%)	Type (3)	Percent (%)	Type (4)	Percent (%)
Paddy fields (PF)$^+$	UB	36.7	RH	35.4	WB	14.2	DL	8.4
Dry land (DL)$^-$	UB	52.6	FL	42.5	PF	−31.7	RH	21.1
Forested land (FL)$^-$	GL	136.0*	DL	−31.1	PF	−13.5	RH	6.3
Grass land (GL)$^+$	FL	121.8*	UL	−65.9	WB	46.9		
Water body (WB)$^-$	GL	160.8*	PF	−120.5	UL	74.6		
Urban and other build-up land (UB)$^+$	PF	66.6	DL	25.3	FL	3.4		
Rural housing land (RH)$^+$	PF	81.4	DL	12.8	FL	5.2		
Unused land (UL)$^+$	GL	75.1	WB	24.8	DL	3.0		

Note: −conversion loss to, +conversion gain from, * "conversion gain" occurred even when the net change was "conversion loss" (and vice versa).

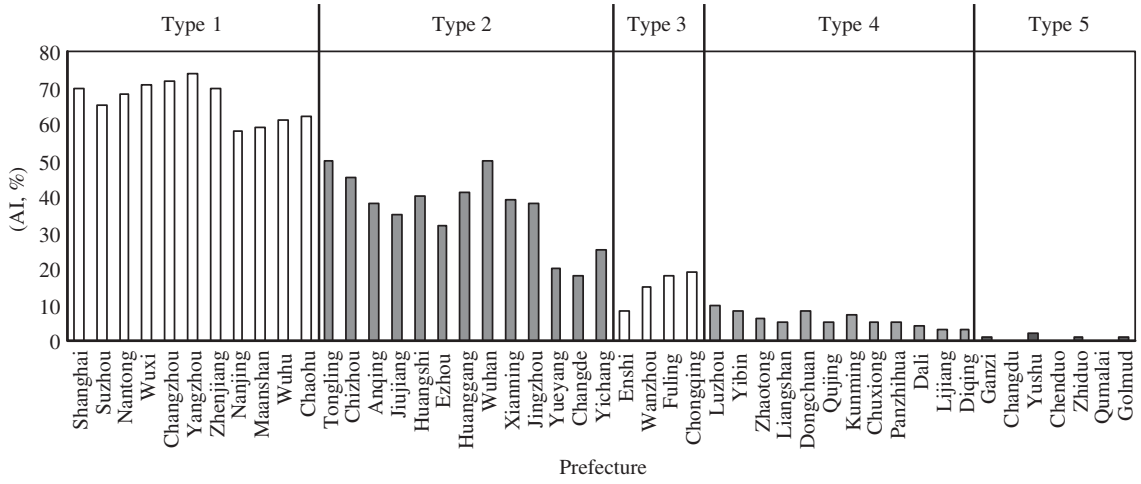

Fig. 3. Aggregation index (AI) of every prefecture in the study area.

influenced by physical factors, farmer's income, concerned policy and other factors. The decline of farmer's income will naturally lower the proportion of rural housing in the increase of total construction land; e.g., there is an obvious descending trend in every curve in 1991 and 1992 (Fig. 5), which is related to the continuing decline in the price of agricultural products from 1990 to 1993 in China.

In contrast with the other four regions, the region of Ganzi–Yushu is characterized by the lowest economic developmental level, where economic density is only 10.3 thousand RMB¥ per km^2, a vast territory with a sparse population where population density is merely 3.6 person/km^2, and the most adverse circumstances with average elevation above 4200 m and coldest month average

