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Cultivated land protection and rational use in China

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ABSTRACT

Cultivated land protection is an important way to ensure food security, social stability and sustainable development. As one of the main causes of cultivated land loss, the spatio-temporal pattern of illegal cultivated land use and driving forces have not been systematically investigated. This study first reviewed the evolution of China's cultivated land protection policy in the past four decades, then used spatial analysis technology to explore the spatio-temporal patterns of China's illegal cultivated land use, and finally applied an econometric model to assess the impact of population growth, economic development and rising housing prices on illegal cultivated land use at the national and regional levels based on the balanced provincial panel data from 1999 to 2017. The results show that in the past 40 years, China has attached great importance to the protection of cultivated land, and established a relatively perfect cultivated land protection system. The quantity of cultivated land in China kept a dynamic balance on the whole, but the quality of cultivated land has dropped sharply, and regional human-land conflicts has become prominent. The driving forces of cultivated land loss in China varied across regions. Illegal use of cultivated land was also one of the important driving forces of cultivated land reduction in China. The number of illegal land use cases and the area appropriated have experienced a process of first increase and then decrease over the past two decades. The accumulated cases and area of illegal farmland use in the eastern region were larger than that in the central and western regions, but both showed a rapid downward trend over the past two decades, demonstrating that the illegal use of cultivated land in eastern China has been controlled to a certain extent. Population growth and land urbanization have a significant positive impact on illegal cultivated land use area in China and its three regions, while economic development has not driven but curbed illegal land use. The rise of commercial housing prices has no significant impact on illegal farmland use in rural China. We proposed measures to further control the illegal use of cultivated land, and believed that it is necessary and urgent to stop illegal occupation of cultivated land from the source

1. Introduction

Cultivated land is the lifeblood and main carrier of food production. Cultivated land security is an important guarantee and foundation of food security (Deng et al., 2006; Liu, 2018; Qu et al., 2019; Lai et al., 2020). As the most populous country in the world, China has largely managed to feed approximately 21% of the world population with only 9% of the global cultivated land (Carter et al., 2012; Zhou et al., 2020a). However, China is a developing country with more people and less land (Yang and Li, 2000). In 2017, China's per capita arable land area was less than 0.1 ha, far below the world average (Ma et al., 2020). Therefore, the Chinese government has always attached great importance to cultivated land protection and regarded it as a basic national policy (Lichtenberg and Ding, 2008; Jiang et al., 2013; Liu et al., 2017; Wu et al., 2017; Huang et al., 2021). Over the past 40 years, China has established a relatively complete system of farmland protection policies, which has effectively reduced the large-scale loss of farmland (Liu et al., 2010, 2014; Liu et al., 2017; Su et al., 2020; Zhou et al., 2020a; Liu and Zhou, 2021). Since 1978, China's cultivated land area has been increasing and decreasing alternately, but the rate of cultivated land loss has gradually slowed down (MLR, 2018). Urban expansion has been identified as one of the main causes for China's cultivated land lost (Jiang et al., 2012; Jin et al., 2013; Liu et al., 2014; Deng et al., 2015; Xia et al., 2016; Liu et al., 2017; Yang et al., 2018). Economic growth has

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also been recognized as one of the main driving forces of cultivated land loss in China (Liu and Guo, 2015). Therefore, local governments have often needed to make a trade-off between farmland protection and economic growth (Jin et al., 2013).

Illegal use of land is the act of occupation, use, transfer, sale, exchange, lease, destruction of land and other illegal use of land by the perpetrator in violation of land use and planning management laws and regulations without legal and effective approval (Tang and Chung, 2002; Xu et al., 2012). According to China's current laws and regulations, illegal land use includes illegal land transfer, destruction of cultivated land, illegal land occupation or use without approval, illegal land grant, land transfer at low prices and others (Chen et al., 2015b; MLR, 2018).[i] Most illegal land use cases are driven by economic interests (Cheng et al., 2015a; Lian et al., 2019). Illegal use of cultivated land has resulted in a large-scale reduction of cultivated land in developing countries (Tellman et al., 2020a; 2020b). Illegal cultivated land use is prevalent in rural China, where arable land has been converted to non-agricultural purposes and peasants have no alternative but to illegally build houses on cultivated land (Qu et al., 1995; Tang and Chung, 2002; Ding, 2003; Lin and Ho, 2005; Chen et al., 2015b; Lian et al., 2019). Between 1999 and 2017, the number of illegal land use cases in China has decreased from 157,968 to 40,651, and the illegal land use area increased from 26,925.74 ha in 1997–80,873.14 ha in 2007, and then gradually decreased to 21,109.87 ha in 2017 (MLR, 2018). Official data show that by then end of 2019, China's illegal cultivated land use area has reached 76,173 ha, of which more than one-tenth was the occupation of basic farmland (People's Daily, 2020). The current illegal use of cultivated land in rural areas is prevalent and is spreading across the country, which has aroused widespread concern.

Extensive studies have been focused on the current situation, types, consequences and driving forces of illegal cultivated land use in China (Tang and Chung, 2002; Ho and Lin, 2003; Lin and Ho, 2005; Xu et al., 2009; Chen et al., 2015a, 2015b; Lian et al., 2019; 2020). Population growth, economic development, land finance and unreasonable allocation of land resources have been acknowledged as the main driving forces for illegal cultivated land use in China (Ho and Lin, 2003; Liu et al., 2012; Zhong et al., 2014). Some scholars discussed the reasons of illegal land use from the perspective of land exchange market. The prevalence of illegal land use is related to the lagging development of land market (Lin and Ho, 2005). Back land market or informal land exchange market breeds illegal land use (Ho and Lin, 2003; Lin and Ho, 2005; Xu et al., 2009). Land market development can help to curb illegal land use, especially in eastern China (Chen et al., 2015b). Lian et al. (2019) discussed the relationship between market-led transactions and illegal land use in China, and found that the market-led transaction to lease land-use rights can help to reduce illegal land use. Illegal land use not only imposes financial costs of local governments, but also triggers land conflicts, damages the rights and interests of farmers and endanger social stability and sustainable development (Cai, 2003; Ding, 2003; Wang and Scott, 2008; Hui and Bao, 2013; Lian et al., 2019). These studies have provided unique insights into the causes and consequences of illegal land use in China, and supported the development of land use decision-making. However, the factors affecting illegal land use are complex, and may well be different in different regions of the country. So far, few studies have systematically studied the characteristics and driving forces of the spatio-temporal pattern evolution of illegal cultivated land use in China and its different regions over the past two decades. Therefore, the main aims of this study were to systematically explore the spatiotemporal characteristics of cultivated land dynamic change and illegal cultivated land in China over the past two decades, and used econometric models to quantitatively measure the effects of population growth, urbanization, economic development and rising housing prices on illegal cultivated land use in China and its eastern, central and western regions.

2. Theoretical framework and hypothesis

The Chinese government has always attached great importance to the protection of cultivated land and has formulated specific laws, regulations and institutional guarantee systems to protect cultivated land (Lichtenberg and Ding, 2008; Wu et al., 2017). The laws and regulations most directly related to the protection of cultivated land in China include the Land Administration Law (revised four times in 1998, 2004, 2012 and 2019 since its implementation in 1987), the Implementation Regulations of the Land Administration Law (revised three times in 2011, 2014 and 2020 since its implementation in 1998), and the Basic Farmland Protection Regulations (implemented since 1999) (Zhou et al., 2020a). Under the constraints of these laws and regulations, China has established a complete cultivated land protection system including the control of land use, approval of farmland conversion, dynamic balance of cultivated land, balance of occupation and compensation, target responsibility and legal responsibility of cultivated land protection (Fig. 1). Land use control, also known as 'Land Use Zoning Control' (Japan, the United States and Canada), 'Land Planning Permission' (Britain), and 'Construction and Development Permission system' (France and South Korea), refers to a system in which a country or region prepares land use plans, delimits land use areas, and determines land use restrictions to make land owners and users use land in strict accordance with the purposes determined by the state (Hong et al., 2017). Its purpose is to ensure the rational use of land resources and the coordination of economic, social development and environment, with legal effect and mandatory. Since 1999, China has implemented the land use control system to divide land into agricultural land, built-up land and unused land, and strictly restrict the conversion of agricultural land to built-up land and implement special protection for cultivated land (Wang et al., 2012; Hong et al., 2017; Zhou et al., 2020a). These systems not only help to ensure the quantity and quality of China's cultivated land, but also clarify the responsibility subject of cultivated land protection, which greatly reduces the loss and non-agricultural use of cultivated land (Liu et al., 2014; Wang et al., 2012; Zhou et al., 2020a).

In fact, the protection of cultivated land is a complex project, and no system design can be done once and for all. Population growth, economic development, increased housing demand and economic interests have been considered as the main driving force of illegal cultivated land use in China (Ho and Lin, 2003; Zhong et al., 2014). Illegal use of cultivated land and fixed asset investment are significantly positively correlated (Lu and Huang, 2012). Previous studies have shown that there are significant differences in the factors affecting land violations in eastern, central and western China (Long and Chen, 2011; Chen et al.,

[i] Illegal Land transfer includes: 1) illegal transfer, lease and mortgage of the right to use state-owned land obtained by way of allocation without approval; 2) illegal sale, transfer or lease of the right to use land collectively owned by farmers for non-agricultural construction; 3) illegal transfer of the right to use state-owned land obtained by way of transfer; 4) sale or transfer of the right to use state-owned land He is responsible for the illegal transfer of land. Illegal land occupation includes: 1) illegal occupation of land without approval or by deception; 2) illegal sale, transfer or lease of the right to use the land collectively owned by farmers for non-agricultural construction; 3) occupation of land in excess of the approved amount; 4) taking back the land illegally approved and used by law, and the parties concerned refuse to return it; 5) occupying land not in accordance with the approved location and scope of land use; 6) occupying cultivated land to build kilns and graves or destroying planting conditions by building houses, digging sand, quarrying, mining and soil on cultivated land without authorization; 7) illegal occupation of basic farmland to build kilns, houses, graves, sand digging, quarrying, mining, earth fetching, stacking solid wastes or engaging in other activities to destroy basic farmland and planting conditions; 8) land desertification and salinization caused by land development, etc. Other illegal acts include idle land, destroying or changing the sign of basic farmland protection zone without authorization, not using land according to the approved use, refusing to fulfill the obligation of land reclamation, etc.

