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Full Length Research Paper

Effects of shifting surplus farm labor and grain subsidy on land use in Loess Plateau of Northern Shaanxi Province, China

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This paper analyzed the factors influencing the relationship between population, cultivated land and grain on the shifting of surplus farm labors and providing grain subsidy in the Loess Plateau of northern Shaanxi Province of China. We supposed four scenes about cultivated land pressure index from 1998 to 2008, and introduced Mann-Kendall's non-parametric test method. The results showed that cultivated land pressures assume significant downward trend in Suide, Mizhi, Jiaxian and Zizhou Counties; however, cultivated land pressures in Wubu and Qingjian County are descending with limited effect by shifting of surplus farm labors and providing grain subsidy. The results implied that, the government should guide to further implement the Grain for Green Project.

Key words: Plateau, pressure index, cultivated land, surplus farm labors.

INTRODUCTION

Since the Grain for Green project was implemented in 1999, the accumulative afforested area has been more than 2,667 million ha with more than 4,300 million Yuan invested and one million peasants involved in the project (Zhu, 2003). It has gained outstanding achievements and made a great contribution to the economic development and ecological reconstruction in China. At the same time, it is also a project protecting ecological environment at the expense of grain production. So it invariably influences the relationship between population, arable land use and grain production (Kong, 2007; Wang, 2004). Protecting the forest resources and ecological environment and ensuring food security are two significant subjects of the Chinese government.

Lots of researches on relationship of food security and Grain for Green Project (GGP) have been done from different perspective since 1999; however, the results have been contradictory. On the one hand, some of the results demonstrated that reduction in cropland has little impact on grain production owing to improved per unit area yield (Li, 2001; Zhang, 2004). On the other hand, other studies showed that reduction in croplands influenced grain production significantly, since the reduction of farmlands were too many (Zhong, 2000; He, 2004; Liu, 2007). Generally, these studies paid much attention on the impact of GGP on total yield of grain production with simple quantitative change between cropland decrease and grain yield. However, the processes driving the changes are largely unknown. Studies on the influence of shifting of surplus farm labors and the implementation of grain subsidy on cultivated land are still few, especially on county level and in fragile

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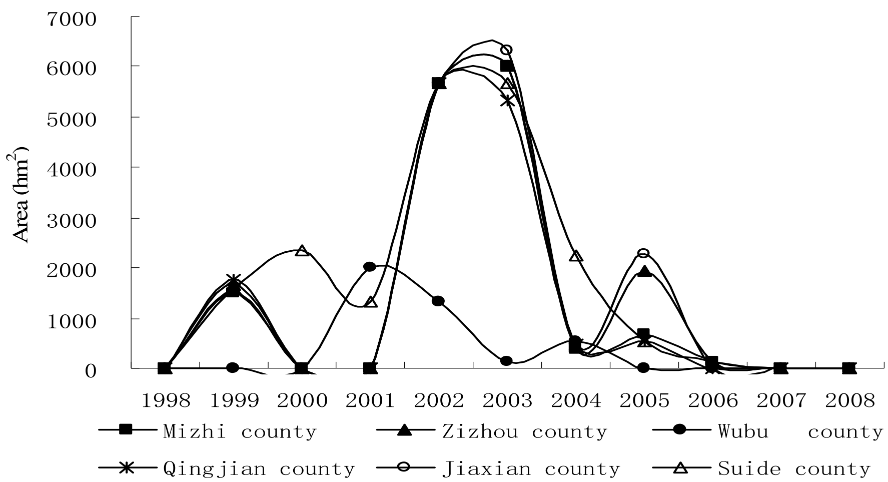

Figure 1. Changes area of conversion of cropland to forest land in Grain for Green.

ecosystems such as the Loess Plateau.

MATERIALS AND METHODS

Study area

The study was conducted in six counties located in the south of Yulin Cit (109° 29' to 110° 47'E, 36° 04' to 38° 23'N) in Northwest China. It has an area of 9434.5 km^2 and a population of 1.5 million. The prevailing climate is of a typical medium temperate and warm temperate climate. The annual temperature ranges from -6 to 11.3℃ and precipitation is between 400 to 600 mm, 70% of which falls from May to September. Vegetation in this area is very sparse. Dominant soils in the study area are cultivated Loessial soils with loose soil texture and less nitrogen, phosphorus and potassium contents (Wang, 1991). Area of soil erosion accounts for 90% of the total land area, and farmland. Slope land with ≧ 15° accounts for 60% of arable land. The farming system is mainly for food, and it is based on traditional methods. The areas of Grain for Green project by 2009 are shown in Figure 1.