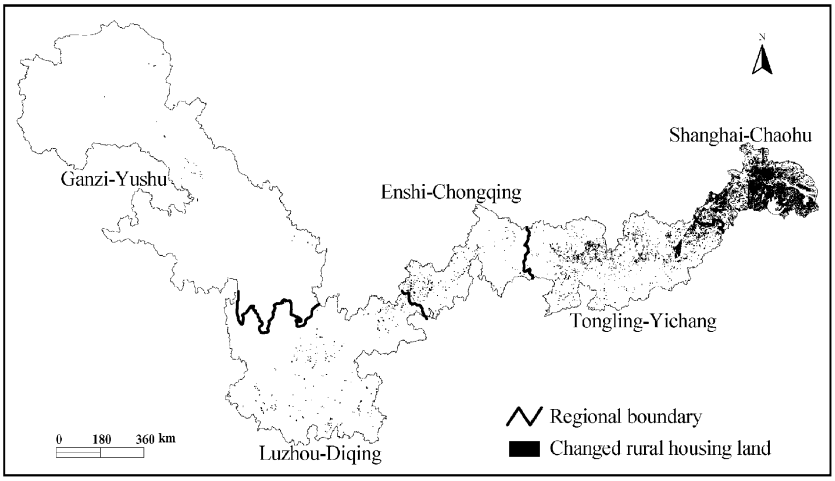

Fig. 4. Regional types of rural housing land change in the study area.

temperature of −18.4 °C (Table 4). Before 1990, the annual share of rural housing in the increase of total construction land is relatively low, because local people were mainly herdsmen who usually roved around as nomads. However, the share of rural housing in the increase of total construction land has increased by a big margin since the policy of "*Si Pei Tao*" (which means to form a complete set with four kinds of measures, i.e. surrounding pasture with railings and implementing rotated herding, building covered pen for livestock, cutting grass to store as forage and building settlements for nomad) was carried out since 1990. Currently, the annual share is still rising and has reached 38.4% in 2001, although there was a bit of decline because of widespread suffering from big snow-disasters in this region both in 1995 and in 1999 (http://www.nj.qhei.gov.cn/gzdt/ysz.shtml).

The economic developmental level in the region of Luzhou–Diqing is higher than that of Ganzi–Yushu, but lower than that of the three eastern regions. Its local socio-economic development mainly focuses on agriculture. The average elevation in most part of this region is above 1500 m (Fig. 2), and most of the area belongs to a special region, such as mountainous or hilly areas, frontier regions and regions with ethnic minorities, in which the area limitations of rural housing are permitted to be more flexible. The annual proportion of rural housing in the increase of total construction land has been in a high level, although it has fluctuated sometimes, and reaches 29.5% in 2001. However, it can be seen from the curve in Fig. 5 that the increase of the proportion in this region is lower than that in Ganzi–Yushu.

In the region of Enshi–Chongqing, local economic development is in a medium level in TYR (Fig. 2 and Table 4), but recently the speed of economic development has accelerated, which caused the share of rural housing in the increase of total construction land to decline. It declined especially around 1997, because Chongqing was set-up as a municipality directly under the Central Government in 1997, including Qianjiang prefecture and three cities in the rank of prefecture, i.e. Chongqing, Wanxian and Fuling, in Sichuan province formerly. Increased urban and other build-up land far exceeded that of rural housing land around 1997, which caused the share of rural housing in the increase of total construction land between 1997 and 1999 less than 10%. Only by 2001 has the share reinstated to the so-called normal level with 13.7%.

Influenced by the developed coastal areas, the economic developmental level in the region of Tongling–Yichang is higher than that in Enshi–Chongqing. The annual proportion of rural housing in the increase of total construction land in this region also has an overall declining trend, from 23.4% in 1987 to 9.3% in 2001.

The region of Shanghai–Chaohu is characterized by a smooth relief, favourable climate, dense population and the highest economic developmental level in TYR (Fig. 2 and Table 4). The annual share of rural housing in the increase of total construction land in this region has maintained the level of 5% or so, after a rapid decline between 1990 and 1992. This demonstrates a trend of equilibrium between rural housing and other construction activities.

In general, the change curves in Fig. 5 illustrate the comparative role between urban region and rural area in the aspect of regional socio-economic development. It is found that every region is in a different stage of economic growth, respectively, through calculating the value of purchasing power parity GDP per capita (PPPGDPpc) of every region (Table 5).