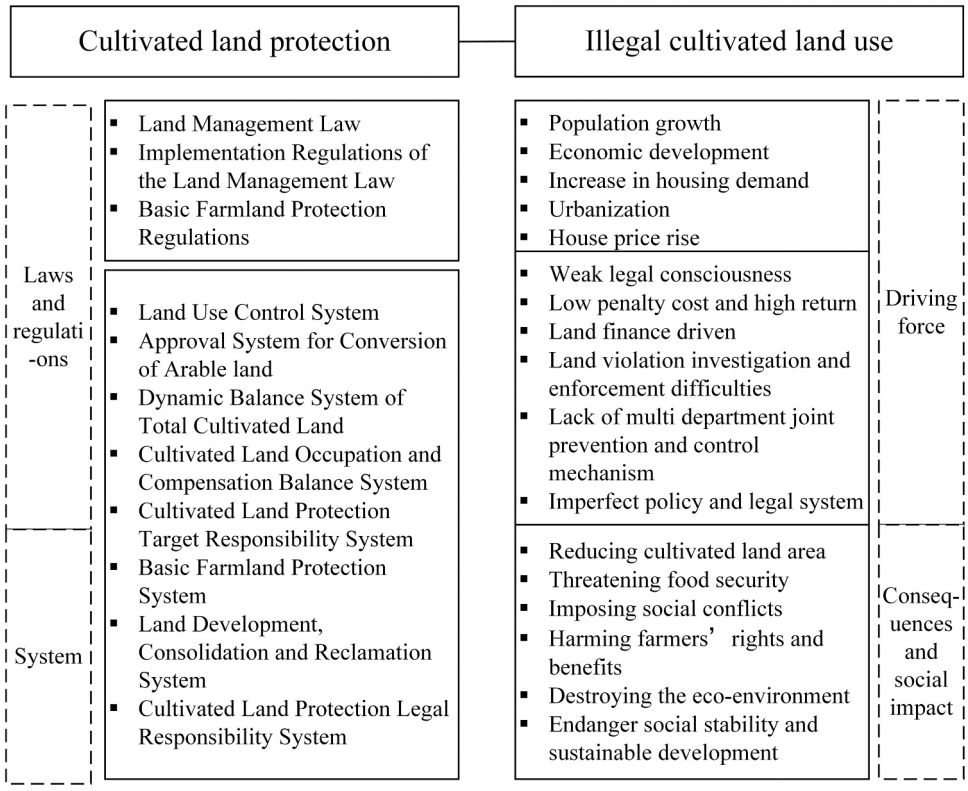

Fig. 1. Cultivated land protection and illegal use.

2015). The relationship between economic growth, urbanization, industrial structure and land violations depends on the stage and mode of economic development (Long and Chen, 2011). The development of the land market has obvious regional differences in the illegal use of cultivated land in China (Chen et al., 2015a). The main reasons for illegal use of cultivated land also lie in the weak legal consciousness of some farmers and local officials, the low cost and high income of illegal cultivated land and the financial drive of land, the difficulty in investigating and enforcing the law of land violations, and the imperfect mechanism of preventing and controlling land violations by various departments (Tang and Chung, 2002; Xu et al., 2012). In addition, black land market (or informal land transaction market) has provided a platform for illegal land use (Ho and Lin, 2003; Lin and Ho, 2005; Xu et al., 2009). The market mechanism is considered to be an effective way to reduce illegal land use (Ko et al., 2017). Illegal land use has serious social consequences. It not only leads to the loss of cultivated land and threatens food security, but also causes social conflicts, harms farmers' rights and interests, destroys the ecological environment, and endangers social stability and sustainable development (Cai, 2003; Ding, 2003; Wang and Scott, 2008; Chen et al., 2015b; Lian et al., 2019). The way to deal with illegal cultivated land use is to stop the birth of land illegal activities from the source.

Based on the above-mentioned theoretical cognition, we proposed the hypothesis, i.e., the areas with faster population growth and economic development have stronger impact on the illegal use of cultivated land (measured by illegal land use area), and rising housing prices have a positive effect on illegal use of cultivated land. We need to answer these two questions, that is, whether there is more illegal land use in the economically developed areas of eastern China than in the central and western regions. Whether the socio-economic development and rising housing prices in the eastern region have a greater impact on the use of illegal arable land than in the central and western regions. To estimate the effects of different socio-economic development levels on illegal cultivated land, followed by the zoning standards of previous studies (Liu et al., 2018a), we divided the country into three regions: eastern, central and western. The eastern region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Shandong, Fujian, Guangdong and Hainan, and the central region includes Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan, and the western region includes Inner Mongolia, Ningxia, Qinghai, Gansu, Xinjiang, Shaanxi, Tibet, Guangxi, Chongqing, Sichuan, Yunnan and Guizhou.

3. Data and methods

3.1. Data sources

The data used in this study include the data of the increase and decrease of cultivated land in 31 provinces of China from 1999 to 2017, the cases of land violation and the land, cultivated land area, population, economy, urbanization rate, cultivated land occupied by built-up land and housing price. Among them, the data on cultivated land dynamic change and relevant illegal land use are from China Land and Resources Statistical Yearbook (CLRSY) 2000–2018 (MLR, 2018). The data of population size, GDP and urbanization rate are from China Statistical Yearbook. The commercial housing price data are available from China Real Estate Statistical Yearbook (FAIS, 2018). In the data of the dynamic change of cultivated land, the sources of cultivated land lost include construction occupation, disaster destruction, ecological conversion (mainly returning cultivated land to forest) and agricultural restructuring, and the sources of gained cultivated land include land consolidation (including land development, reclamation and rehabilitation) and agricultural restructuring. Since 2010, the CLRSY has no longer announced the increased cultivated land area through land development, reclamation and rehabilitation, and only reports the total increased arable land area added by land consolidation. For the sake of comparison, we merged the newly added cultivated land area of each sub-item before 2010 into the gained cultivated land area by land consolidation. In China, land consolidation includes land development,

reclamation, rehabilitation and restoration (Zhou et al., 2020b). Land illegal data include the number of illegal land use cases and the involved land area at the provincial, municipal, county and township governments and village as well as enterprises and individuals, which is the illegal land use cases and involved land (cultivated land) area that occurred and were filed that year.

3.2. Methods

3.2.1. Trend analysis

Followed a previous study (Cutter and Finch, 2008), we used the slope of illegal land use area for each province from 1999 to 2017 to reflect the changing trend of cultivated land occupied by construction purpose and illegal use of cultivated land in China in the past 20 years. A positive slope indicates that cultivated land occupied by construction purpose and illegal occupation of cultivated land have experienced a growth trend, and a negative slope indicates a downward trend. The slope is negative, and the larger its absolute value is, and the faster the decline is.

3.2.2. Econometric model

We used the following econometric model to assess the impact of population growth, economic development, urbanization and housing price on the illegal cultivated land occupation for the entirety of China and for the three regions over the past two decades. The calculation formula can be expressed as follows:

$$\mathrm{IALU}_{it} = c + \alpha_1 POP_{it} + \alpha_2 GDP_{it} + \beta_1 URBA_{it} + \beta_2 Constr_{it} + \beta_3 Price_{it} + \varepsilon_{it}$$

Where the dependent variable IALU_{it} is the area of illegal arable land use for the *i*-th province in the *t*-th period. *POP*, *GDP*, *URBA*, *Constr* and *Price* are total population size, GDP level, urbanization rate, cultivated land area occupied by construction use and housing price, respectively. α and β are the estimated coefficients of the independent variable. c is the constant, and ε is the error item.

Two steps were performed to examine the effects of population and economic growth, urbanization and housing price on the illegal cultivated land use for the entirety of China and for the three regions (i.e., eastern, central and western China). First, the presence of unit roots in the all variables was verified before proceeding to any econometric analysis (Cong and Shen, 2013; Pesaran, 2007). Second, the effects of population and economic growth, urbanization and housing price on illegal cultivated land use for the entirety of China and for the three regions were estimated using two methods: fixed effects (FE) and the linear regression with Driscoll-Kraay standard errors (DK). The DK estimates are robust to general forms of cross-sectional and temporal dependence (Liu et al., 2015), so we only focused on the DK models' estimation results.