According to a report of the State Forestry Administration Bureau, the State Development Planning Commission, and the Ministry of Finance (2002) for every hectare of forest or pasture redeveloped, farmers in the upper parts of the Yangtze River receive 2250 kg of grain every year, while farmers would receive 1500 kg of grain every hectare every year in the upper and middle parts of the Yellow River. This policy is welcomed by most of the farmers (Xu and Cao, 2002).

Data source

The data of the six counties during 1998 to 2008 derive from multiple sources:

(i) The planted areas for vegetation under the GGP collected from yearly cities verification reports on the GGP project;
(ii) The forest resource survey data of Yulin city Forestry Department, PR China;
(iii) Statistical yearbook of six counties from 1998 to 2008; and
(iv) Shared data base of ecological environment in the Loess Plateau from 1950 to 1998 by Institute of Soil Water Conservation, Chinese Academy of Sciences and Ministry of Water Resources (including: population, farmland and per-capita grain output).

Shifting of surplus farm labors

Shifting of surplus farm labors are estimated using Equation (1):

$$Qi=\{(Pi\times Ni) - Nai\times 10000\}/Nyi \quad (1)$$

Where Qi is shifting of surplus farm labor in i year, Pi is the total rural population in i year, Ni is the net income per peasant in i year, Nai is net income in agriculture in i year, Nyi is the average annual net income in per.

Cultivated land pressure index model

Cultivated land pressure index model is used in showing capacity of land resources. Cultivated land pressure index is defined as the ratio of minimum per capita arable land area to actual per capita arable area, and the formula is as follows (Cai, 2002):

$$K = S_{min}/S \quad (2)$$

Where K is cultivated land pressure index; S_{min} is the minimum per capita land area (ha/person), it is the minimum per capita cultivated land area for self-sufficiency in grain production. S is an existing per capital cultivated land area (ha/person). If $K>1$, it indicates that cultivated land resources face remarkable pressure for grain; if $K<1$, it indicates that cultivated land resources have no pressure for grain; If $K=1$, it indicates that cultivated land resources are critical state pressure for grain. S_{min} is dependant on a number of factors using Equation (3):

$$S_{min} = \beta \times \frac{Gr}{P \times q \times k} \quad (3)$$

where, β is a grain self-sufficiency rate in some regions, Gr is the lowest survival grain for one person (kg/person), q is grain yield per unit area (kg/ha), p represents a ratio of grain growing area to the total seeding area, k represents the multiple crop index. Now the remaining task is to assent effects of shifting of surplus farm labors and providing grain subsidy factors on K. The paper considers four scenarios as in Table 1.

Mann-Kendall non-parametric test method

The Mann-Kendall trend test is one of the widely used non-

Table 1. Changes of K under four scenarios.

Scenario 1	Scenario 2	Scenario 3	Scenario 4
$a=0; Qi=0$ $Gr=300$ ha/person; $\beta=1$	$a=0; Qi>0$ $Gr=300$ ha/person; $\beta=1$	$a>0; Qi=0$ $Gr=(300-a)$ ha/person; $\beta=1$	$a>0; Qi>0$ $Gr=(300-a')$ ha/person; $\beta=1$
$k=\frac{S_{\min}}{C_i / P_{total}}$	$k=\frac{S_{\min}}{C_i / (P_{total}-Q_i)}$	$k=\frac{S_{\min}}{C_i / P_{total}}$	$k=\frac{S_{\min}}{C_i / (P_{total}-Q_i)}$
$S_{min}=\beta\times\frac{Gr}{P\times q\times k}$	$S_{min}=\beta\times\frac{Gr}{P\times q\times k}$	$S_{min}=\beta\times\frac{(Gr-a)}{P\times q\times k}$	$S_{min}=\beta\times\frac{(Gr-a')}{P\times q\times k}$

a represents average per capita grain subsidy (kg/person); *Qi* is shifting of surplus farm labors in i year (persons); P_{total} is the total population in i year (persons); *Ci* is cultivated land area (ha); $a'=1500*S_{total}/(P_{total}-Qi)$, S_{total} is the areas of conversion of cropland to forest land in i year (ha).

