Spatiotemporal dynamics of reclamation and cultivation and its driving factors in parts of China during the last three centuries*

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Received October 25, 2003; revised December 10, 2003

Abstract Different from other similar studies, in this paper, most of the data were excerpted from historical archives and documents, and were used to study the spatiotemporal dynamics of cultivated land resources in China during the last 300 years. It is clear that these data may help reveal land use change dynamics and its regional differences, but they may be problematic due to the constraints of the original data in the Ming Dynasty, Conversion of Land Area for the purpose of collecting land taxes, and the deliberate or inadvertent omission of cultivated land area during land surveys, therefore, such data were adjusted to our need. In processing the data, we made great efforts to analyze the historical context of their sources and reduced the possible errors. The results show that the cultivated land area increased most quickly in the early Qing Dynasty, and slowed down after the middle Qing Dynasty, and then was stable in the late Qing Dynasty until 1949, and has been decreasing since then. It is also found that the cultivated land use varied greatly in different regions. The east of the country was cultivated much more heavily than the west, but in some western provinces cultivated land area increased more quickly. It is considered that the driving factors of such cultivated land area change include the increase of the population, the political issues, and the impacts of wars. Natural environmental factors and the introduction of new crops might also have affected the cultivated land use change in the past 300 years.

Keywords: land use, China, last three centuries.

Human activities have resulted in the widespread transformation of the Earth's land cover. These changes in land cover have profound impacts on environmental systems around the globe. Scientists now recognize that Land Use & Land Cover Change (in brief LUCC) is an important driver of the terrestrial ecosystems evolution[1]. Studies show that LUCC affects both the structure and process of the ecosystem[2]. The dynamics of reclamation and cultivation, an important component of LUCC, also affects the functioning of the terrestrial ecosystem, including the process of the carbon circulation. The cultivated land is an important carbon pool, in which about 3 Gt carbon is sequestrated in the crops above the ground, and about 128 Gt carbon is sequestrated in the cultivated soils. The sum of the carbon sequestrated in the cultivated land accounts for 5.29% of the total carbon in the terrestrial ecosystems[3].

In China, a country of agricultural tradition, the cultivated land area accounts for 13.3% and 9.08% of her total land area and the total cultivated land area of the world respectively[4,5]. Chinese history reclamation and cultivation were always highly regarded; there is an old Chinese saying that hunger breeds discontentment. During the past few hundred years, the reclamation and cultivation in China have undergone dramatic changes. The correct knowledge of these changes is crucial to the understanding of the evolution of global ecosystems of historical times and its effects on today and the future. Although abundant data from historical documents are available, the correctness and consistency of these data have long been questioned[6,7]. It is the goal of this study to analyze these historical materials based on certain rules, and appreciate the long-term trends that have shaped the present and may affect the future.

1 Sources and processing of the data

The time in the history we are interested in is from the Qing Dynasty to the present. Based on the political systems, it can be divided into three different periods, the Qing Dynasty, the Republic of China

* Supported by the Chinese Academy of Sciences (Grant No. KZCX1-SW-01-09), and Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences (Grant No. CXIOG-E01-05-01)

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(1912 ~ 1949), and the People's Republic of China (1949 ~ present). For each period the data come from different sources.

1.1 Data sources

Materials used to study the cultivated land use change in each of three periods are as the following:

1.1.1 The Qing Dynasty (1644 ~ 1911) For this period, most of the data come from official government publications and local chronicles authorized by the government. The former includes *Wenxian Tongkao of the Qing Dynasty*, compiled during the reign of Qian Long, *Hubu Zeli* of Jia Qing era. The latter includes *Comprehensive Geography of the Great Qing Dynasty* (*Daqing Yitong Zhi*) also compiled during the reign of Qian Long and finished in 1784, and *Jiaqing Chongxiu Yitong Zhi* compiled during the reign of Jiaqing. Besides, some data obtained from contemporary research work[8] are also used.

1.1.2 Time of the Republic of China (1912 ~ 1949) The most important materials for this period are the investigation results of cooperative research of the department of agricultural economics, Nanjing University and other related units, such as the Statistical Bureau of National Government. These data involved the studies of many distinguished scientists in the studies of land use, such as Buck, Baker, Wong, Zhang, Chen and Qiao et al. Furthermore, some statistical data of the State Statistical Bureau[9, 10] are also used.

1.1.3 Current time (after 1949) Many statistical materials for this period of time are available, which are also more precise than those of the Qing Dynasty and the Republic of China. For example, there are many different sources of data on cultivated areas, for which Verburg listed as many as nine different groups of data when he studied the spatial pattern of land use in China[11]. Among them, those issued by the State Statistical Bureau, and those issued by the State Land Administration, have been most frequently cited. Although recorded for different purposes by different institutions, these two data sets are closely correlated, and in very good accordance with each other (ten time points were chosen in each data series randomly, $r=0.9431$, $p<0.001$). The data from the State Statistical Bureau are adopted in this study because they have been systematically collected for a longer time.