4. Results

4.1. China's cultivated land protection policy since 1978

The evolution of arable land protection policies is the miniature of the transformation of land use (Liu et al., 2018b). Since the implementation of the reform and opening policy in 1978, with the rapid economic development, urbanization, and industrialization, China's arable land has dropped sharply, the contradiction between more people and less land has gradually become apparent, and the awareness of arable land protection has begun to sprout, and China has introduced some arable land protection policies and regulations (Liu et al., 2017). So far, China has formed a comprehensive multi-level farmland protection system including land use planning, basic farmland protection, land use control, farmland requisition and compensation balance (dynamic balance), and land development, consolidation and reclamation (Yan et al., 2015; Liu et al., 2017; Wu et al., 2017; Qu et al., 2019; Zhou et al., 2020a; Lai et al., 2020). In the past 40 years, China's farmland protection policy has gone through five stages, namely, the preliminary exploration (1978–1985), the system establishment exploration (1986–1996), the initial system formation (1997–2002), the system improvement (2003–2013), and the system maturity (2014–2020) (Fig. 2; Liu et al., 2017, 2018b).

In the late 1970s, China implemented the household contract responsibility system, which mobilized farmers' enthusiasm for production, promoted the overall development of rural economy, and increased farmers' willingness to build houses. At the same time, the country encouraged the development of township enterprises, further promoting the occupation of cultivated land. In view of the illegal use of cultivated land, the Chinese government proposed to stop the excessive occupation of cultivated land to build houses and standardize the expropriation of cultivated land to supplement construction land, but did not issue specific measures to protect cultivated land. Since the mid-1980s, the rise of China's township enterprises and the local government's excessive dependence on land finance have brought about the second round of land expropriation peak. At that time, China began to explore the establishment of laws and regulations for the protection of cultivated land. In June 1986, the land management law was promulgated, and there were laws for the protection of cultivated land. China began to work out the general land use planning, and then proposed to levy the cultivated land occupation tax and establish the land survey system. More importantly, during this period the country proposed the cultivated land protection system for the first time. However, the cultivated land protection policy at that time was lack of systematicness, and the implementation of cultivated land protection policy was limited, so the illegal cost of destroying cultivated land was low.

Since 1996, China has entered a period of rapid urbanization, and the implementation of the western development policy has greatly promoted the process of farmland conversion. China's efforts to protect cultivated land had been gradually increased, and the cultivated land protection policy system had been initially established, which is mainly manifested in three aspects: first, the establishment of the Ministry of Land and Resources has implemented the responsibility of cultivated land protection; second, the land management law had been revised to build a framework system of cultivated land protection policy; and third, the county issued a series of cultivated land protection policy documents (Liu et al., 2017; Lai et al., 2020). During this period, due to the imperfection of land expropriation policy, rapid industrialization and urbanization led to the continued existence of the problem of illegal occupation of cultivated land (Liu et al., 2018b). In 2004, China revised its land management law again, made clear the difference between land expropriation and requisition, and set a red line for the protection of 120 million ha (equal to 1.8 billion mu) of cultivated land. Then the country put forward to implement the strictest farmland protection system. In 2005, China put forward and implemented the policy of linking the increase and decrease of urban and rural construction land. In 2011, the country issued and implemented land reclamation regulations and in 2012, set the objectives, conditions, contents and technical standards of high standard farmland construction. Since 2013, China has put forward and vigorously promoted the measures of comprehensive land improvement and multi planning integration, and then promoted the legislation of cultivated land occupation tax, compilation of territorial spatial planning and legislation (Liu and Zhou, 2021). On the whole, China's cultivated land protection policy has changed from only emphasizing quantity to paying equal attention to quantity and quality, and then to the trinity of quantity, quality and ecology (Liu et al., 2018b).

4.2. Dynamic change in China's cultivated land area

In the past two decades, China's arable land has shown a trend of first decreasing and then increasing. Land consolidation measures such as the reclamation of waste and degraded land and the development of unused

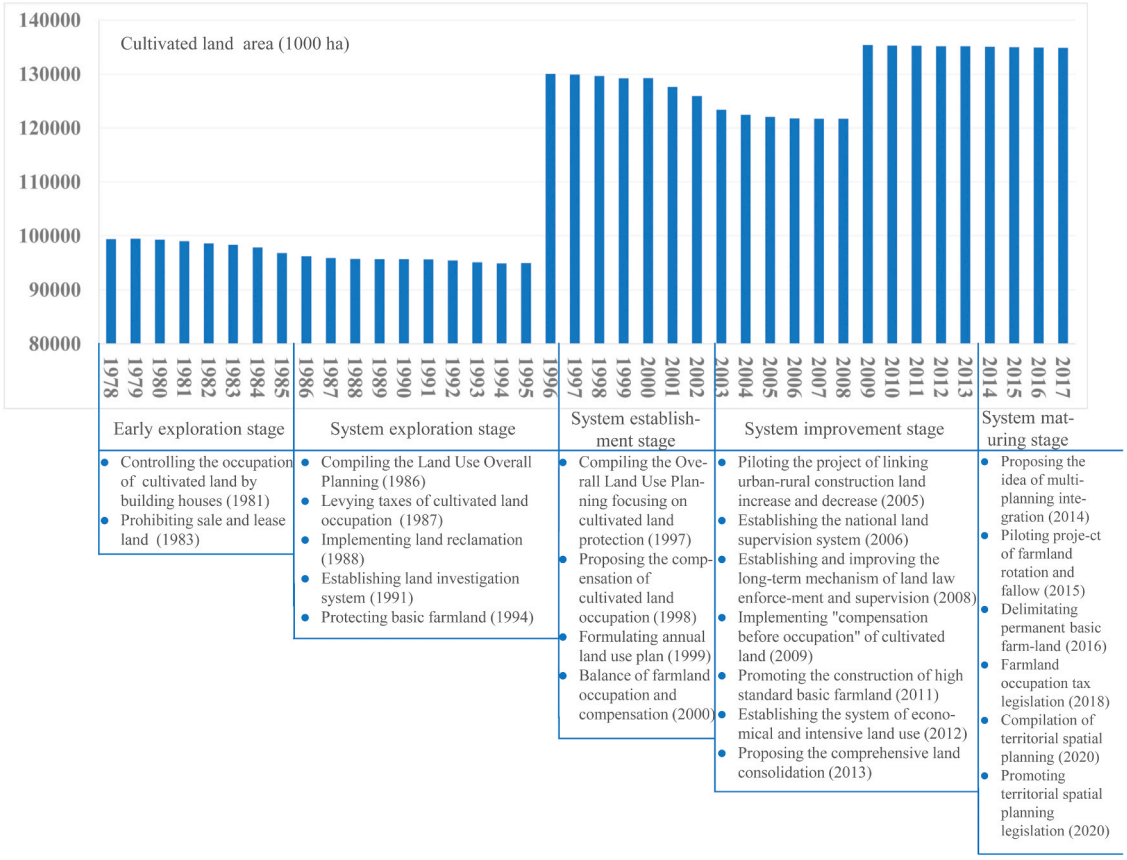

Fig. 2. China's cultivated land protection and cultivated land area.

land were the main way to increase cultivated land, and its contribution to the increase of arable land area has increased from 60% in 1999 to 95% in 2017 (Fig. 3a). Except for 2013, the increase in cultivated land in China was smaller than the decrease in cultivated land in other years. Especially before 2006, China experienced severe cultivated land loss. From 1999–2017, the main driving forces for the reduction of China's arable land has also constantly changing. Before 2006, the implementation of China's policy of returning farmland to forests was the main driving force for the reduction of cultivated land. Since 2006, cultivated land occupied by construction purposes has become the main contributor to the reduction of cultivated land in China, and its proportion of cultivated land loss increased from 25% in 2006 to 82% in 2017. The adjustment of agricultural structure was also one of the main causes for the reduction of cultivated land in China, but its contribution to the reduction of cultivated land has dropped from about 30% before 2010 to about 10% afterwards (Fig. 3b).

Spatially, from 1999 to 2017, 13 of the 31 provinces across the country showed a decrease in the area of arable land. Among them, the provinces with the most evident reduction in the amount of arable land included Shaanxi (1.2 million ha), Shanxi (0.53 million ha), Jiangsu (0.45 million ha), Guizhou (0.38 million ha) and Yunnan (0.21 million ha). In the past 20 years, the cultivated land area of most provinces in eastern China has shown negative growth, while that of central and western China has shown positive growth. Beijing, Shanghai, Shaanxi, Qinghai, and Shanxi were the top five provinces with the fastest annual decline in cultivated land area. During the period 1999–2017, the provinces with more than one million ha of arable land area increased included Heilongjiang (6.58 million ha), Jilin (2.98 million ha), Sichuan (2.27 million ha), Inner Mongolia (1.75 million ha), Guangxi (1.73 million ha) and Xinjiang (1.26 million ha).

In the past 20 years, 70% of China's increase in arable land came from land consolidation (Fig. 4a). Among the 31 provinces in mainland China, the contribution of land consolidation to increase arable land in 21 provinces exceeded the national average level, especially in Tianjin, Jiangxi, Chongqing, Hunan and Anhui provinces. Regionally, the area of cultivated land loss and supplement in the western region was larger than that in the eastern and central regions (Table 1). The area of supplementary cultivated land in the three regions was far less than the area of cultivated land loss. The area of supplementary cultivated land in the western, eastern and central regions was 3.46 times, 2.08 times and 1.47 times respectively. The increasing area of cultivated land in the western region was 1.86 times and 1.24 times of that in the central and eastern regions, respectively, and the decreasing area was 2.35 times and 1.67 times of that in the central and western regions. Further statistics demonstrate that the driving force of cultivated land loss varied across provinces. The loss of cultivated land in the eastern region was mainly due to the conversion of farmland to forest (grain for green, GFG) (67.6%), the central region due to the GFG (48.6%) and built-up area expansion (33.3%), and the eastern region due to built-up area expansion (38.1%) and agricultural planting structure adjustment (37%). Natural disasters in eastern, central and western regions caused 3.1%, 3.8% and 4.5% loss of cultivated land, respectively. The top five provinces with the most evident reduction in cultivated land due to urban expansion included Tianjin, Shanghai, Fujian, Henan and Jiangsu, accounting for 61.43%, 58.32%, 56.55%, 55.28% and 52.85% of their cultivated land loss respectively, which is mainly distributed in the eastern region (Fig. 4b). The top five provinces with the largest reduction in cultivated land due to conversion of farmland to forest or ecological protection were Ningxia, Inner Mongolia, Qinghai, Gansu and Shaanxi. The decrease in cultivated land in Guangdong Province was mainly due to the adjustment of agricultural structure, accounting for 76.2% of the decrease in cultivated land. Furthermore, natural disasters also caused the loss of 10% of the cultivated land in Heilongjiang, Guizhou and Yunnan provinces.