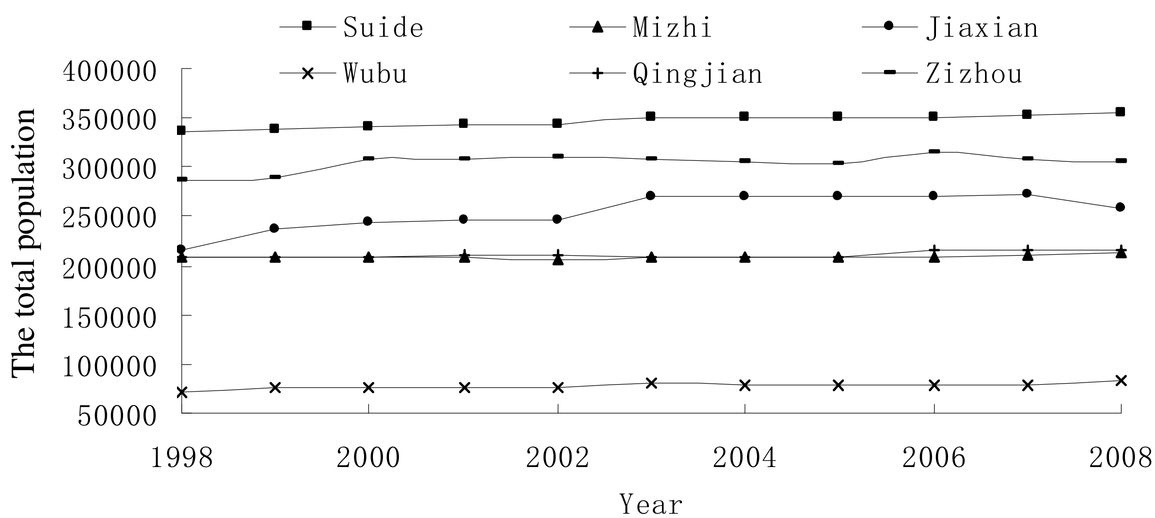

Figure 2. Changes of the total population in six counties.

parametric tests to detect significant trends in time series. The Mann-Kendall trend, being a function of the ranks of the observations rather than their actual values, is not affected by the actual distribution of the data and is less sensitive to outliers. On the other hand, parametric trend test although more powerful, require the data to be normally distributed and are more sensitive to outliers. The Mann-Kendall test, as well as other non-parametric trend tests, are therefore more suitable for detecting trend test, and is therefore more suitable for detecting the trend of *K* in four scenarios from 1998 to 2008.

RESULTS

Population

Figure 2 shows that the average total population growth rate was 5.1, 2.9, 17.9, 15.5, 3.6 and 6% in Suide, Mizhi, Jiaxian, Wubu, Qingjian and Zizhou County from 1998 to 2008, respectively. The population density was divided into three layers during 1998 to 2008: 170～190 people/ km^2 in Suide, Mizhi and Wubu, 140～160 people/ km^2 in Zizhou, 110～120 people/ km^2 in Jiaxian and Qingjian. Though, the United Nations indicated that population density in the semiarid area in 1997, should not surpass 20 people/ km^2.

Shifting of surplus farm labor

The average shifting of surplus labors increased by 22.6, 15.5, 152, 8.1, 7.6 and 8.9% in Suide, Mizhi, Jiaxian,