1.2 Methods

The raw data from those historical documents, especially those pertaining to the Qing Dynasty, may not be as reliable as desired. They must be carefully analyzed and corrected, and used with caution.

1.2.1 Corrections of the data of the Qing Dynasty. The data of the Qing Dynasty are prone to errors for several reasons. First, they were restricted by the concept of Original Fixed Number of cultivated land area[7]. When the Manchu People entered North China and began their conquest of the whole country, most government archives preserved in the palace of the Ming Dynasty, including the agricultural documents, were destroyed. The records of land use can be only found today are those registered during the reign of Wan Li[12]. Hereafter, such loss of data deeply affected almost all the agricultural statistics on the Qing Dynasty. Second, since such records were created to collect land taxes, Conversion of Land Area was used to tax on an equal-land-yield basis. As a result, the same land areas with different land qualities might be reported as different amounts. Third, in the course of land statistics, the records of some lands might be lost or deliberately hidden. Finally, the units of land measurement in different regions may differ from each other.

According to records of *Hubu Zeli*, *Qishi Lu* and other ancient books, the cultivated land area in the middle and the late Qing Dynasty remained almost unchanged, which is consistent with some other studies[12~14]. According to Yan et al.[15] and Du[16], from the 1870s to the 1930s, the cultivated land areas did not increase in most parts of China, and even decreased in some regions, with the exceptions of some newly cultivated areas, especially Northeast China.

Being cautious about the reliability of these data, we still assume that they can reflect the general trend of cultivated land area change in the Qing Dynasty and show the regional differences. For the convenience of comparing the data of different times, the cultivated land area of each province in 1873 was represented by 100. In the meantime the land areas of each province at other times were calculated *pro rata*, which were named Cultivated Land Area Index (CLAI) in this study (see Fig. 1). As mentioned in

the above paragraph, the average cultivated land area of each province in the Qing Dynasty reached its peak around 1887, and after that, it no longer increased and even decreased in times of war, but rebounded to the value of 1887 in 1952, after the foundation of the People's Republic of China. The highest cultivated land areas of each province in 1887 were substituted by the data of 1952. Since then the total cultivated land area of the whole country has been falling steadily (see Table 1). Then the actual cultivated land area of each province was calculated based on the CLAI (see Table 2).

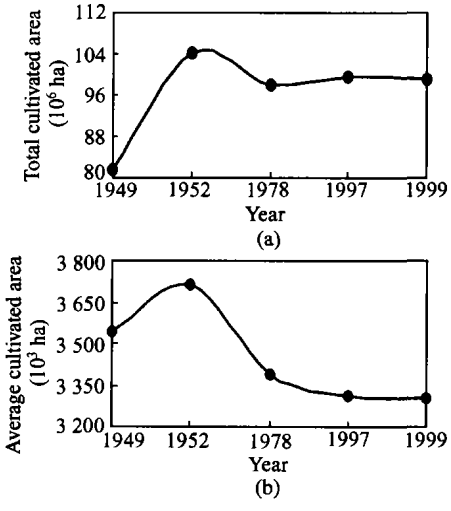

Fig. 1. Cultivated land area change since 1949 in China. (a) total cultivated land area; (b) province average cultivated land area.

1.2.2 Data of the Republic of China (1912 ~ 1949) and after the foundation of New China (1949 ~ now) Compared with that of the Qing Dynasty, the data of the cultivated land area of the Republic of China (1912 ~ 1949) are more complete and authoritative. They were edited by scientists of the Department of Agricultural Economics, Nanjing University, based on 1532 reports compiled by agricultural statisticians from different provinces[9, 15]. The cultivated land dynamics was represented by land index, defined in a very similar manner to that of the Qing Dynasty discussed above. The cultivated land area of each province in 1873 was also supposed to be 100, so that these data can be used directly to join the data series of the Qing Dynasty (see Fig. 1).

After 1949, statistics of the State Statistical Bureau about cultivated land area were used.

1.2.3 Treatment of regionalism problems During the past 300 years, the boundaries between China's provinces frequently changed, making the study of each province's cultivated land area dynamics difficult. Therefore we choose the Interior 18 Provinces of China for the Qing Dynasty as the study area because of their relatively stable territories. Since the borders of these provinces did not change much in the Republic of China era[17], the Interior 18 Provinces of China are also regarded as the study area of this period.

This study area corresponds to the current China's domain except for Northeast China, Inner Mongolia, Qinghai, Tibet and Taiwan (see Fig. 2). From the late Qing Dynasty to the early times of New China, Hebei, Rehe, and Chahaer were included in Zhili Province; Suiyuan was included in Shanxi Province, Shanghai in Jiangsu Province; Ningxia in Gansu Province; and Xikang in Sichuan Province. In order to keep the data in accordance for this period, Hebei, Tianjin and Beijing were incorporated into a special region called Jingjin Region; Shanghai was included in Jiangsu Province; and Ningxia was included in Gansu. This new regionalism is used to calculate the cultivated land use change of the present time.