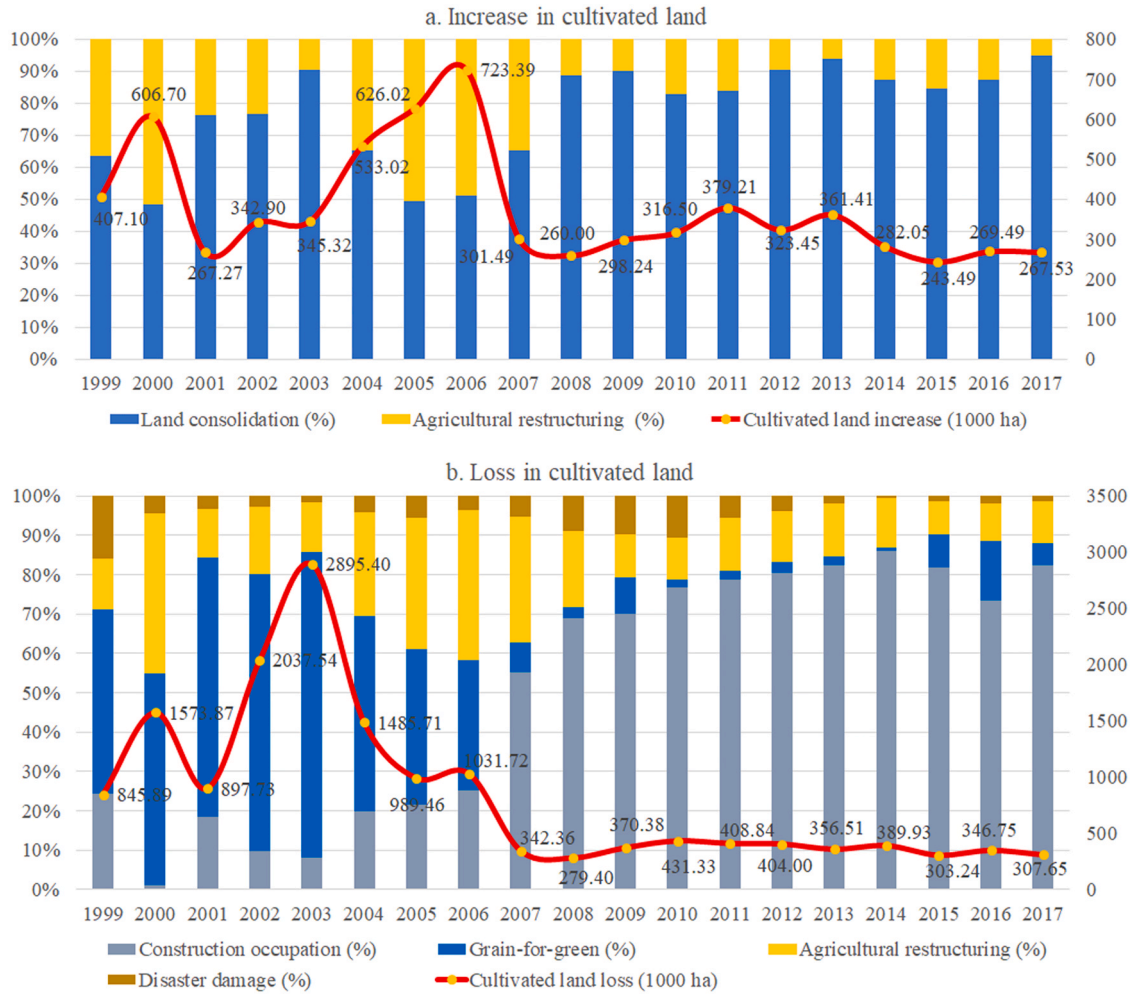

Fig. 3. Increase and decrease in China's cultivated land between 1999 and 2017. (Note: Data source: National Statistical Yearbook of Land and Resources of China 2000–2018).

The cultivated land occupied by construction purposes was the main driving force for the loss of cultivated land in China. From 1999–2017, the area of cultivated land occupied by construction use in China increased from 206,300 ha to 253,700 ha, with an average annual increase of 1.16% (Table 2). In the past two decades, the area of cultivated land occupied by construction use in 25 of China's 31 provinces showed an increasing trend. The top six provinces with the fastest average annual growth rate were Tibet (15.04%), Hainan (6.90%), Henan (6.38%), Qinghai (6.34%), Ningxia (5.93%) and Gansu (5.62%). To protect cultivated land, China has implemented a strict cultivated land protection system since 2003. The trend of occupation of cultivated land for construction use in the eastern coastal areas has been curbed, which has led to a decline in the area of cultivated land occupied by construction uses in this area in the past 20 years. The average annual growth rate of cultivated land occupied by construction purpose in the western region was higher than that in the central and eastern regions. In terms of quantity, the top five provinces with the largest amount of cultivated land occupied by construction purposes in 2017 were Henan (24,732 ha), Shandong (23,355 ha), Jiangsu (20,944 ha), Sichuan (16,739 ha) and Anhui (15,000 ha). Henan (1137 ha/year) was the province with the fastest average annual growth of cultivated land occupied by construction use, followed by Hubei (780 ha/year), Guizhou (619 ha/year), Anhui (533 ha/year) and Sichuan (488 ha/year).

4.3. Spatial-temporal patterns of illegal cultivated land use over the past two decades

Random occupation of cultivated land to build houses touches the red line of cultivated land protection, threatening national food security. At present, the illegal occupation of cultivated land in rural areas in China to build houses is spreading all over the country. Statistics demonstrate that from 1999 to 2017, there were a total of 913,262 illegal land use cases in China, and the number of cases was higher in the eastern region (342,098 cases) than in the central (289,638 cases) and western regions (281,526 cases), involving 4.27 million ha of illegal land area (including 0.18 million ha of cultivated land). Over the past 20 years, China's illegal land use cases and illegal land use area have shown a trend of first increasing and then decreasing. Overall, the cases and areas of illegal land use and illegal arable land use area have all shown a downward trend, with an average annual decline rate of 8.03%, 3.71%, and 2.74%, respectively. Spatially, in the past 20 years, except for Guangdong and Xinjiang, the number of illegal land use cases in the remaining 29 provinces has shown a downward trend. The number of illegal land use cases in the eastern region has declined at a slower rate than in the western and central regions. The number of illegal land use cases dropped from 22,554 cases in 1999 to 12,633 cases in 2017 in the eastern region, from 35,117 cases to 2979 cases in the central region, and from 35,082 cases to 4943 cases in the western region, with an average annual decline rate of 3.17%, 12.81% and 10.32% respectively (Fig. 5).

