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Original Research Paper

# Relationship Analysis Between Cultivated Land Resource Change and Economic Growth: A Case Study in Sichuan Province, China

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## ABSTRACT

Based on the statistics in Sichuan province during 1978-2010, the dynamic process of cultivated land area change and economic growth was analysed firstly. And then, the regression model between cultivated land area and pre capita GDP was established. At last, the cultivated land area under different levels of economic growth was predicted according to the established regression model. The results were that the cultivated land area in Sichuan province showed the decreased trend and the decreased trend can be divided into three phases, slowly decreasing phase, drastically decreasing phase and eased phase, in the past 33 years. The cultivated land area and pre capita GDP were negatively correlated and the correlation equation was a logarithmic decreasing function in Sichuan province. With the gradual increase of the per capita GDP, the cultivated land area will decrease slowly in the future, but the decreasing trend may be stabilized. Combined with the development status of Sichuan province, the results indicated that the contraction between the cultivated land area and pre capita GDP can be mitigated or even eliminated with scientific land management strategy, input increase and technological transformation. On the basis of the study, the protection suggestions were proposed from the point of view of avoiding occupation and degradation of cultivated land.

## INTRODUCTION

In many natural resources, cultivated land is an important resource for human survival and life. Therefore, protection of cultivated land resources has been one of the most important elements of land management. However, with the rapid socio-economic development in China, cultivated land resources face tremendous pressure (Jin 2013). In the past 40 years, a large amount of cultivated land is occupied in China, while reduction of cultivated land was accelerated (Wang 2008). To realize the sustainable development, protection of cultivated land resources is extremely urgent (Li 2009). Therefore, many studies on cultivated land resources protection were carried out in recent years. In these researches, the correlation research between cultivated land resource and socio-economic development can provide effective policy guidance for cultivated land resource protection. In the field, Jin et al. (2013) taking Wenling City as an example to evaluate public participation in the farmland protection issues with selection experimental method. Wang et al. (2008) with STIRPAT model, taking time-series data of cultivated land and socio-economic impact factors of Suzhou during 1978-2005 as an example, analysed the effect of population, industrial structure and the level of urbanization to the cultivated land area and the correlation between wealth and cultivated land occupation. Long et al. (2007) used the remote sensing image data and socio-economic data, taking Kunshan City as an example to investigate the city's land-use change and socio-economic driving factors. The previous studies have played a role of reference and guidance to local socio-economic development of cultivated land resources protection.

Sichuan province is one of the main grain producing provinces in China (Jiang 2007). In the policy of the western development strategy of China, the economy of Sichuan province has rapidly developed and infrastructure investment is getting to increase each year. Under the background, it is important to study the correlation between the cultivated land resources and economic development in Sichuan province.

This paper focuses on the research and analysis of the dynamic process of cultivated land change and economic growth in Sichuan province, quantitative characterization between the area changes of cultivated land and economic growth, cultivated land area forecasts and protection under different levels of economic growth. The study was designed to provide references for the protection of cultivated land resources in Sichuan province.

## MATERIALS AND METHODS

**Study area:** Sichuan province is located in the southwest of China, and in the upper reaches of the Yangtze River. Sichuan

is an agricultural province with large population. Comparing the other 11 western provinces of China, economic development of Sichuan province is on top of them (Wu 2010). At present, Sichuan province is composed of a sub-provincial city, 17 prefecture-level cities and 3 autonomous prefectures. The total area is 4,85,000 square kilometres. The vertical climate change is obvious and there is a variety of climate types and it is suitable to develop the agriculture and builds up the agricultural economy predominantly in plant industry (Zeng 2009). However, it has less per capita agricultural resource, and more natural disasters, poor ecological environment, and thus the safety systems of agricultural production, especially safety system of food production is fragile (Xia 2005). With the rapid economic development in Sichuan province, in order to achieve sustainable development, the protection of cultivated land resources and management has become an urgent task at present.

**Basic data:** The study adopted the data of cultivated land area, GDP, per capita GDP, per capita cultivated land area during 1978-2010 in Sichuan province. The date is attained from the reference (Statistics Bureau of Sichuan Province, 2010; Statistics Bureau of Sichuan Province 2011).

**Research scheme:** (1) Utilizing statistical method, analyse the process of economic growth in Sichuan province and the change process of cultivated land area, and change rate of cultivated land area, while explore change of per capita cultivated land area, complete the analysis of dynamic process between Sichuan province's cultivated land change and economic growth. (2) Select per capita GDP as economic indicator, establish regression model between cultivated land area and per capita GDP, analyze the accuracy of the regression model, and achieve quantitative characterization between cultivated land area and economic growth. (3) Predict the cultivated land area under different levels of economic growth based on a regression model. (4) Promote cultivated land protection suggestions based on the above research conclusions. Specific research scheme is shown in Fig. 1.