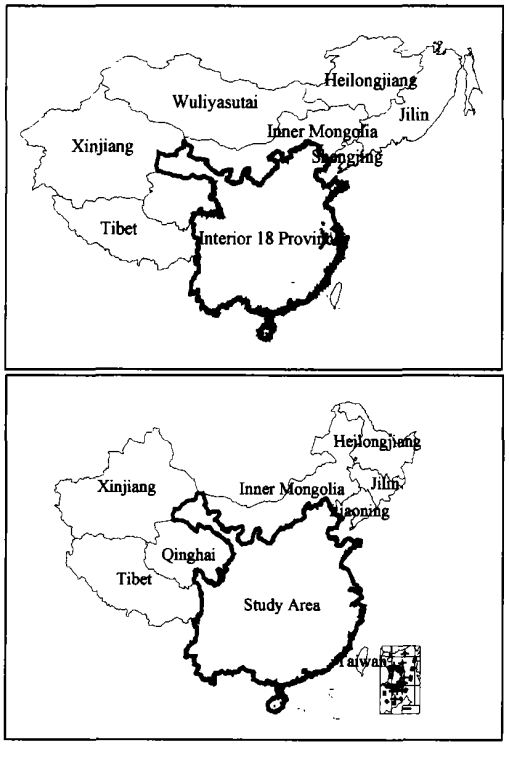

Fig. 2. Illustration of the studied area (The upper and lower figures represent current and the Qing Dynasty respectively).

Table 1. Change of cultivated land index of the studied area from year 1661 to 1933

Province	1661	1685	1724	1784	1820	1873	1887	1893	1913	1933
Sichuan	2.56	3.72	46.36	99.59	100.48	100.00	100.07	102.00	104.00	110.00
Guizhou	40.01	35.74	54.17	78.39	103.04	100.00	102.96	115.00	121.00	130.00
Hunan	82.41	44.33	99.73	99.89	100.34	100.00	110.82	88.00	89.00	88.00
Yunnan	55.44	68.96	76.78	88.94	100.82	100.00	99.14	111.00	133.00	131.00
Guangxi	60.02	86.82	90.78	99.54	99.94	100.00	100.07	105.00	117.00	123.00
Guangdong	72.94	87.93	92.34	97.55	99.74	100.00	100.99	101.00	101.00	102.00
Jiangxi	96.13	97.71	105.05	100.01	100.75	100.00	102.43	99.00	93.00	91.00
Hubei	90.02	91.25	93.20	94.58	94.91	100.00	99.62	104.00	109.00	128.00
Henan	53.38	79.66	91.76	101.77	108.27	100.00	99.81	99.00	117.00	115.00
Shandong	75.28	93.96	100.80	93.93	89.73	100.00	127.89	103.00	105.00	99.00
Zhili/Jingjin	62.94	74.40	96.06	93.17	96.19	100.00	118.63	98.00	100.00	98.00
Shanxi	76.54	83.55	92.41	103.48	98.62	100.00	106.24	103.00	110.00	110.00
Anhui	94.48	103.96	100.36	96.38	97.43	100.00	120.65	106.00	107.00	107.00
Shaanxi	92.36	112.67	118.63	100.75	118.38	100.00	118.39	98.00	95.00	91.00
Gansu	57.19	43.80	92.58	48.69	104.78	100.00	71.27	116.00	117.00	118.00
Fujian	80.52	87.17	103.57	99.86	110.38	100.00	104.70	96.00	92.00	81.00
Jiangsu	97.52	104.26	107.07	100.26	100.75	100.00	116.02	101.00	102.00	110.00
Zhejiang	97.49	96.70	98.92	96.87	98.97	100.00	100.84	102.00	73.00	78.00
Total	1287.24	1396.58	1674.74	1693.66	1823.52	1800.00	1900.55	1847.00	1885.00	1910.00

Notes: (1) Original data of 1661, 1685, and 1724 were obtained from Vols. 1, 2 and 3 of *Wenxian Tongkao of the Qing Dynasty*, and here they were cited from Statistics of Registered Permanent Residence, Plowlands and Land Taxes in Past Dynasties in China[8]; the data of 1784 were extracted from *Comprehensive Geography of the Great Qing Dynasty* (Siku Quanshu version); the data of 1820 were from *Jiaqing Chongxiu Yitong Zhi*; the data of 1873 were from *Hubu Zeli* (revised in 1874), and also cited from Liang[8]. Data of 1873, 1893, 1913 and 1933 were obtained from surveys made by the Statistical Bureau of National Government (The Statistical Bureau of National Government, 1946). (2) When the data of 1873 were used, Zhili included Hebei, Rehe and Chahaer; and Shanxi included Suiyuan; Jiangsu included Shanghai; Gansu included Ningxia; Sichuan included Xikang.