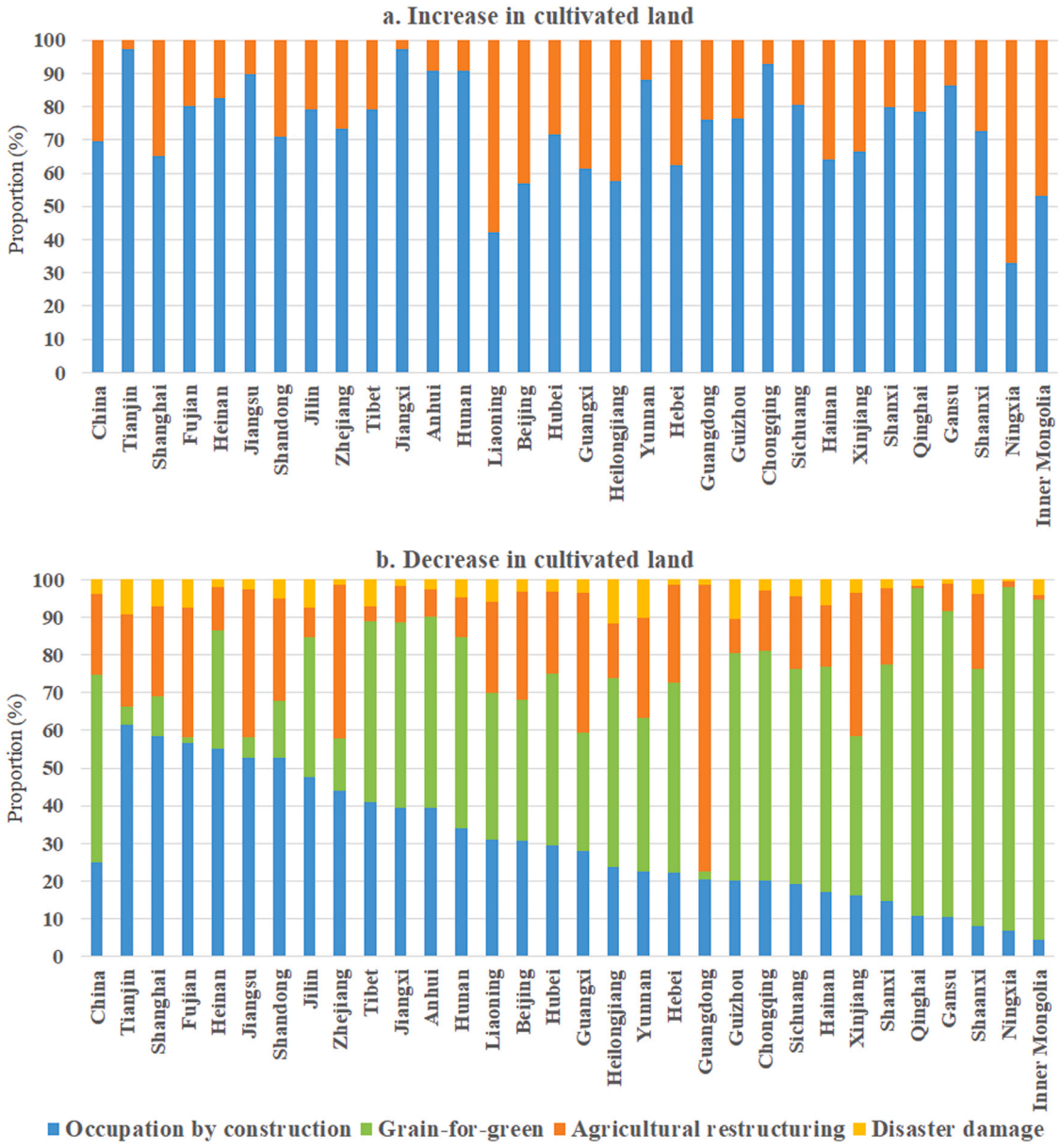

Fig. 4. (a) Sources of cultivated land increase and decrease in China's 31 provinces between 1999 and 2017. (b) (Notes: Data are available from the National Statistical Yearbook of Land and Resources of China 2000–2018; The figure does not include the data for 2009–2012 due to missing data).

Table 1
Statistics of cultivated land supplement and loss in eastern, central and western regions of China between 1997 and 2017.

Regions	Farmland supplement (million ha)			Farmland loss (million ha)				
	Total	LC	APSD	Total	OCP	GFG	APSD	ND
Eastern region	447	316.14 (70.65%)	131.31 (29.35%)	928	353.74 (38.09%)	201.98 (21.75%	344.00 (37.04%)	28.91 (3.11%)
Central region	298	230.27 (77.35%)	67.41 (22.65%)	659	219.39 (33.27%)	320.56 (48.62%)	94.46 (14.33%)	24.96 (3.79%)
Western region	555	358.54 (64.58%)	196.66 (35.42%)	1549	206.24 (13.31%)	1047.10 (67.59%)	226.18 (14.60%)	69.74 (4.50%)

Notes: Land consolidation (LC); Agricultural planting structure adjustment (APSA); Occupation by construction purpose (OCP); Natural disasters (ND). Data are available from the National Statistical Yearbook of Land and Resources of China 2000–2018; The data does not include the data for 2009–2012 due to missing data. The number in brackets is the proportion

The illegal land use in China was dominated by individuals. About 70% of illegal land use cases were caused by individuals, followed by enterprises and institutions (20%). The illegal land use by village collective organizations accounted for about 6%, and that by provincial, municipal, county, and township government departments accounted for only 4% (Fig. 6a). The illegal land use area by enterprises and institutions accounted for about 60%, and that by individuals and village-level organizations accounted for about 23% and 10%, respectively (Fig. 6b). Similarly, the illegal cultivated land use area was mainly occupied by enterprises, institutions and individuals, accounting for about 50% and 25% respectively (Fig. 6c).

There were various forms of illegal land use in China, but the illegal

Table 2
Area of cultivated land occupied by construction use in China's 31 provinces between 1999 and 2017.

Province	Regions	1999	2005	2010	2017	Slope (ha/year)	AAGR (%)
China	–	2062.85	2131.72	2337.19	2537.30	50.42	1.16
Henan	Central	81.23	129.27	165.18	247.33	11.38	6.38
Hubei	Central	65.95	50.89	149.97	128.09	7.80	3.76
Guizhou	Western	111.13	31.29	107.51	139.28	6.20	1.26
Anhui	Central	77.23	84.10	11552.5	150.01	5.33	3.76
Sichuan	Western	172.59	98.67	145.24	167.39	4.88	-0.17
Shaanxi	Western	39.77	39.32	91.32	83.26	3.79	4.19
Xinjiang	Western	60.97	26.00	57.94	74.90	3.69	1.15
Yunnan	Western	91.65	80.61	67.69	97.06	3.07	0.32
Hunan	Central	57.04	36.48	62.53	72.15	2.98	1.31
Gansu	Western	18.19	17.12	21.85	48.63	2.95	5.62
Jiangxi	Central	44.69	40.93	75.05	73.25	2.83	2.78
Guangxi	Western	46.41	114.21	85.10	82.37	2.82	3.24
Jilin	Central	36.27	21.50	47.43	53.43	2.65	2.18
Hebei	Eastern	164.78	208.43	86.48	142.08	2.52	-0.82
Chongqing	Western	73.61	55.86	63.02	64.46	1.79	-0.73
Heilongjiang	Central	93.38	19.60	102.08	34.45	1.43	-5.39
Inner Mongolia	Western	41.30	48.83	25.07	43.47	1.13	0.29
Liaoning	Eastern	93.55	55.00	101.38	36.98	0.99	-5.03
Ningxia	Western	7.03	21.78	26.05	19.84	0.89	5.93
Hainan	Eastern	3.74	3.50	12.97	12.43	0.70	6.90
Qinghai	Western	3.17	30.89	13.10	9.58	0.69	6.34
Shanxi	Central	80.20	26.47	74.41	43.97	0.65	-3.28
Fujian	Eastern	50.17	61.73	56.32	43.91	0.55	-0.74
Tibet	Western	0.66	5.00	2.86	8.28	0.36	15.04
Guangdong	Eastern	133.51	69.24	78.41	81.00	-0.50	-2.74
Tianjin	Eastern	7.75	16.24	26.72	13.07	-0.79	2.94
Jiangsu	Eastern	132.86	186.45	151.02	209.44	-3.15	2.56
Shandong	Eastern	150.57	231.16	191.76	233.56	-3.16	2.47
Beijing	Eastern	19.76	18.35	7.25	8.65	-3.58	-4.49
Shanghai	Eastern	27.39	55.93	19.67	12.41	-5.00	-4.31
Zhejiang	Eastern	76.29	246.89	109.15	102.58	-5.47	1.66

Notes: The data comes from the National Statistical Yearbook of Land and Resources of China 2000–2018 (Unit: 100 ha). AAGR is average annual growth rate.

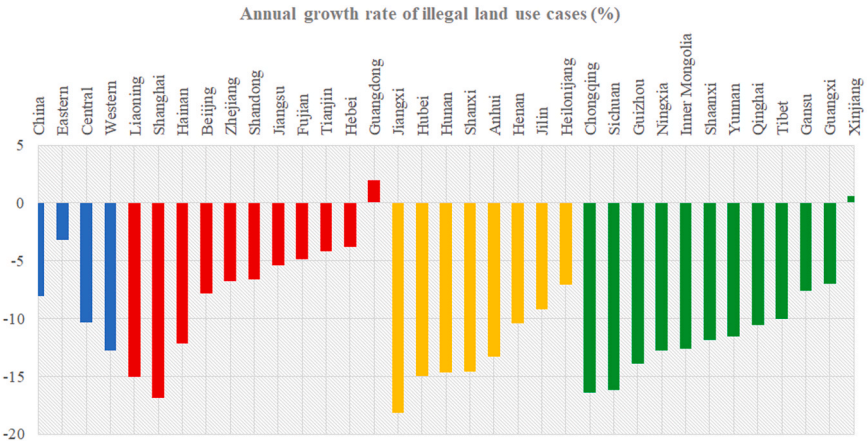

Fig. 5. Annual growth rate of illegal land use cases in China's 31 provinces and its eastern, central and western regions between 1999 and 2017. Red, orange and green represent the eastern, central and western regions, respectively. Notes: Data are available from the National Statistical Yearbook of Land and Resources of China 2000–2018. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

use of cultivated land was the main type of illegal land use. In other words, illegal occupation of cultivated land was the main body of illegal land use in China. The income of selling cultivated land, or building houses on cultivated land to sell in China's rural areas was much higher than that of agricultural planting, which is an important reason for the long-standing but unstoppable phenomenon of illegal use of cultivated land. The illegal occupation of cultivated land without permission has become the main type of illegal land use in rural China over the past two decades. The number of illegal land use cases without approval in China has decreased from 60,798 cases in 1999–19,606 cases in 2017, but its proportion to illegal land use cases increased from 65.5% to 95.5%. In addition, in the past 20 years, the illegal use of cultivated land in this country has shown a process of first increasing and then decreasing. The illegal use of arable land in this country was 3421 ha in 1999, peaked in 2007 (21,262 ha), and then began to decline, falling to 8290 ha in 2010 and 3317 ha in 2017 (Fig. 7). Furthermore, the illegal cultivated land use by enterprises and institutions was the main source of illegal cultivated land use in China, followed by individuals and village collective organizations. The illegal occupation of cultivated land by enterprises and institutions has gradually become the main body of illegal cultivated land use in China, and its proportion has increased from 28.54% in 1999 to 63.01% in 2017 (Fig. 7). The proportion of illegal cultivated land occupied by China's provincial, city and county governments has gradually decreased from 14.96% in 1997 to 6.02% in 2017.