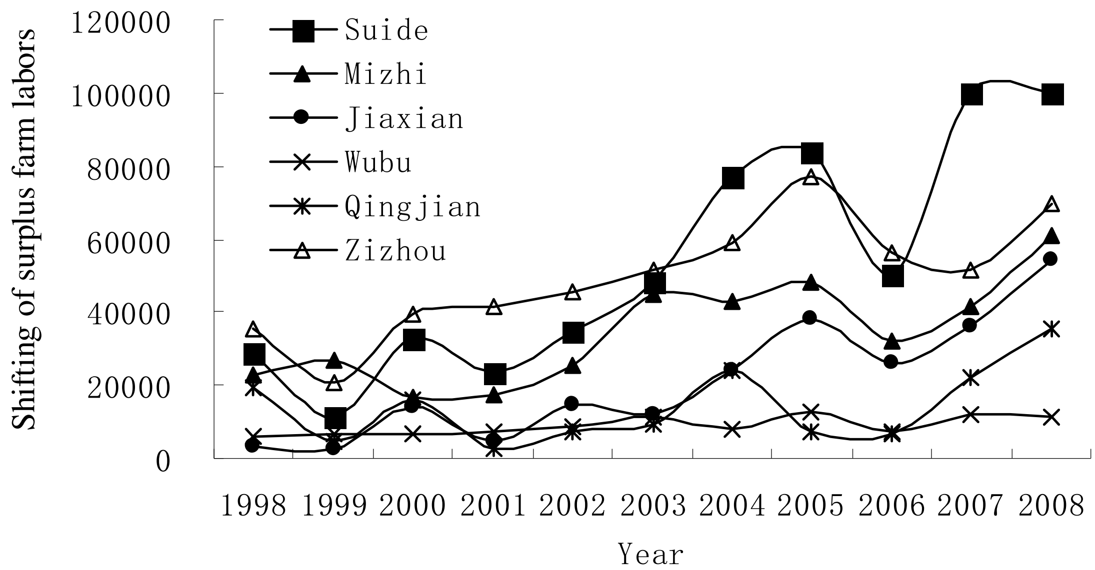

Figure 3. Changes of shifting of surplus farm labors in six counties.

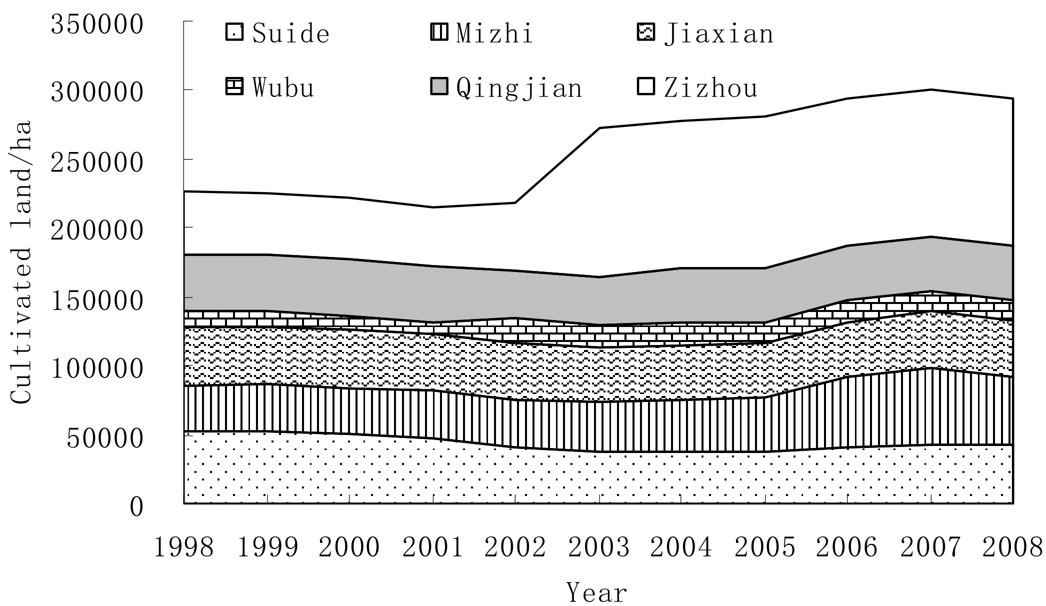

Figure 4. Changes of cultivated land in six counties.

Wubu, Qingjian and Zizhou Counties during 1998 to 2008, respectively. These changes show an increasing trend of shifting of surplus labor (Figure 3). Shifting of surplus labors were influenced by population growth and land use changes, and so on.