Table 2. Change of cultivated land area in the studied area from year 1661 to 1933 (Unit: 1000 ha)

Province	1661	1685	1724	1784	1820	1873	1887	1893	1913	1933
Sichuan	140.26	203.73	2537.97	5451.81	5500.82	5474.50	5478.50	5583.99	5693.48	6021.95
Guizhou	732.23	654.12	991.42	1434.75	1885.96	1830.34	1884.60	2104.89	2214.71	2379.44
Hunan	2735.58	1471.53	3310.75	3315.90	3331.01	3319.66	3678.80	2921.30	2954.50	2921.30
Yunnan	1357.88	1688.86	1880.58	2178.31	2469.20	2449.19	2428.20	2718.60	3257.42	3208.43
Guangxi	1543.06	2232.10	2333.74	2559.15	2569.30	2570.88	2572.69	2699.42	3007.92	3162.18
Guangdong	2389.81	2880.97	3025.61	3196.22	3267.91	3276.45	3308.89	3309.21	3309.21	3341.98
Jiangxi	2578.66	2621.07	2817.92	2682.82	2702.64	2682.53	2747.70	2655.70	2494.75	2441.10
Hubei	3628.63	3678.30	3757.12	3812.76	3825.91	4031.07	4015.90	4192.31	4393.87	5159.77
Henan	4790.05	7147.60	8233.77	9131.56	9714.83	8972.93	8956.00	8883.20	10498.33	10318.87
Shandong	5581.87	6966.77	7473.64	6964.13	6652.99	7414.48	9482.70	7636.91	7785.20	7340.33
Zhili/Jingjin	4660.42	5508.45	7112.82	6898.62	7121.90	7404.19	8783.30	7256.10	7404.19	7256.10
Shanxi	3330.99	3636.02	4021.52	4503.07	4291.73	4351.69	4623.13	4482.24	4786.86	4786.86
Anhui	4527.88	4982.06	4809.47	4618.97	4669.21	4792.38	5781.80	5079.93	5127.85	5127.85
Shaanxi	3539.56	4317.80	4546.13	3860.99	4536.56	3832.16	4537.00	3755.51	3640.55	3487.26
Gansu	3530.43	2703.61	5715.03	3005.66	6467.95	6172.77	4399.50	7160.42	7222.15	7283.87
Fujian	987.99	1069.53	1270.79	1225.30	1354.32	1226.98	1284.64	1177.90	1128.82	993.85
Jiangsu	5207.72	5568.00	5717.85	5354.10	5380.44	5340.32	6195.77	5393.72	5447.13	5874.35
Zhejiang	1973.08	1957.16	2002.04	1960.71	2003.12	2023.98	2041.00	2064.46	1477.51	1578.70
Total	53236.10	59287.68	71558.17	72154.83	77745.8	77166.5	82200.12	79075.81	81844.45	82684.19

2 Spatiotemporal dynamics of cultivated land area in China during the past 300 years

The spatiotemporal dynamics of cultivated land area in China during the past 300 years was analyzed based on the data mentioned above.

2.1 General trend of cultivated land area

The average CLAI of the provinces in the studied area between 1661 and 1933, and after 1949 can be used to analyze the general trend of cultivated land area use change in the studied area.

In Fig. 3, the change of total cultivated land area in this period was represented by the solid lines, and simulated by linear function and polynomial. It can be seen that the total cultivated land area was increasing during this period. Furthermore, the trend can be expressed as a parabolic curve by the following formula.

$$CLAI = -0.56x^2 + 9.96x + 63.17,$$

where y is Cultivated Land Area Index, and x is the serial number of the year.

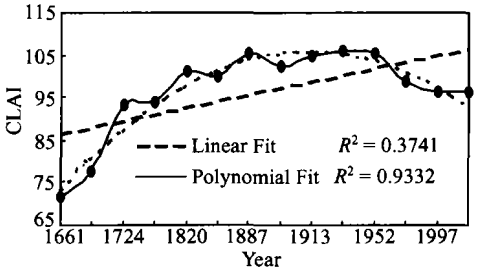

Fig. 3. Illustration of cultivated land index change from 1661 to 1933.

The CLAI increased quickly in reigns of Kang Xi, Qian Long and Yong Zheng, and stayed at the peak value of 107 during Tong Zhi and Guang Xu reigns. It began to drop at the end of the 19th century, and recovered after the foundation of New China in about 1952, and then dropped steadily.

2.2 Intensity of cultivation and reclamation in China during the past 300 years

The data on cultivated land areas are processed by GIS software to analyze the spatial distribution of the cultivation and reclamation over time. The results are illustrated in plate I.