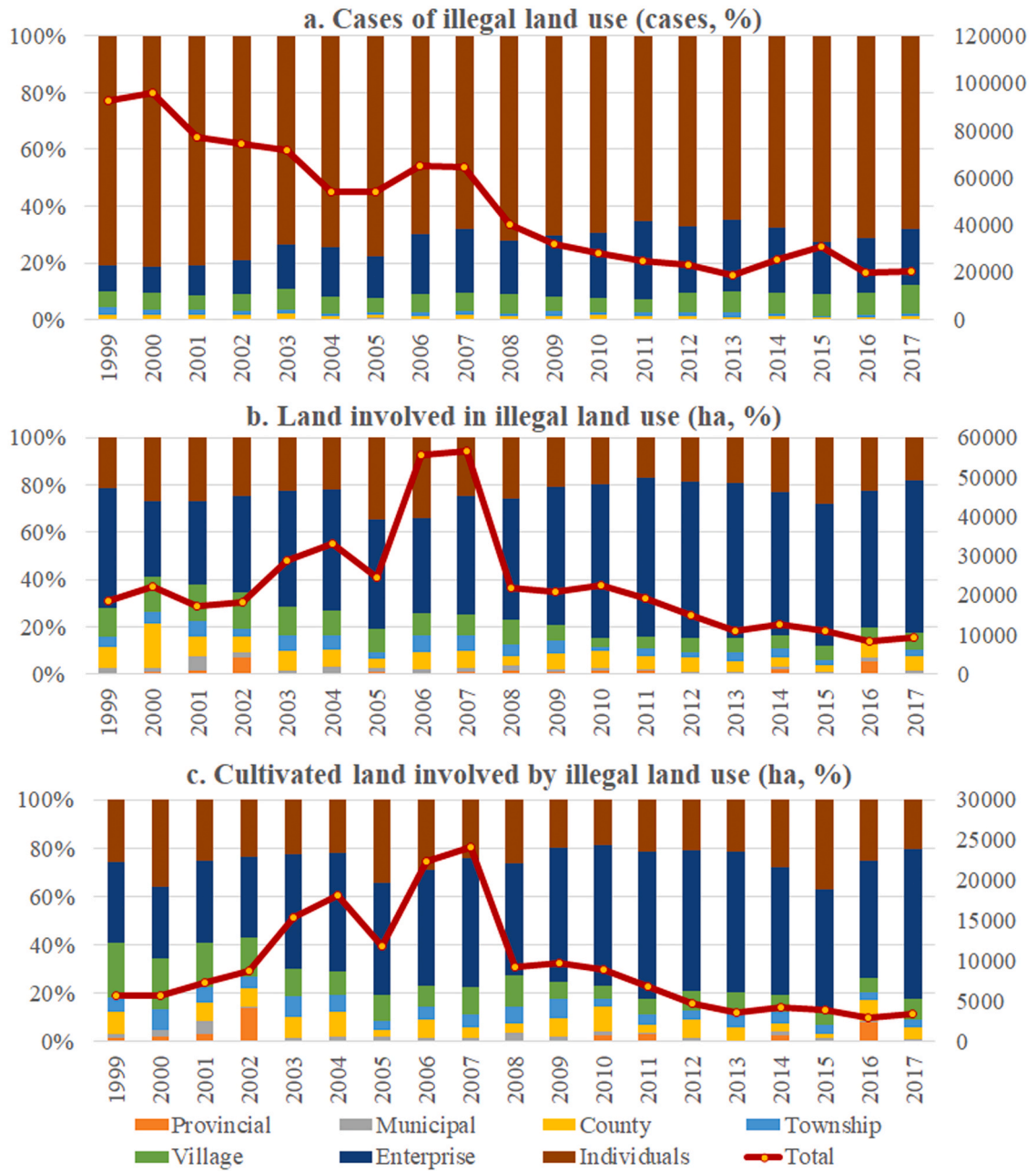

Fig. 6. Cases of illegal land use and involved cultivated land area in China between 1999 and 2017. The data is the illegal land use that occurred during the year). (Note: The data comes from the National Statistical Yearbook of Land and Resources of China 2000–2018.

Fig. 8 shows the spatio-temporal patterns of illegal occupation of cultivated land in China's 31 provinces between 1999 and 2017. In 1999, Shandong was the province with the largest amount of illegal cultivated land use, followed by Yunnan and Inner Mongolia (Fig. 8a). By 2017, Jiangsu, Shandong, Guangdong and Chongqing were the provinces with the most serious illegal cultivated land use (Fig. 8b). Between 1997 and 2017, China's accumulated area of illegal cultivated land use showed a gradient decreasing law from the east to the middle and to the west (Fig. 8c). During the same period, the cumulative area of illegal arable land in eastern, central and western China was 76,268 ha, 47,405 ha, and 29,298 ha, respectively. From the perspective of changing trends, the area of illegal cultivated land use in Heilongjiang, Jilin, Qinghai, Anhui, Xinjiang, Fujian, Guangxi, Guizhou and Hunan provinces has shown an upward trend (Fig. 8d). The province with the most evident downward trend was Shandong, followed by Henan, Jiangsu, Hebei and Zhejiang. The provinces with the most obvious increasing trend were Heilongjiang, Qinghai, Jilin and Anhui. Regionally, the illegal use of cultivated land in Northeast, Southwest, and Northwest China is on the rise, and the illegal use of cultivated land in most of the eastern coastal areas has a downward trend, which means that to some extent, the illegal use of cultivated land in the eastern region has been effectively curbed.

4.4. The effects of socioeconomic development, urbanization and housing price on illegal farmland use

Based on the DK model, the estimates of the impact of population and economic growth, urbanization and housing price on illegal cultivated land use for China and the eastern, central and western regions are shown in Table 3. For the entirety of China, the increase in illegal cultivated land use area was significantly positively correlated with population growth and built-up area expansion, but significantly

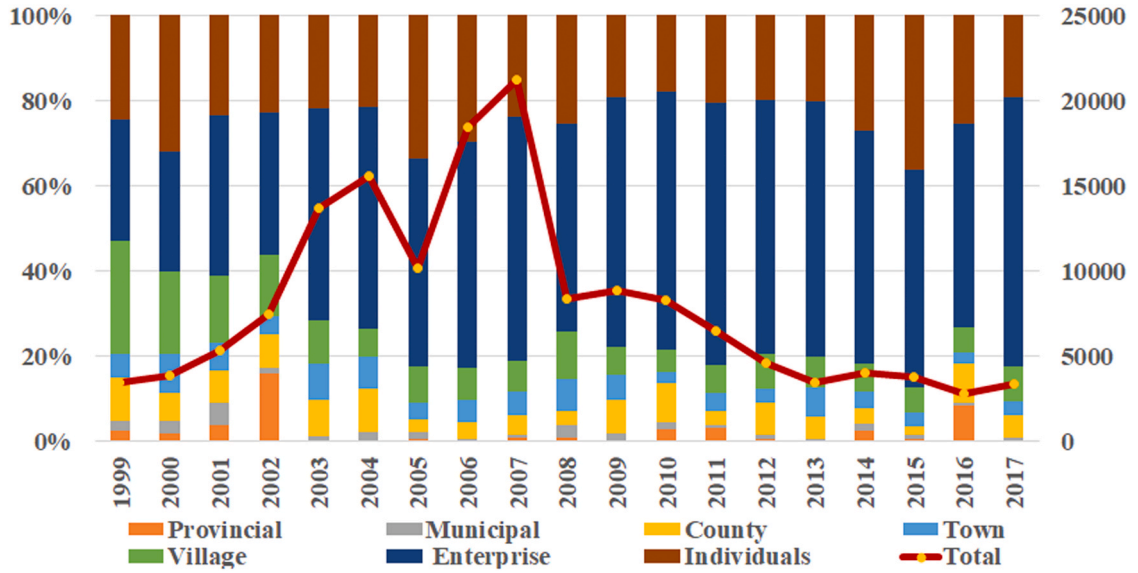

Fig. 7. (a) Sources of illegal land use and involved cultivated land area in China between 1999 and 2017. (b) (Note: The data comes from the National Statistical Yearbook of Land and Resources of China 2000–2018. The data is the illegal land use that occurred during the year).

negatively correlated with economic growth. Population urbanization (the transfer of rural population to cities) and housing prices were positively correlated with the illegal occupation of cultivated land, but their correlation was statistically insignificant at a level of 10% or higher. The estimated coefficients of population growth and cultivated land occupied by built-up land on the illegal occupation of cultivated land were 0.06 and 0.03, respectively. This indicates that population growth and built-up area expansion contributed to the increase in illegal occupation of cultivated land in China over the past two decades. Economic growth has a certain inhibitory effect on the illegal use of cultivated land.