By calculating the average proportion of rural housing in the increase of total construction land in every region between 1992 and 2001,[4] the change trendline shows that the average proportion decreases gradually from the upper reaches to the lower reaches in TYR. The power change

[4]To some extent, analyzing the proportion of rural housing in the increase of total construction land after 1992 will be more helpful to reflect the underlying laws of the proportion change, because only after implementing the policy of *"Si Pei Tao"* since 1990 were settlements for nomad in the region of Ganzi–Yushu begun to be built; moreover, there is an obvious descending trend of the proportion in every region (Fig. 5) in 1991 and 1992 because of the declining price of agricultural products.

Table 4
Comparison of selected physical and socio-economic indicators in different regional types

Region	Average value of AI	Number of included counties	Total area (thousand km^2)	Annual average precipitaiton	Coldest month average temperature (°C)	Average elevation (m)	Population density (persons/km^2)	Rural population density (persons/km^2)	Economic Density (10^4 RMB¥/km^2)	Possessing grain per capita (kg)
Shanghai–Chaohu (type 1)	66.36	59	68	1120	−2.5	12.7	726.8	605.3	838.72	514.6
Tongling–Yichang (type 2)	36.23	87	173	1333	−1.2	179.1	329.8	289.7	269.13	449.2
Enshi–Chongqing (type 3)	15	35	90	1142	0.4	742.4	320.6	279.2	176.27	459.7
Luzhou–Diqing (type 4)	5.75	95	267	1021	−1.9	1843.7	134.6	119.6	48.01	382.2
Ganzi–Yushu (type 5)	0.72	36	522	452	−18.4	4260.7	3.6	2.9	1.03	265.8

Source: see Fig. 2.

trendline can also be regarded as the curve of regional land use transition, indicating the rural housing land transition phases for every region (Fig. 6).

Discussion

According to our research, the concerning management measures for rural housing land in TYR are suggested as follows:

(1) Rural housing land in the regions of Ganzi–Yushu and Luzhou–Diqing will most likely increase in the next decades. At present, the rural housing land per capita in Yushu prefecture is 126.6 m^2, which is lower than that in Hainan prefecture (with 374.4 m^2 per capita), one of relatively developed areas in the same Qinghai province. However, the nomads in the two prefectures have only begun to build settlements. The present settlement area is still small, and will increase with the development of the local economy. Accordingly, the concerned local management departments should pay more attention to guiding and carrying out scientific village planning, so as to promote the construction of village's infrastructure and optimize villager's living conditions.
(2) The proportion of rural housing in the increase of total construction land in the two regions of Enshi–Chongqing and Tongling–Yichang is declining gradually, and tending towards an equilibrium between rural housing and other construction activities. Although the rural housing in these regions can fundamentally meet the needs of local people, the desire to improve their living conditions is getting stronger with the development of the local economy. Farmers prefer to build their houses in the valleys (instead of the hillside), and they prefer to settle close to roads and other available infrastructure. The houses usually have small-scale household (in which only three persons or so live), and larger courtyards. There is a short cycle of replacing old house with a new one. As a result, there is more idle rural housing land, vacant rural housing, with unoccupied land in villages, and often one household owns two or more houses.[5] Hence, local management departments should actively promote the consolidation of rural build-up land, set down and implement rational plans of consolidating villages according to the general land use planning and local developing strategy, in order to enhance the intensity of land-use in town and village and save land for further needs. Meanwhile, local governments should register idle rural housing land, vacant rural housing, unoccupied land in villages, and cases where one household owns two or more houses according to local conditions, in order to estimate the actual potential of existing build-up land. When houses are reconstructed, extended or newly

[5]MLRC, 2004. The Investigating and Researching Reports on How to Manage Rural Housing Land.