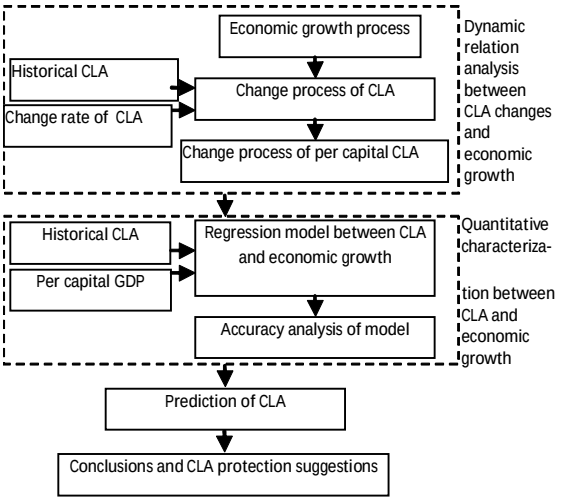
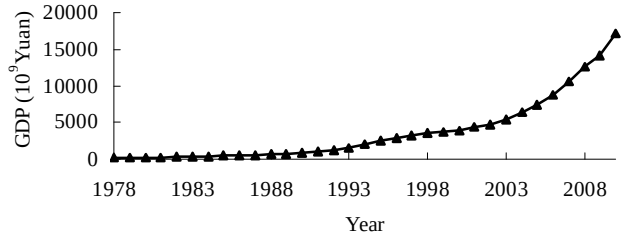



Fig. 1: Research scheme, CLA: Cultivated land area.

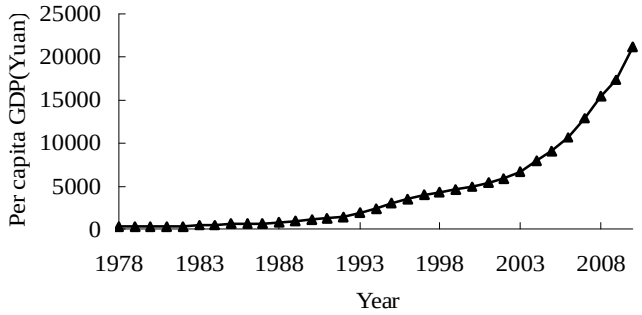
## RESULTS AND DISCUSSION

**Dynamic process between cultivated land area change and economic growth:** Fig. 2 shows the trend of GDP (Fig. 2a) and per capita GDP (Fig. 2b) of Sichuan province from 1978 to 2010. Economic growth can be represented by GDP or GDP per capita (Cai 2007), then Fig. 2 shows the process of economic growth during 1978-2010 in Sichuan province. According to Fig. 2, it can be found that Sichuan provincial GDP and per capita GDP had a significant increase since 1978. During 1978-2010, the total of GDP increased from $184.61 \times 10^9$, Yuan to $17,185.48 \times 10^9$ Yuan, while per capita GDP increased from 261 Yuan to 21,182 Yuan. In summary, the GDP and per capita GDP had the same growth trend, namely they increased slowly at the previous period and increased rapidly at the later period.

Fig. 3 shows cultivated land area and cultivated land area change rate during 1978-2010. Fig. 4 shows the process of change of per capita cultivated land area in Sichuan province during 1978-2010. From Fig. 3, it can be found that overall cultivated land area was decreasing in Sichuan province. The cultivated land area decreased from $490.91 \times 10^4 hm^2$ in 1978 to $401.07 \times 10^4 hm^2$ in 2010. In the past 33 years, cultivated land area in Sichuan province reduced $89.84 \times 10^4 hm^2$. Reduction each year was $2.7224 \times 10^4 hm^2$. According to Fig. 3, the rate of change of cultivated land area can be broadly divided into the following three phases: the first phase is the year of 1978-1998. The rate of change of the province's cultivated land area was negative (except for 1980, the value is 0.0010), but the annual reduction rate of the phase fluctuated around -0.4%. The phase shows that during 1978-1998 cultivated land area was slowly declining year by year. For this phase the main reason is due to increase of the rural population, urbanization, and the continuous development of the non-agricultural industry (Li 2004); the second phase is from 1999 to 2003. The rate of change of the province's cultivated land area was negative and the rate of change of the phase was more negative. In the second phase, the rate of change in 2002 was negative maximum (-5.24%). The phase shows that the province's cultivated land was drastically reduced year by year. The main reasons for the decrease of the phase included the reasons in the first phase, and the started engineering in 1999, which returning farmland to forest (grass) (Zhou 2009); the third phase is from 2004 to 2010. The rate of change of the province's cultivated land area was positive, but the rate of changes was less than 1%. The phase shows that decreasing trend of the




(a) GDP




(b) Per capital GDP

Fig. 2: Change trends of GDP and per capita GDP during 1978-2010 in Sichuan province.