The cultivation index, which is defined as the ratio of cultivated area to total land area, is used to represent the spatial intensity of cultivation and reclamation. Therefore, average cultivation index reflects the long-term cultivation intensity of each province. The result of this calculation shows that intensities of cultivation and reclamation differed significantly between different provinces. Northeastern provinces such as Henan, Jiangsu, Shandong, Hubei, Shanxi, Anhui and Zhili were highly cultivated in the whole study period, from the beginning of the Qing Dynasty to the present. In contrast, western provinces of the country, such as Sichuan, Yunnan, Gansu, and Guangxi, were lightly cultivated, as shown in Plate I. The intensities in northeastern provinces were far higher than that in other provinces, especially those in the west, which were almost 50 times lower than the former. The cause of these cultivation and reclamation distribution patterns may be that the northeast has the most fertile farmland in the country, and has long been fully cultivated in the history. It is also worth noting that between these two periods, the cultivation index of Gansu Province slightly dropped, while that of Guizhou Province increased.

2.3 Spatial distribution of cultivated land area in China during past 300 years

Having shown the trends of cultivation change of the whole country, we are still interested in the regional distinctions between the provinces. In Fig. 4 the CLAI of each province at different times is plotted to illustrate the spatiotemporal characteristics of cultivation.

2.3.1 The Qing Dynasty By the end of the Ming Dynasty, many farm lands had been abandoned due to the successive wars. When political and social systems were rebuilt at the beginning of the Qing Dynasty, the desolated land began to be reclaimed, which is called the "recovering increase" in the literature[13]. Soon after, with the rapid increase of population, people needed more cropland to feed themselves, and they expanded cultivation quickly to previously desolated areas, especially western provinces like Sichuan, Guizhou, and Gansu. The increase in cultivation was accelerated after 1724, when the population increased most rapidly and many people were immigrated to the west, where they cut the wood and grew new crop breeds (Plate I(a)). As a result the agricultural land in production became larger than almost any time in history. The fast growing quantity of cultivated land helped the development of agriculture, but perhaps undermined the ecological environment[18].

On the other hand, cultivation increase in eastern provinces, such as Anhui, Jiangsu and Zhejiang, was relatively slow, since in these areas cultivation had almost reached its limit, and there were hardly any uncultivated arable lands left. Thereafter this trend of cultivated land areas persisted until the end of 19th century (see Plate I (b), (c)).

2.3.2 Times of the Republic of China and the present time Generally speaking, during the time of the Republic of China, there were not many extensive activities of cultivation, and the cultivated land area appeared to be stable (see Plate I (c)).

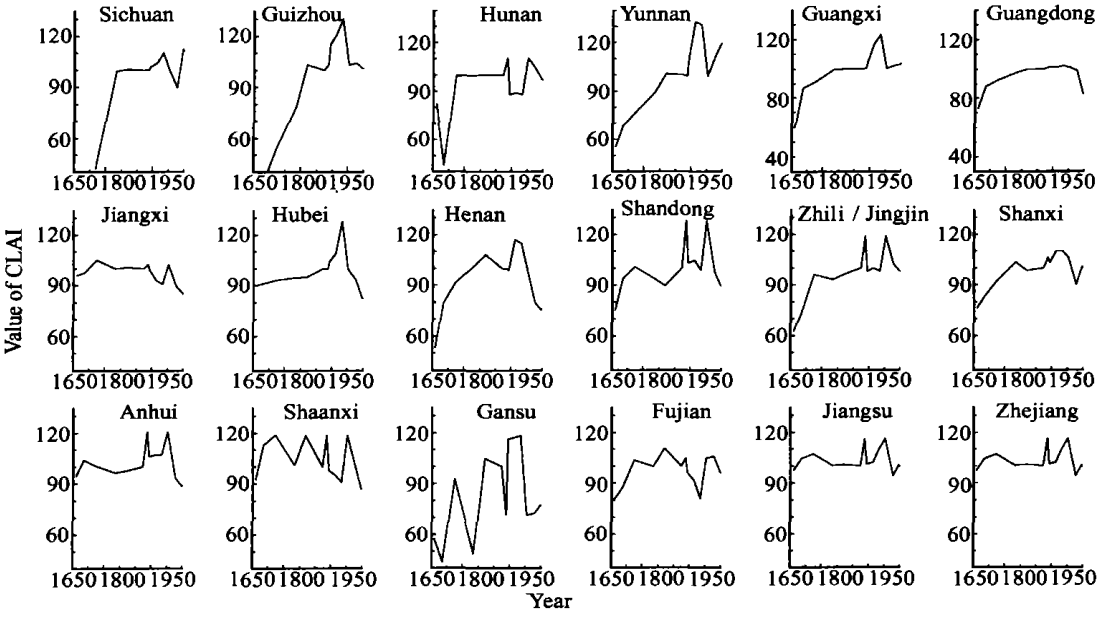

Fig. 4. Change of CLAI of each province over time; from year 1661 to 1999.