The effects of population and economic growth, urbanization and housing price on illegal cultivated land use varied across regions. Similar to the national scale, the estimated coefficients of population growth and economic development were statistically significantly correlated with the area of illegal cultivated land use in the three regions at the 1% level. The expansion of built-up areas in the eastern region was significantly positively correlated with illegal cultivated land occupation area. There was a significant positive correlation between population urbanization, housing prices and illegal land use area in the central region. The estimated coefficients of population growth on illegal farmland occupation area were 0.08, 0.17, and 0.03 in the eastern, central, and western regions, respectively, which means that the effect of population growth on illegal farmland occupation in the central region was greater than that in the eastern and western regions. Economic growth did not promote the illegal occupation of cultivated land in the three regions, but inhibits it. Housing price had no obvious effect on illegal occupation of cultivated land. These results do not support our hypothesis. There was no obvious regional difference in the impact of economic growth on the illegal cultivated land use in the three regions. On the one hand, this may be related to the fact that China has attached great importance to the regulation of illegal use of cultivated land in recent ten years. On the other hand, it may be related to the fact that the performance evaluation of the Chinese government does not rely too much on GDP. With the economic growth, the legal awareness of residents is gradually improving, which leads to the reduction of illegal occupation of cultivated land.

5. Discussion

Cultivated land protection is related to national food security, ecological security and social stability. The Chinese government has always put cultivated land protection on the political agenda. Facing the national conditions with more people and less land, since the 1980s, China has established a strict land management system, a farmland protection system, and an efficient and intensive land use system (Liu et al., 2017; 2018a). As early as the mid to late 1990s, China began to implement a system of dynamic balance and basic farmland protection to strictly protect the quantity and quality of farmland (Wu et al., 2017). The land use control system implemented in China since 1999 has largely restricted the conversion of cultivated land to non-agricultural purposes (Hong et al., 2017; Wang et al., 2018; Han et al., 2020). Since 2004, China has implemented a policy to link the increase and decrease of urban and rural construction land to stimulate empty waste or inefficient use of land resources in rural areas (Zhou et al., 2019; Zhou et al., 2020). Despite these efforts, the country's arable land quality in some areas has continued to deteriorate (Su et al., 2010; Su et al., 2020), and the problem of continued farmland non-agriculturalization and extensive use has become increasingly serious (Liu et al., 2014; Li et al., 2017). Over the past 20 years, the balance of increase and decrease in the amount of cultivated land in China has been basically guaranteed, but its quality has declined significantly (Song and Pijanowski, 2014; Wu et al., 2017; Su et al., 2020). Illegal occupation of cultivated land is one of the important driving forces for the decrease in the amount of cultivated land in China.

Illegal occupation of cultivated land by individuals or enterprises, was one of the main reasons for China's cultivated land loss. The illegal cultivated land occupation by individuals to build houses not only leads to the loss of cultivated land, but also causes the waste of land resources. Our statistics show that over the past 20 years, the cultivated land area illegally occupied by individuals in rural China has accumulated to 44,314 ha. To some extent, the illegal occupation of cultivated land has caused one farmer household to have multiple houses in rural areas, which violates the requirement of one household per house stipulated by the Chinese Land Administration Law. China's second and third agricultural census data show that the proportion of rural households with one residence in the country dropped from 92.5% to 87.0% from 2006 to 2016, and the proportion of rural households with multiple residences

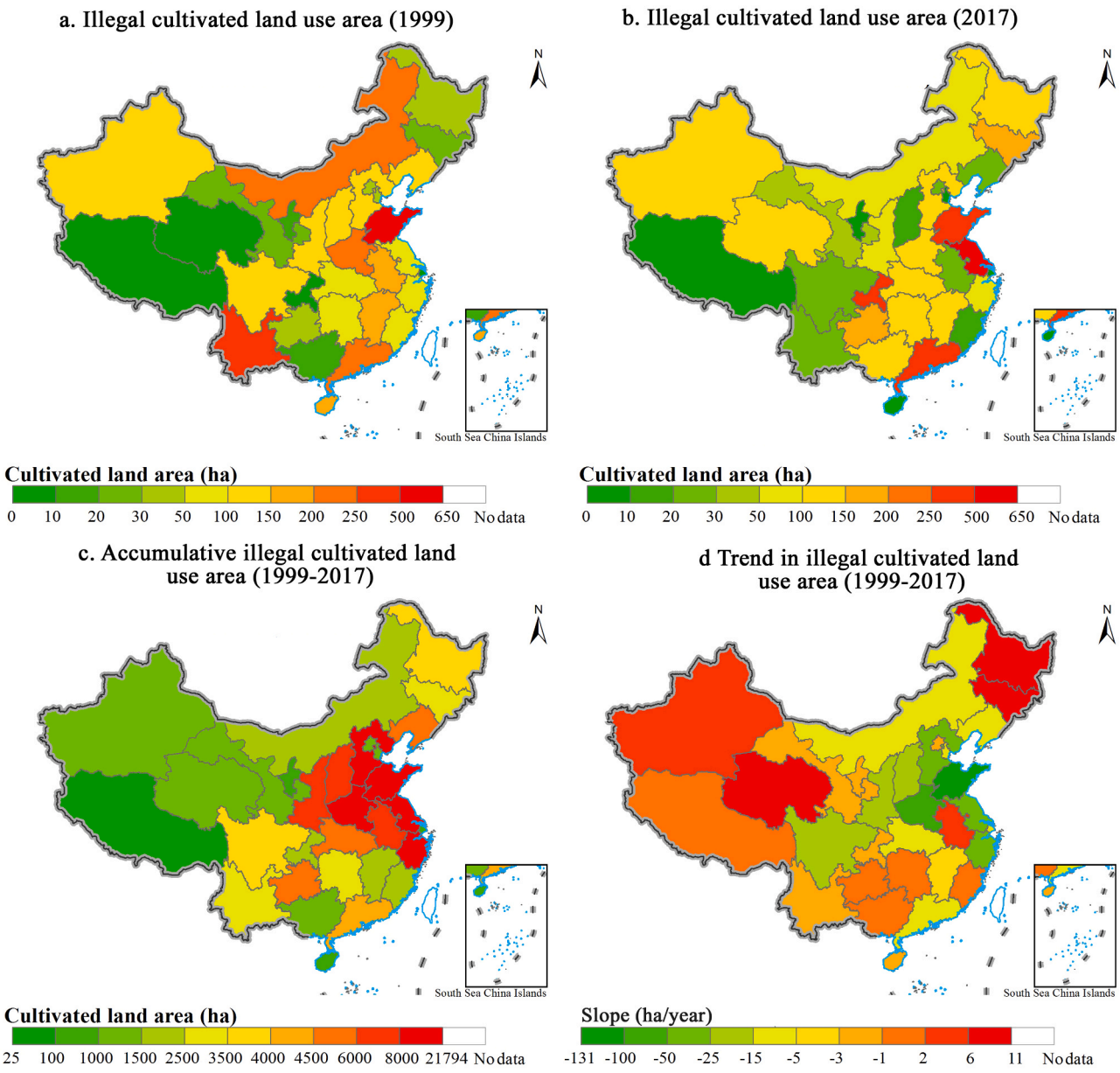

Fig. 8. Illegal cultivated land use in China's 31 provinces between 1999 and2017. (Note: The data comes from the National Statistical Yearbook of Land and Resources of China 2000–2018. A positive slope indicates the increase of illegal cultivated land area, and vice versa. The greater the absolute value of the slope is, the faster the illegal cultivated land area rises or falls).

increased from 6.8% to 12.5%, an increase of 5.7% points in ten years (NBS, 2017). A recent survey of 140 typical villages in 28 provinces across the country also demonstrated that the vacancy rate of rural homesteads nationwide was 10.7% (Li et al., 2019). To prevent the illegal occupation of cultivated land to build houses from the source, China has proposed in recent years that the rural villagers' housing construction must implement the requirements of "One Household, One House" in accordance with the law, and strictly implement the standards set by various provinces.

The illegal use of land in rural China was driven by multiple factors. Our estimated results demonstrate that population growth has a positive impact on the area of illegal arable land used in China and the eastern, central and western regions. Economic growth can help reduce illegal occupation of arable land. Urbanization only has a significant positive impact on the illegal occupation of cultivated land in the central region. More importantly, the increase in housing prices has no significant correlation with on the illegal occupation of cultivated land. To a large extent, the illegal occupation of cultivated land in rural areas to build houses only meets the housing needs of rural households and their own residences, rather than obtaining more economic benefits. In other words, the increase in housing prices does not have a significant effect on illegal occupation of cultivated land in rural areas. When villagers' existing housing cannot meet the needs of their family's population growth, because the homestead application in China takes a long time and strict review procedures, some villagers have no choice but to illegally occupy farmland to build houses. Furthermore, although the number of illegal arable use cases in China has decreased significantly over the past two decades, the illegal land use phenomenon is still everywhere in rural areas. This can be attributed to the fact that law enforcement of land illegal acts is difficult and the effect is not obvious. Because the rural population in China is relatively scattered, illegal land occupation is not easy to be detected, which brings difficulties to relevant departments for land law enforcement. At the same time, the penalties for illegal activities on land are not strong enough, resulting in

Table 3
Estimated results for illegal cultivated land occupation in China and its three regions.