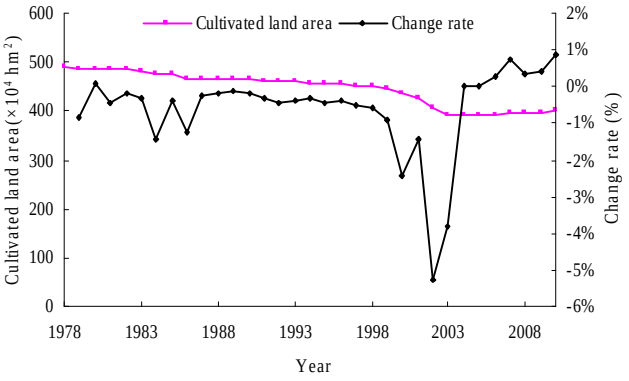



Fig. 3: The trend of cultivated land area and cultivated land change rate during 1978-2010 in Sichuan province.~

province's cultivated land area was gradually easing.~This may be related with the land consolidation work of government departments, so a small increase was found in cultivated land.

Per capita cultivated land area in Fig. 4 reflects a consistent trend with cultivated land area in Fig. 3, namely the overall trend is decline. This shows that the process of change of per capita cultivated land is closely related to the process of change of the cultivated land area. In Fig. 4, per capita cultivated land area was 0.0694hm$^2$ in 1978, while it decreased to 0.0446hm$^2$ in 2010. Since 2000, per capita cultivated land area in Sichuan province was lower than the

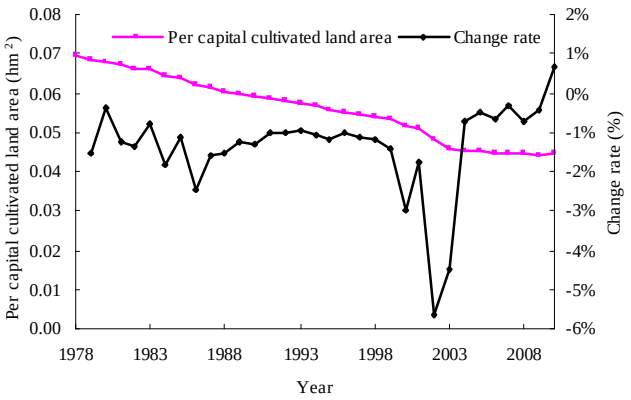



Fig. 4: Per capital cultivated land area and its change rate.

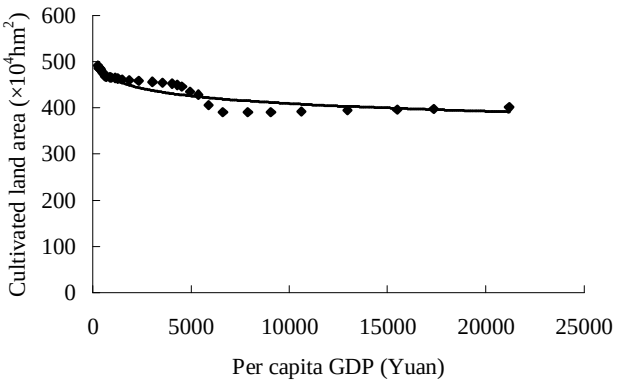



Fig. 5: Fitting curves between cultivated land area and per capita GDP during 1978-2010.

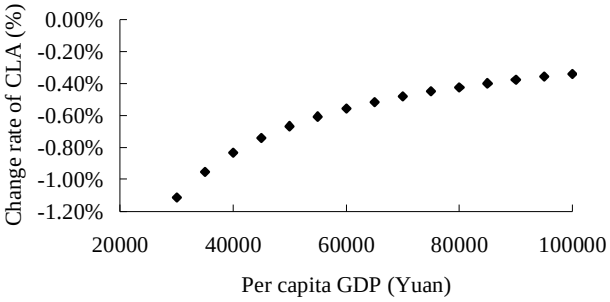



Fig. 6: Change rate of cultivated land area under the different levels of economic growth.