According to the statistical data of the State Statistic Bureau, the cultivated land areas began to drop in most eastern provinces after 1949. In some western provinces, such as in Gansu, Yunnan, and Sichuan, the cultivation was on the increase. This is discussed in detail in another paper of our research (see Plate I (d))[19].

3 Analysis of driving forces of cultivation and reclamation

A variety of driving factors were responsible for the cultivation change in the last 300 years. The impacts of human activities on the physical environment were among the most significant ones, which will be discussed below.

3.1 Population growth

Throughout the ancient Chinese history, population was closely related to the quantity of agricultural land. The relationship between the population and the cultivated land area between the beginning of the Qing Dynasty and 1918 is illustrated in Fig. 5. It shows that the increase of population and cultivated land area correlated with each other very well[12, 20].

During the Qing Dynasty the total population rose from less than 100 millions to 400 millions[21]. The major population boom occurred between the middle 18th centrary and the late 19th century. The fast growing population had to be supported by an

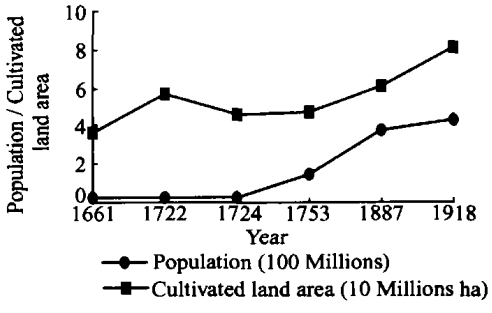

Fig. 5. Illustration of the relationship between population and cultivated land area in the Qing Dynasty and Early Republic of China.

increase in the farm production. Besides technological innovations, which accounted for productivity increase, a major factor contributing to agriculture production was acreage increases. In some regions, such as in Zhili, Shandong and some provinces in the south of the Changjiang River, where almost all arable land had been brought into production, people had to cultivate aggressively on barren lands and wooded areas[14]. Some of them left their homeland for the vast and sparsely populated areas in Northeast China, Inner Mongolia and Sichuan. During this period there were great demands for cultivated lands, which resulted in the increase of crop prices and the exhaustion of the country's potential of cultivation and reclamation.

3.2 Governmental policy issues

Many people were killed or driven out of their

homes during the successive wars at the end of the Ming Dynasty. At the beginning of the Qing Dynasty, agriculture was almost destroyed. According to the records of *Huangqing Zouyi* and *Qing Shizu Shilu*, some of the developed agricultural regions, such as Zhili, Shandong, Henan, Hunan, Guangdong, Guangxi, and some provinces in the south of Changjiang River, were "desolate and uninhabited", and "hardly cultivated". The Qing government had to change this situation.

(1) Reform of land tax systems. The late Ming Dynasty suffered a lot from natural disasters and political problems. In order to cope with the huge cost of maintaining its power, the government imposed heavy taxes. Most of the governmental policies of the Ming Dynasty including the tax systems were adopted by the Qing Dynasty. The Qing government soon realized that heavy taxes prevented the recovery of agriculture, and began to change the situation. In the reign of Shun Zhi, the government began to revise its tax systems. One important action is connecting land taxes with property rights. The lands would be confiscated by the government if the owners refused to pay taxes. This forced the rich families to pay due taxes to the government[12]. On the other hand, according to the *Encyclopaedia of Taxes and Corfé* (Fuyi Quanshu), many measures were taken to lower the land owners' taxes during and after the reign of Kang Xi. This greatly helped the recovery of the country's economy.

(2) Reform of corfé tax policies. The most important regulation enforced about tax system was the combination of taxes with corfé. The emperor Kang Xi decided to freeze the quota of corfé tax for each local government. The direct effect was that no extra corfé taxes were collected due to population increase in the district. This greatly stimulated both the cultivation and the population growth during the whole Qing Dynasty.

(3) Encouragement of reclamation and improvements of water systems. Other actions were taken to encourage land reclamation. In the middle of Kang Xi reign, land owners were allowed to postpone the paying of land taxes, officials responsible for regional reclamation were rewarded, and lands were returned to monarchs of the Ming Dynasty by the name "Civil Lands" (Geng Ming Tian), etc. These measures contributed to the rapid increase of cultivated land area in Sichuan, Yunnan, Shaanxi provinces.

Still in the reign of Kang Xi, renovation of public facilities and agricultural infrastructure took place, of which the improvement of irrigation system was one of the most important achievements in agriculture. Chen Huang, a water-control expert, was the leading figure in the success of controlling the Yellow River at that time. These series of changes led to the increase of cultivated land areas in Henan, Jiangsu and other provinces along the Yellow River.

3.3 Wars and rebellions

During the past few hundred years, China suffered from many wars, including domestic rebellions and invasions of foreign forces, which had profound impacts on society and economy, and also influenced the dynamics of cultivated land area in certain regions at certain times.