Cultivated land

There were variations in the changes of cultivated land in the six counties (Figure 4). The average cultivated land reduced at the rate of 1.6, 0.4 and 5.2% in Suide, Jiaxian and Qingjian from 1998 to 2008, respectively. However, the average growth rates of cultivated land were 4.3, 3.1 and 12% in Mizhi, Wubu and Zizhou from1998 to 2008, respectively. Apparently, a number of cultivated lands were converted to forest land or grassland since 1999. Nevertheless, cultivated land enlarged mainly based on “tree-crop” intercropping (it is considered as cultivated lands to grow crop under trees) model (Wang, 2007), the

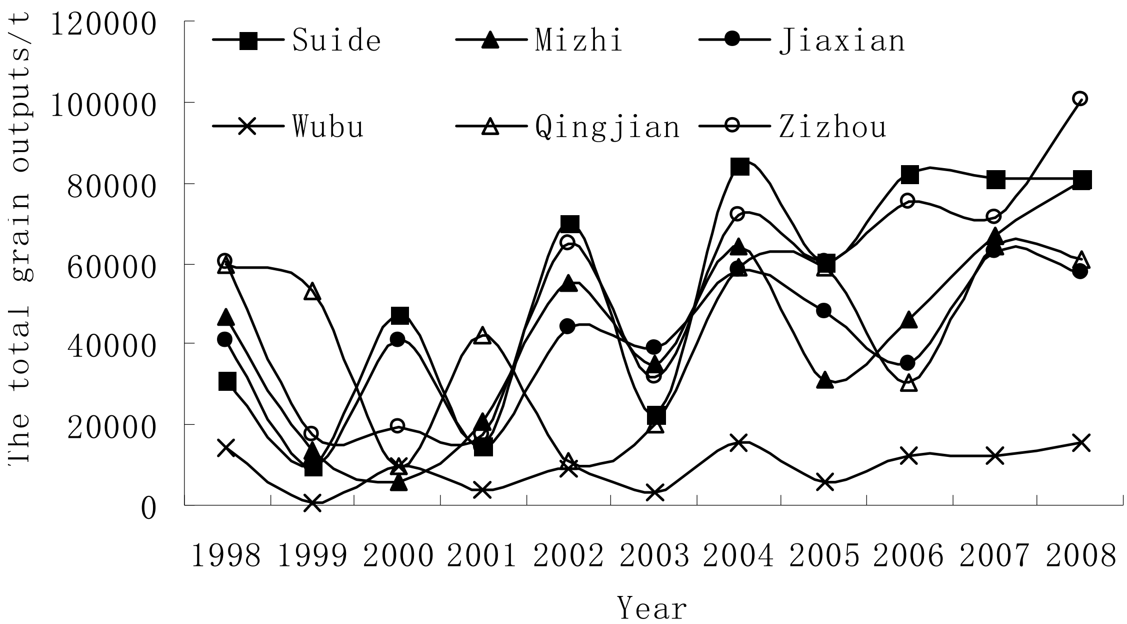

Figure 5. Changes of the total grain outputs in six counties.

fear is that the act of tree-crop is forbidden by government owing to curtailing function of forest for soil and water conservation; but some researches indicated that tree-crop may be feasible to some extent (http://www.stats.gov.cn).

The total grain outputs

Dynamic changes of the total grain outputs varied in the six counties during 1998 to 2008, but these changes posed increasing trend as a whole from 1998 to 2008 (Figure 5). The average total grain outputs growth rate was 159, 72.2, 41.9, 10.9, 1.6 and 66.3% in Suide, Mizhi, Jiaxian, Wubu, Qingjian and Zizhou counties from 1998 to 2008, respectively. This accounted for a higher per unit area yield level. However, the total grain output was very low in 2000 and 2001 probably as a result of drought disaster.