amount designated by the Food and Agriculture Organization of the United Nations, the alarming value is 0.053 hm$^2$ (Lin 2008). Contrast to the curve of the rate of change in Figs. 3 and 4, it indicated that the earlier trend of cultivated land area and the rate of change of per capita cultivated land was more consistent, but later the rate of change of cultivated land area (after the year of 2004) was positive, while in the same period the rate of change of per capita cultivated land area was negative (except for 2010). Further analysis of change rate of per capita cultivated land area in Fig. 4 was

Table 1: The estimated value and relative error of historical cultivated land area from 1978 to 2010.

| Year | True value ($\times10^4hm^2$) | Estimated value ($\times10^4hm^2$) | Relative error % | Year | True value ($\times10^4hm^2$) | Estimated value ($\times10^4hm^2$) | Relative error % |
|---|---|---|---|---|---|---|---|
| 1978 | 490.91 | 495.65 | 0.97 | 1995 | 456.04 | 437.47 | -4.07% |
| 1979 | 486.67 | 493.24 | 1.35 | 1996 | 454.31 | 433.82 | -4.51% |
| 1980 | 487.16 | 490.82 | 0.75 | 1997 | 451.99 | 430.80 | -4.69% |
| 1981 | 485.12 | 489.60 | 0.92 | 1998 | 449.49 | 429.31 | -4.49% |
| 1982 | 484.19 | 486.82 | 0.54 | 1999 | 445.47 | 427.99 | -3.92% |
| 1983 | 482.82 | 484.10 | 0.27 | 2000 | 434.61 | 425.92 | -2.00% |
| 1984 | 475.84 | 480.88 | 1.06 | 2001 | 428.44 | 423.99 | -1.04% |
| 1985 | 474.12 | 477.15 | 0.64 | 2002 | 405.99 | 421.83 | 3.90% |
| 1986 | 468.12 | 475.39 | 1.55 | 2003 | 390.37 | 419.05 | 7.35% |
| 1987 | 466.92 | 472.21 | 1.13 | 2004 | 390.44 | 414.89 | 6.26% |
| 1988 | 466.11 | 467.38 | 0.27 | 2005 | 390.60 | 411.62 | 5.38% |
| 1989 | 465.48 | 464.80 | -0.15 | 2006 | 391.66 | 407.88 | 4.14% |
| 1990 | 464.71 | 460.81 | -0.84 | 2007 | 394.59 | 403.14 | 2.17% |
| 1991 | 463.23 | 457.93 | -1.14 | 2008 | 395.95 | 398.91 | 0.75% |
| 1992 | 461.19 | 454.59 | -1.43 | 2009 | 397.61 | 396.25 | -0.34% |
| 1993 | 459.38 | 449.21 | -2.21 | 2010 | 401.07 | 391.51 | -2.38% |
| 1994 | 457.96 | 443.71 | -3.11 | | | | |

Table 2: Predictive value of cultivated land area under the different levels of economic growth.

| Per Capita GDP(Yuan) | Cultivated land area ($\times10^4hm^2$) | Per Capita GDP(Yuan) | Cultivated landarea ($\times10^4hm^2$) |
|---|---|---|---|
| 25000 | 387.58 | 65000 | 364.95 |
| 30000 | 383.26 | 70000 | 363.19 |
| 35000 | 379.61 | 75000 | 361.56 |
| 40000 | 376.45 | 80000 | 360.03 |
| 45000 | 373.66 | 85000 | 358.59 |
| 50000 | 371.16 | 90000 | 357.24 |
| 55000 | 368.90 | 95000 | 355.96 |
| 60000 | 366.84 | 100000 | 354.74 |

found that change rate of per capita cultivated land area in Sichuan province was less negative after the year of 2004 and change rate always fluctuated around zero, which may be associated with cultivated land area increased slightly in this period and population growth slowly declined.

**Quantitative characterization of relationship between cultivated land area and economic growth:** Relationship between cultivated land area change and economic growth is in existence (Liu 2008). On the basis of the above analysis, taking per capita GDP as independent variable, the quantitative relationship between per capita GDP and cultivated land area change was deduced as the following.

The Pearson correlation coefficient was calculated in SPSS13.0. The Pearson correlation coefficient between per capita GDP and cultivated land area is -0.8490 ($P < 0.01$). When the absolute value of Pearson correlation coefficient between two indicators is more than 0.8, it can be regarded as highly relevant (Cong et al. 2008), so further regression analysis between per capita GDP and cultivated land area was carried out.

In regression analysis of per capita GDP and cultivated land area, due to large change of per capita GDP, logarithmic fitting is taken. Fig. 5 shows a fitting for both. The function equation of fitting curve ($R^2 = 0.8644$) is:

$$y = 627.469\text{-}23.689\ln(x) \quad ...(1)$$

Where, $y$ is cultivated land area ($\times 10^4hm^2$), $x$ represents per capita GDP (Yuan). The equation (1) depicts quantitatively the relationship between the change of cultivated land area and per capita GDP.