(1) Revolt of the Three Feudatories (San Fan Zhi Luan). Three Ming turnover generals Wu Sangui, Shang Kexi, and Geng Jingzhong started a fierce revolt to challenge the Qing's rule in 1674. This is said to be one of the largest civil wars in history and involved most provinces of south China. In Hunan and Yunnan battles were fought with Wu Sangui's forces; in Guangxi and Fujian with Geng Jingzhong's forces; and in Guangdong with Shang Zhixin's forces. A loyal follower of Wu Sangui, Wang Fuchen, the police chief of Shaanxi Province, rose up and brought Shaanxi and Gansu into war against the Qing army. The war lasted until 1681 and severely damaged China's agriculture. As a result, the cultivated land area dropped significantly. The comparison of the CLAI in 1685, soon after the war was ended, with the yearly average CLAI and with the CLAI before the war of each province shows that the former was much lower than the latter in the provinces involved in the war (see Fig. 6).

(2) Rebellions in middle and late 18th century. At the end of Qian Long reign, political corruption, overpopulation, and other social problems caused the Qing Dynasty to decline. People in hopeless situations began to rise up against the government. The most famous movements were the White Lotus Sect Rebellion, the uprising of farmers led by Wang Lun, and the Triad Sect (Sanhe Hui), etc. Although most of these uprisings broke out in remote areas, they affected some central regions, and caused the abandonment of some farmland, which explains the decrease of cultivated land area in the 1780s (see Fig. 3).

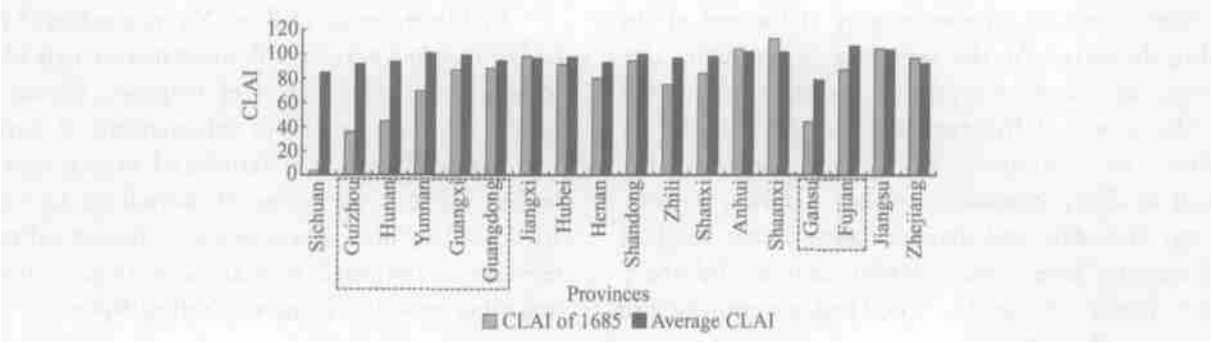

Fig. 6. Comparison between cultivated land area in 1685 with yearly average.

(3) The Taiping Rebellion. Another major upheaval occurred then was the Taiping Rebellion led by Hong Xiuquan. It is the most brutal civil war in Chinese history, which lasted nearly 15 years and killed more than 20 million lives. Agriculture suffered seriously, especially in regions directly involved. As a result, the increase rate of cultivated land index in Anhui, Hubei, Jiangxi and Jiangsu provinces dropped to far lower than other provinces (see Fig. 4).

Besides, other wars, such as the Opium Wars, the war of Resistance against Japanese Agression, the battles between the warlords, etc. also affected cultivation at that time.

3.4 Other factors

Natural factors and the introduction of new crops also greatly influenced the agriculture in China during this period, and might have connection with the change of agricultural land areas.

(1) Natural factors. Since agriculture and cultivation rely heavily on the climate, the climate change and related natural disasters are direct factors to influence cultivation and reclamation. Although the long-term climate change had little effects on agriculture, the mesoscale period of shift from warm to cold in North China and Northeast China was responsible for the drought and flood[22]. There were more such natural disasters in the cold period, and vice versa. The studies of Wang and Huang[22] on the relationship between natural disasters and crops price in the Qing Dynasty in the delta of the Yangtse River also show that natural disasters were one of the determining factors in cultivation.

(2) Introduction of new crops. In the Qing Dynasty many new fruits and crops were introduced to China from abroad, which helped Chinese people to obtain better nourishment. Among these new breeds, corn (*Zea mays*) and potatoes (*Solanum tuberosum*), introduced in the 18th century, were considered the most important, since they have high yield and can be grown on lands of poor qualities which were not suitable for traditional crops[23]. The cropland increase near the mountains and other harsh places could be attributed to the cultivation of these crops. According to historical records crops grown in most of the mountain regions in Shaanxi, Sichuan, Guizhou, Zhejiang, Guangdong and Guangxi were corn and potatoes, the main sources of food for the people in these areas[13].