Variable	The entirety of China		Eastern region	
	FE (1)	DK (2)	FE (3)	DK (4)
POP	0.32*** [0.17 0.47]	0.06***[0.01 0.10]	0.34***[0.09 0.59]	0.08***[0.01 0.16]
GDP	-0.02***[− 0.02 − 0.01]	-0.01***[− 0.01 − 0.00]	-0.02***[− 0.02 − 0.01]	-0.02***[− 0.02 − 0.00]
URBA	2.64 [− 1.21 6.49]	1.01 [− 2.24 4.26]	2.81 [− 3.53 91.6]	1.99 [− 5.27 9.26]
Constr	0.03***[0.02 0.04]	0.03***[0.00 0.05]	0.05***[0.03 0.06]	0.05***[0.03 0.06]
Price	0.01 [− 0.00 0.03]	0.003 [− 0.00 0.02]	0.01 [− 0.00 0.03]	0.01 [− 0.00 0.03]
Const	-1220***[− 1837 − 602]	-157**[− 315 0.65]	-1532***[− 2584 − 480]	-367*[− 758 22]
AC test	$F(1,30)= 6.02$***		$F(1,10)= 18.782$***	
CD (p)	12.25(0.00)		1.592 (0.111)	
CIPS	$I(0)$		$I(0)$	
HK test	$x^2(30) = 1.7e+05$***		$x^2(11) = 5626$***	
RMSE		390.43		458.38
R2	0.198	0.3297	0.333	0.508
Obs.	589	589	209	209
Variable	Central region		Western region	
	FE (5)	DK (6)	FE (7)	DK (8)
POP	-0.34 [− 0.89 0.21]	0.17***[0.05 0.28]	0.10[− 0.06 0.26]	0.03***[0.00 0.06]
GDP	-0.04***[− 0.06 − 0.02]	-0.04***[− 0.06 − 0.01]	-0.01***[− 0.01 − 0.00]	-0.01***[− 0.01 − 0.00]
URBA	25.19**[4.89 45.49]	14.47***[3.89 25.06]	0.02 [− 2.64 2.69]	0.76 [− 0.64 2.14]
Constr	0.01 [0.00 0.17]	0.01 [− 0.00 0.03]	0.01 [− 0.00 0.02]	0.01 [− 0.00 0.12]
Price	0.06 [− 0.03 0.17]	0.05*[− 0.00 0.12]	0.01[− 0.01 0.38]	-0.01 [− 0.01 0.01]
Constant	1299 [− 1586 4185]	-1050**[− 1830 − 270]	151 [− 659 356]	32.72 [− 10.85 76.30]
AC test	$F(1,7)= 1.055$***		$F(1,11)= 17.092$***	
CD (p)	1.315 (0.188)		5.723 (0.000)	
CIPS	$I(0)$		$I(0)$	
HK test	x^2 (8)= 1077***		x^2 (12)= 27128***	
RMSE		417.65		159.02
R^2	0.138	0.22	0.08	0.14
Obs.	152	152	228	228

Notes: POP is population size; GDP is Gross domestic product; URBA is urbanization rate; Constr is area of cultivated land occupied by built-up land; Price is the price of commercial housing. AC is autocorrelation test, and CD is the test statistic from the test along with the corresponding p-value in parentheses. The null hypothesis is cross-sectional independence. The stationary of the residuals is determined from the Pesaran (2004) CIPS test and *I* (0) means stationary. HK test is modified Wald test for groupwise heteroskedasticity; RMSE is the root mean squared error. FE and DK are the fix effect and the linear regression with Driscoll-Kraay standard errors models, respectively.

* Indicate statistical significance at the 10% level.
** Indicate statistical significance at the 5% level.
*** Indicate statistical significance at the 1% level.

low cost of illegal activities for villagers and high profits from them. From 2000–2017, China only recovered 29,299 ha of cultivated land illegally occupied according to law, which is less than one-fifth of the illegally occupied cultivated land (MLR, 2018). Another important factor in the illegal occupation of farmland in rural areas in China can be attributed to the incomplete investigation and punishment mechanism for illegal land. The inter-departmental linkage mechanism for investigating and prosecuting land violations in China is not complete, and a strict accountability system has not been truly established, which is unable to deter illegal land use. Due to the lack of specific laws and policies for illegal land use, usually after the land violations occur, there are difficulties in actual investigation and enforcement.

The global pandemic of Corona Virus Disease 2019 (OVID-19) has sounded an alarm for mankind. Food and Agriculture Organization of the United Nations (FAO) estimates that by the end of 2020, 130 million people in the world will be suffering from food insecurity or chronic hunger (FAO et al., 2020). Food security has once again aroused great concern all over the world. As the largest developing country in the world, the illegal occupation of cultivated land in some rural areas in China threatens its food security. To ensure food security, the Chinese government is trying to curb illegal occupation of arable land to build houses in rural areas. On July 29, 2020, China's Ministry of Natural Resources and the Ministry of Agriculture and Rural Affairs have jointly introduced measures to prevent illegal occupation of cultivated land. It is not allowed to occupy permanent basic farmland to build houses, to forcibly occupy more farmland to build houses, to buy, sell and transfer farmland to build houses illegally, to build houses illegally on contracted farmland, to set up names to build houses illegally, to occupy farmland to build houses in violation of the "One House, One House" regulation, to sell houses illegally, to approve and approve houses illegally (MAR, 2020). Subsequently, measures to stop farmland conversion were introduced, including prohibition of illegal occupation of farmland for afforestation, construction of green channel beyond the standard, illegal occupation of farmland for Lake landscaping, occupation of permanent basic farmland to expand nature reserves, illegal occupation of farmland for non-agricultural construction, illegal land grant (General Office of the State Council, 2020).

Nonetheless, five priorities need to be taken urgently to ensure the implementation of these measures and effectively prevent the illegal cultivated land use in China. First, this country needs to strengthen the publicity of laws, enhance the public's awareness of land management law, and warn the consequences of illegal land use acts through publicity and education, so that the public can realize that everyone is responsible for protecting cultivated land. Second, there is an urgent need to establish an illegal land use inspection system and a multi-sectoral land violation monitoring system, and use modern technology such as big data, remote sensing, unmanned aerial vehicle, and the Internet of Things to regularly monitor illegal land use acts. Third, it is also necessary to unite with the departments of land and resources, discipline inspection, public security and courts to undertake the responsibilities of land supervision and law enforcement in accordance with their respective functions, so as to form a land law enforcement system with multi department linkage and collaborative governance, so as to jointly prevent and crack down on illegal land use acts. Fourth, it is crucial to intensify the investigation and accountability of land violations, and put an end to land illegal activities from the source. The country should strengthen the crackdown on land violations, impose severe penalties on land violations, increase the accountability of local governments or

administrative departments for land violations, and give full play to the deterrent role of law in land violations. At last, local government should use the opportunity that the country is promoting the national strategy of rural revitalization. Rural revitalization planning should reserve space for rural villagers' residential land to achieve a win-win situation of farmland protection and farmers' housing basic rights and interests guarantee.

6. Conclusions

Cultivated land protection is related to national food security and social stability. Illegal occupation of cultivated land will inevitably lead to a sharp decline in cultivated land resources, which seriously threatens national food security, causes social instability and harm the rights and interests of farmers. This paper reviewed the evolution history of China's cultivated land protection policy in the past four decades. Based on the provincial panel data, we used spatial analysis and econometric model to investigate the dynamic changes of cultivated land in 31 provinces in China over the past two decades and explore the spatio-temporal evolution characteristics of illegal arable land use, and to measure the impact of population growth, economic development, urbanization and housing prices on the illegal occupation of cultivated land. The results show that in the past four decades, China's cultivated land protection policy system has undergone a process of continuous improvement. The focus has changed from focusing only on the quantity of cultivated land to paying equal attention to both quantity and quality, and then to the trinity of quantity, quality and ecology. Over the past two decades, the increase and decrease in quantity of China's cultivated land has basically kept a dynamic balance, and the trend of large-scale reduction of the country's arable land in the first ten years has been reversed in the next ten years. Since 2006, the cultivated land occupied by construction use has replaced the GFG policy as the main driving force of cultivated land reduction in China. However, the driving forces of cultivated land reduction in China varied across regions. The returning farmland to forest was the main driving force of cultivated land reduction in western China, while cultivated land occupied by built-up land was the main contributor to cultivated land loss in eastern coastal areas. Land consolidation has played an increasingly important role in the increase in the area of arable land in China.

China has implemented a strict land management system and established a relatively perfect farmland protection system, but illegal cultivated land use is still prominent due to some farmers or officials' weak legal awareness and insufficient law enforcement. Results show that over the past two decades, more than 0.15 million ha of arable land have been illegally occupied in China. The number of illegal land cases and the area involved experienced a process of first increasing and then decreasing. The country's accumulated area of illegal cultivated land use showed a gradient decreasing law from the east to the middle and to the west, but most provinces in the east presented a rapid downward trend. This indicated that illegal cultivated land in eastern China has been controlled to a certain extent over the past two decades. Individuals, enterprises and institutions were the main body of illegal cultivated land occupation. Further estimation results demonstrate that population growth and urban expansion had a significant positive correlation with on illegal occupation of cultivated land in China and its eastern region. There was a significant negative correlation between economic growth and illegal cultivated land occupation area at national and regional scales, which demonstrates that economic development helps to curb the expansion of construction land. Urbanization also had a significant positive correlation with the illegal cultivated land occupation in central China. There was a positive correlation between the rise of house prices and the use area of illegal cultivated land, but the correlation was insignificant, which indicates that the rise of housing prices does not directly promote the illegal occupation of cultivated land in rural China. Our findings have important scientific value for understanding the formation mechanism of illegal occupation of cultivated land in rural areas of China and supporting the decision-making of cultivated land protection.

CRediT authorship contribution statement

Yang Zhou: Conceptualization, Methodology, Data processing, Writing - original draft, Revising & editing, Supervision. **Xunhuan Li**: Methodology, Software, Data process, Formal analysis. **Yansui Liu**: Conceptualization, Methodology, Revising & Editing, Supervision, Funding acquisition.

Conflict of Interest Statement

The authors declare that there is no conflict of interest in this research.

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