CULTIVATED LAND PRESSURE

For Suide county, as may be seen from Figure 6 and Table 2, the values of *Z* by Mann-Kendall non-parametric test were lower than 0 in *K* under four scenarios from 1998 to 2008. This indicates that changes in *K* show a downward trend under the four scenarios. The order of downward trend under the four scenarios were 4 > 2 > 3 = 1. *Qi* was greater than *a* in making *K* more in a downward trend. Only *a* factor was not obvious in making *K* downward trend. Sudden-change points of *K* were 2002 and 2006 under four scenarios (Table 2), because the total grain outputs in 2002 and 2006 were higher than others years, as well as *Qi* were the greatest in 2006 than others. This indicated that, the effect of downward trend of *K* was significant by *Qi* more than *a* factor. For Mizhi county, the values of *Z* were lower than 0 in *K* under four scenarios in Mizhi county from 1998 to 2008, which indicated that changes of *K* show a downward trend under four scenarios, as well as the order of downward trend under four scenarios were scenarios 4 > scenarios 3 > scenarios 2 > scenarios 1 (Figure 6 and Table 2). For the role of *Qi* and *a* factors, a was greater than *Qi* in making *K* downward trend. Only *a* factor was obvious in making *K* downward trend.

Sudden-change points of *K* were 2004 and 2006 under four scenarios (Table 2), because the total grain outputs in 2004 and 2006 were higher than other years, as well as *Qi* were greater in 2006 than others. This indicated that the effect of downward trend of *K* was nearly equal by *Qi* and *a* factor. For Jiaxian county, the values of *Z* were lower than 0 in *K* under the four scenarios from 1998 to 2008, indicating that changes of *K* show a downward trend, with the order of downward trend being scenarios' 4 > 3 > 2 > 1(Figure 6 and Table 2). Only *a* factor was obvious in making *K* downward trend. Sudden-change points of *K* were 2004 and 2007 under four scenarios (Table 2), because the total grain outputs in 2004 and 2007 were higher than other years, as well as *Qi* was the greatest in 2007 than others.

This indicated that the effect of downward trend of *K* was significant by *Qi* more than *a* factor. For Wubu County, the values of *Z* were lower than 0 in *K* under four scenarios from 1998 to 2008, which indicates that changes of *K* show a downward trend under the scenarios.