Sichuan province's cultivated land area was estimated according to the fitting equation from 1978 to 2010. The comparison between the true value and estimated value is given in Table 1. In Table 1, based on per capita GDP data of 33 years, the estimating relative error of the cultivated land over the years is less than 5%, with the exception of the years 2003, 2004 and 2005. For the years 2003, 2004 and 2005, the relative error is higher (respectively 7.34%, 6.26%, 5.38%), According to the previous analysis of dynamic process between cultivated land area change and economic

growth, because the cultivated land changes of the stages greatly fluctuated, the accuracy of the data fitting is affected. With the continuous execution of the policy of returning farmland to forests, Sichuan Province's cultivated land change does not change dramatically. Therefore, relative error is higher for the years 2003, 2004 and 2005, which can be ignored in the regression model. In summary, fitting equation has a high reliability and accuracy.

**Forecast of cultivated land area under the different levels of economic growth:** According to quantitative relationship of cultivated land area and economic growth, the assumed cultivated land area of Sichuan province is given in Table 2 under the different levels of economic growth. It can be seen from the data in Table 2 that the amount of cultivated land area is decreasing with the growth of per capita GDP. When per capita GDP is 25,000 Yuan, the amount of cultivated land forecast is $387.58 \times 10^4 hm^2$, and when per capita GDP is 100,000 Yuan, the amount of cultivated land is $354.74 \times 10^4 hm^2$. According to the data of the cultivated land area in Table 2, the figure of statistic of change rate of the cultivated land area is plotted (Fig. 6). Fig. 6 shows that change rate of cultivated land area is decreasing with the gradual increase of per capita GDP. This indicates that the cultivated land area in Sichuan province will gradually decrease with economic growth, but the trend may be terminated, and ultimately reaches a steady state. The analysis results from Fig. 6 is in accordance with the results obtained by the previous researchers, that the reduction rate of cultivated land area will be decreased when economic development reaches a certain extent (Qu 2004).

## CONCLUSION AND SUGGESTION

**Conclusion:** With the rapid economic growth of Sichuan province, the cultivated land area was gradually decreased over the last 33 years. The change process can be divided into three stages, namely slowly decreasing phase, drastically decreasing phase and eased phase with the land management policy and socio-economic development. During the period, the change of per capita cultivated land area and the change of cultivated land area were consistent. The fitting quantitative relationship of cultivated land area and per capita GDP indicated that cultivated land area was inversely related to the logarithm of decreasing function with per capita GDP. This relationship predicted cultivated land area still slightly decreases with the increase of per capita GDP, but this decrease may be terminated under certain conditions, so that the cultivated land area will maintain a steady state. Combining with investment of economy and science and technology in recent years, the study shows that the amount of cultivated land can remain stable with the socio-economic development and with the help of scientific land management strategy, increase of investment and transformation of technology. Then the negative correlation between cultivated land area and economic growth can be altered and the performance of farmland protection can be enhanced. Therefore, the relationship between cultivated land resource and technology and capital investment should be focused on in the future research.

**Suggestion:** Economic development inevitably affects cultivated land resources, and mainly includes cultivated land occupation, returning cultivated land to forest, cultivated land degradation. For the above effects, returning farmland to forests belongs to ecological protection of the environment. The land of returning farmland to forests is mostly not suitable for cultivation because these lands have the important ecological functions. Nevertheless, the reduction of these lands affects cultivated land area in a certain of time period, but generally it is conducive to sustainable economic and social development, so from cultivated land resources protection the impact of returning farmland to forest is positive.

At present, cultivated land occupation and cultivated land degradation are the two most important aspects of impact on cultivated land resources in the economic development. Reducing unreasonable cultivated land occupation and protecting cultivated land degradation is the main way to solve the current economic development and cultivated land resources contradictions. For reducing unreasonable cultivated land occupation, there were two effective methods which can be used. The first is to establish an effective incentive mechanism to shift from passive protection of cultivated land to positive protection (Qu 2004), and the other is to increase the cultivated land conversion costs or reduce the cultivated land conversion benefits (Qu 2001). For cultivated land degradation, on the one hand, it is necessary to establish scientific and reasonable monitoring and evaluation system, on the other hand, rely on scientific research and technology to develop and utilize cultivated land, in particular, dispose of the problems of transitional fertilizer use, irrigation, reclamation etc. in agricultural planting and to achieve agricultural clean production and reduce cultivated land degradation caused by human activities.

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