4 Conclusions and discussions

In this paper the spatiotemporal dynamics of cultivated land resources in China were studied based on historical archives and documents. The following conclusions can be drawn:

(1) During the last 300 years, cultivated land area has an obvious trend of increase. The increase was most rapid at the beginning of the Qing Dynasty, and became stable in the middle of the 19th century. After 1949, the cultivated land area began to drop steadily.

(2) The cultivated land use has varied with different regions. The east of the country was more heavily cultivated than the west. However, the cultivated land area of some western provinces increased more quickly than that of the eastern provinces.

(3) The major driving factors of spatiotemporal dynamics of cultivated land resources are the increase of the population, the adjustments of related government policies, and the impact of wars. The changes of natural environmental and the introduction of new crops, such as corn (*Zea mays*) and potatoes (*Solanum tuberosum*), also contributed to the cultivated land use change in the past 300 years.

Due to the limitations of the data sources, only primary conclusions can be drawn. If further data are obtained to reduce the error of the statistics in each province, more precise and reliable conclusions can be reached based on the results of this paper. This will be considered in future work.

Acknowledgements Thanks are extended to Dr. Xiaorang Li who helped to improve the English in the last version.

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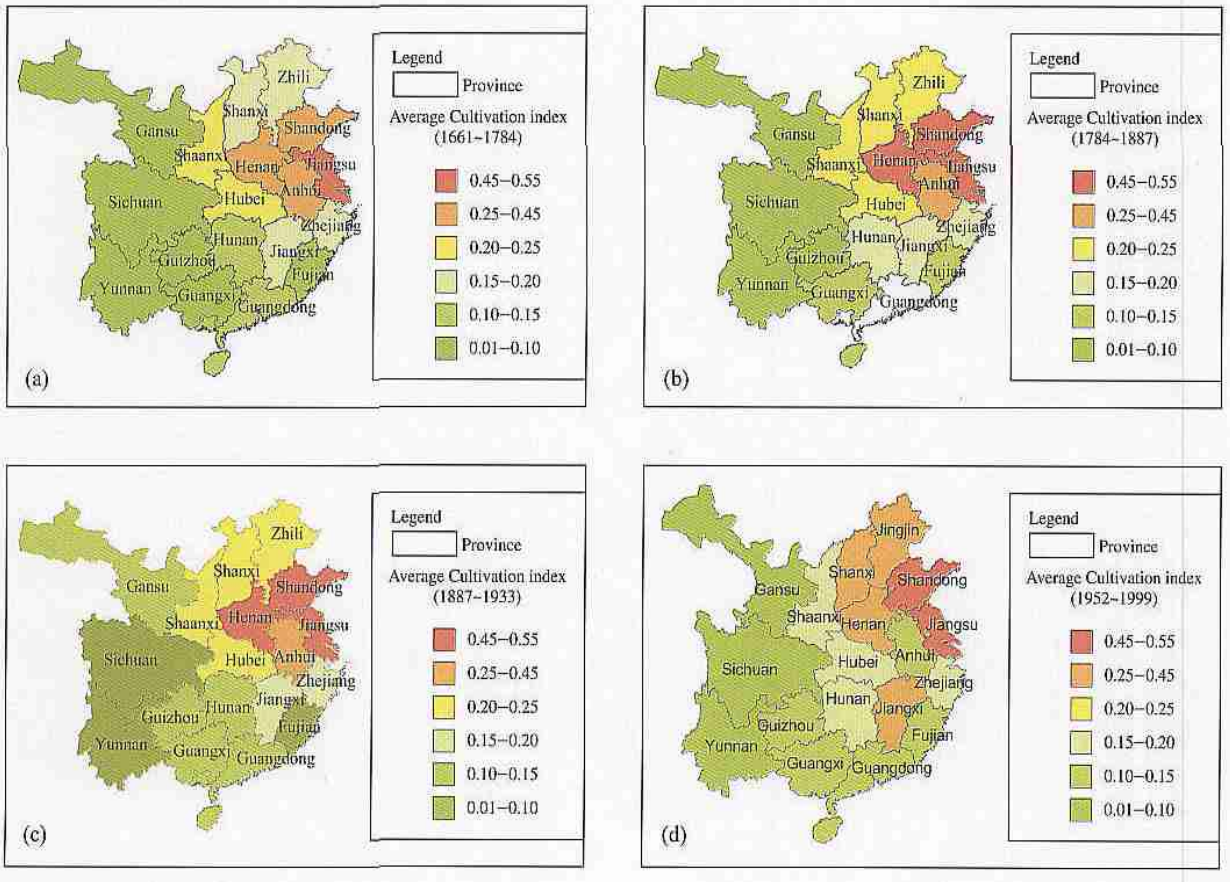

Plate Ⅰ. Spatial characteristics of cultivation and reclamation

(a) From 1661 to 1784; (b) from 1784 to 1887; (c) from 1887 to 1933; (d) from 1952 to 1999