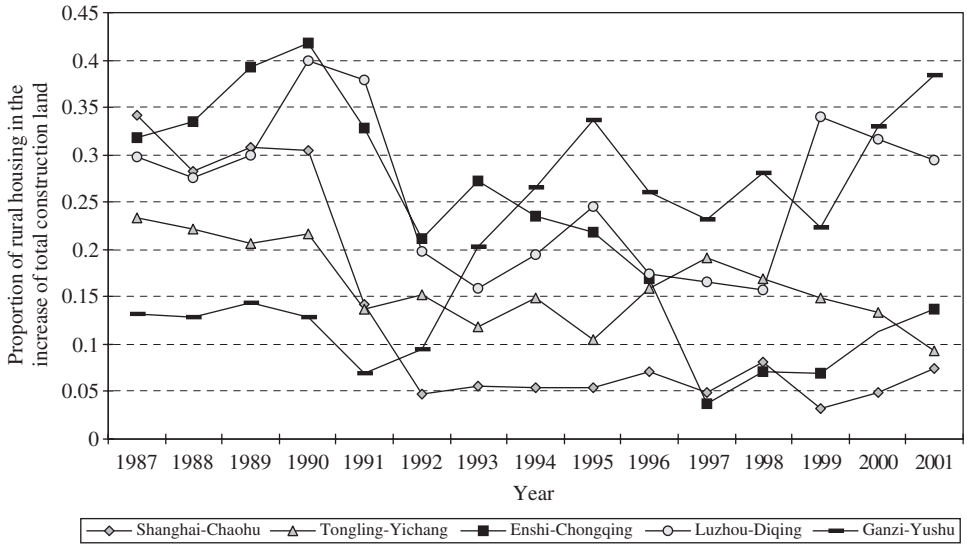

Fig. 5. Change curves of the annual proportion of rural housing in the increase of total construction land in different regions.

Table 5
Corresponding economic growth stage of every region in TYR divided by PPPGDPpc (US$ of 1998)

Region	The values of PPPGDPpc	Economic growth stages classified by Li and Hou (2001) according to the values of PPPGDPpc
Shanghai–Chaohu	5891	Intermediate phase of industralization (5350–8590)
Tongling–Yichang	4166	Primary phase of industralization (3010–5350)
Enshi–Chongqing	2807[a]	Phase of producing primary products (1700–3010)
Luzhou–Diqing	1821[b]	
Ganzi–Yushu	1443	Originality phase (<1700)[c]

Notes: (1) the values of PPPGDPpc (US$ of 1998) of every region was calculated by dividing GDP per capita in a region by the coefficient of 1.959 according to the study of Li and Hou (2001), and the data of GDP per capita are from China's State Statistical Bureau (2000); (2) six economic growth stages were classified by Li and Hou (2001) according to the values of PPPGDPpc (US$ of 1998) from 1700 to 22730, i.e. phase of producing primary products, primary phase of industralization, intermediate phase of industralization, senior phase of industralization, primary phase of developed economy and senior phase of developed economy.

Authors called:

[a]Final phase of producing primary products.

[b]Early phase of producing primary products.

[c]Economic growth stage whose value lowers than 1700 is the originality phase.

built, farmers should make full use of unoccupied land in villages, old housing land, uncultivated slope land and derelict land. Compensation schemes should be implemented by local government so as to let villagers who have vacant rural housing or two or more empty houses return them to collective organization.

(3) There is already a trend of equilibrium between rural housing and other construction activities in the region of Shanghai–Chaohu. Idle and vacant rural housing land are more prominent in this region than in other two regions of Enshi–Chongqing and Tongling–Yichang because of its fast urbanization step, and because more peasants are working in the city. There are also more rural–urban migrants. In order to enhance the utilization of existing rural housing land it is necessary to find an effective way to shift the utilization model of rural housing land. Therefore, some encouraging and restraining mechanism (in the form of policy) should be implemented to utilize rural housing land intensively, e.g., improving legal and managerial system, perfecting the benefit allocation system and standardizing existing market system about shifting the utilization model of rural housing land.

Although China is rapidly transforming itself from an agricultural into an industrial nation, sustainable rural development will be an important theme in developing China for a long time. In order to protect the cultivated land, on the one hand, we should control the expanding of cities, and should pay more attention to curbing excessive rural housing and consolidating rural housing land on the other hand. Land use planning and management is one of the most important measures for economic development. For the purpose of strengthening the management of land resources and enhancing their capability for future economic development, the

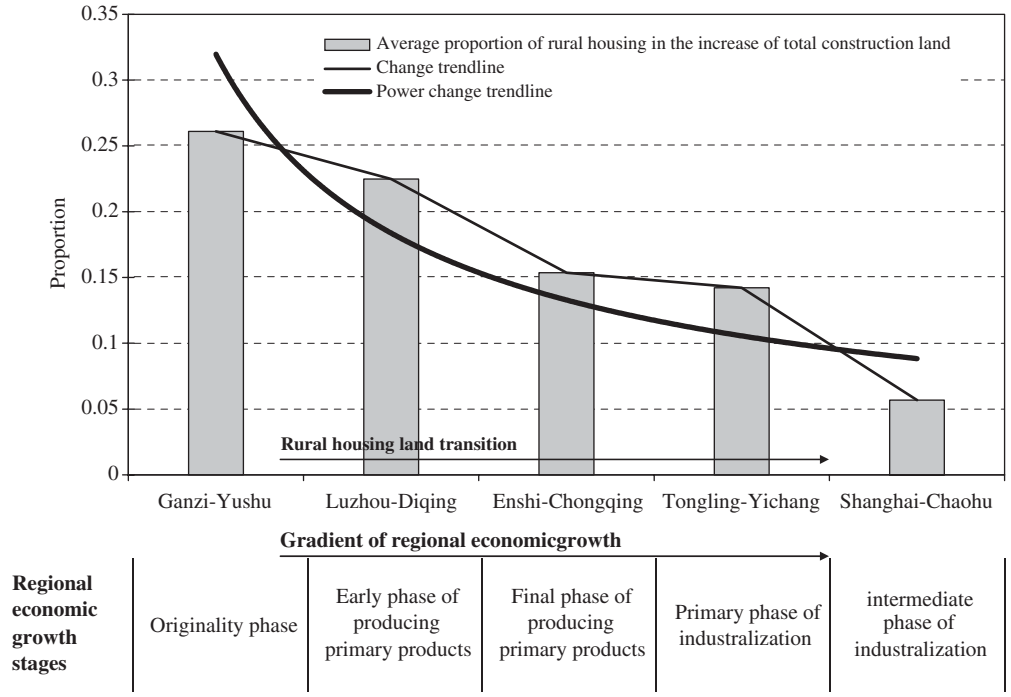

Fig. 6. Corresponding rural housing land transition phase and economic growth stage of every region in the study area.

authors argue that there are some problems in the current rural housing land managerial system in China, such as there are considerable differences in the regulations for rural housing among provinces, even between the provinces with similar physical and socio-economic conditions (Table 1). This situation will do harm to the intensive utilization of land resources and the implementation of national measures concerning land resources.

Usually, a region has its particular rural housing land transition phase corresponding to its socio-economic development level, which needs particular management measures. So, the Central Government is suggested to set down uniform regulations for rural housing according to regional socio-economic developmental level, physical conditions and rural housing land transition phase.

Conclusions

The lack of long-term statistical data of land use in China is a barrier to the research of land use transition. However, China's vast territory and obvious regional differentiation in the level of socio-economic development make it possible to use a spatially comparative research method. By taking the differentiation in regional development we can compensate data deficiencies in a long temporal series, for studying land use transitions. The concept of Transects is a valuable research tool for land-use research. It can be considered a new integrated approach, because it allows us to combine land-use change with socio-economic development.

In the five regional types of rural housing land change defined according to the distribution characteristics of an aggregation index, research results indicated that each region is in a different phase of rural housing land transition, which corresponds to a particular socio-economic developmental level. This confirms our hypothesis that the development of rural housing in every region will undergo specific stages—the proportion of rural housing in the increase of total construction land will decline gradually with the development of the local economy, and the end of the transition corresponds to a new equilibrium between rural housing and other construction activities. Finally, some managerial countermeasures and policy implications were obtained by applying this research to land management issues. The authors argue that there are some problems in the current rural housing land managerial system in China, and the Central Government needs to set down uniform regulations for rural housing according to regional socio-economic developmental level, physical conditions and rural housing land transition phase.

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