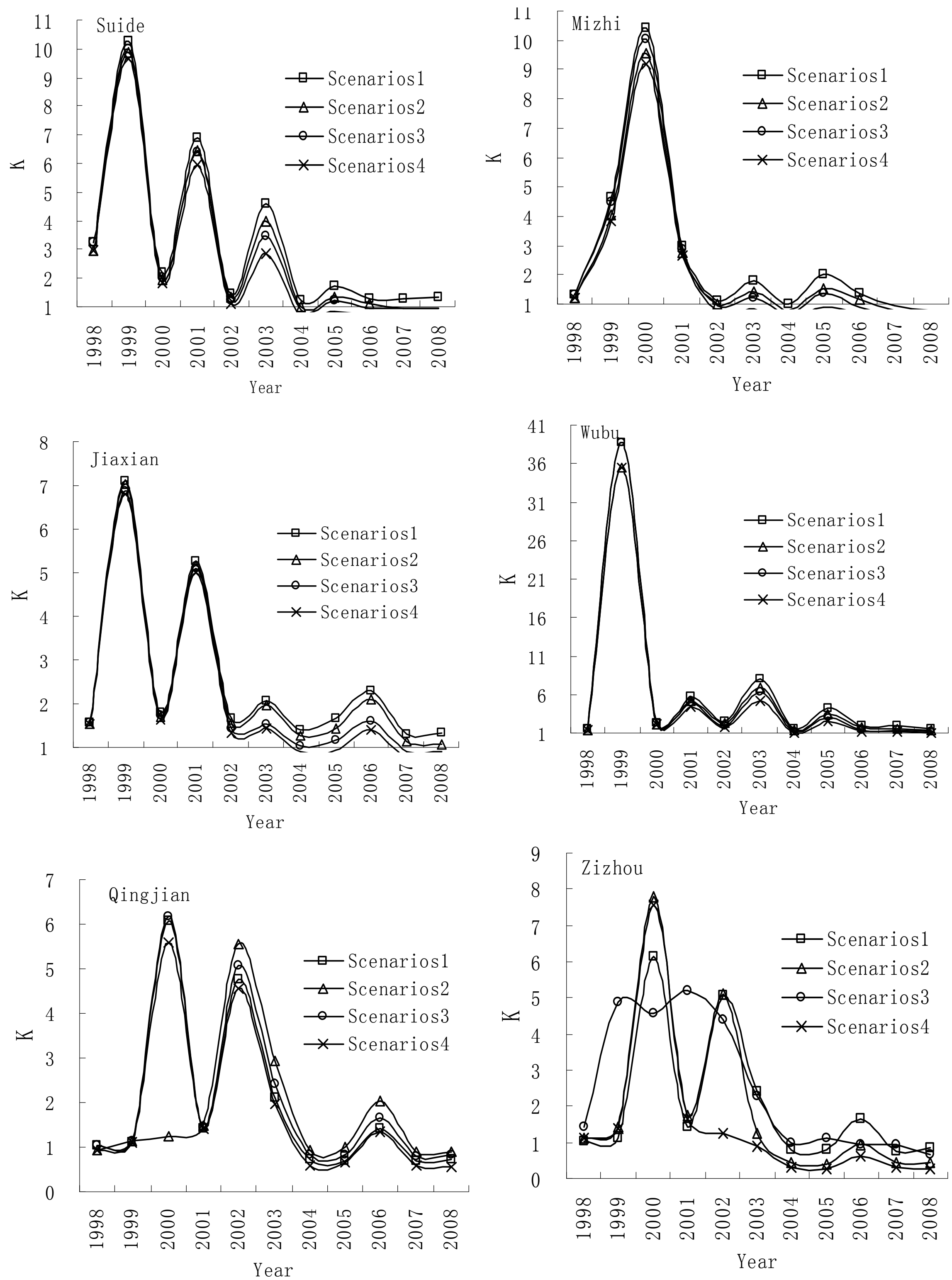

Figure 6. Changes of *K* under four scenarios.

The order of downward trend were scenarios 4 > 3 > 2 > 1 (Figure 6 and Table 2). For the role of *Qi* and *a* factors, a was greater than *Qi* in making *K* downward trend. Only a factor was obvious in making *K* downward trend. Sudden-change points of *K* were 2004 and 2006 under four scenarios (Table 2), because the total grain outputs

Table 2. Cultivated land pressure index in six counties by M-K test during 1998-2008.

		Scenarios 1	Scenarios 2	Scenarios 3	Scenarios 4
	Z	-2.02	-2.8	-2.02	-2.96
Suide	Sudden-change	2002	2006	2002	2006
	Significance	*	2006**	*	2006**
	Z	-2.18	-2.34	-2.65	-2.80
Mizhi	Sudden-change	2006	2006	2004, 2006	2004, 2006
	Significance	*	*	2007**	2007**
	Z	-1.56	-1.87	-2.49	-2.80
Jiaxian	Sudden-change	2004, 2007	2007	2004, 2007	2004
	Significance			*	2007**
	Z	-0.78	-1.25	-1.56	-1.87
Wubu	Sudden-change	2007	2007	2004, 2006	2007
	Significance				
	Z	-0.78	-0.14	-1.25	-1.71
Qingjian	Sudden-change	2004, 2006	2007	2004, 2006	2007
	Significance				
	Z	-1.25	-2.18	-2.80	-2.65
Zizhou	Sudden-change	2004, 2006	2004, 2006	2005	2004
	Significance		*	2007**	2007**

If Z<0, it represents the trend to descend, as well as the smaller Z, the more significant the trend descended. Otherwise, the results were exact opposite. Sudden-changing points represent corresponding years. * represents significance at P<0.05, and ** represents significance at P<0.01. The figure represents certain year under * or **.

in 2004 and 2006 were higher than other years, as well as *Qi* was greater in 2006 than others. This indicated that, the effect of downward trend of *K* was nearly equal by *Qi* and *a* factor.

For Qingjian County, the values of *Z* were lower than 0 in *K* under four scenarios from 1998 to 2008, which indicated that changes of *K* show downward trend under four scenarios. The order of trend was scenarios 4 > 3 > 2 > 1 (Figure 6 and Table 2). For the role of *Qi* and *a* factors, *a* was greater than *Qi* in making *K* downward trend. Only *a* factor was obvious in making *K* downward trend. Sudden-change points of *K* were 2004 and 2006 under four scenarios (Table 2), because the total grain outputs in 2004 and 2006 were higher than other years, as well as *Qi* were the greater in 2006 than others. This indicated that the effect of downward trend of *K* was nearly equal by *Qi* and *a* factor.

For Zizhou County, the values of *Z* were lower than 0 in *K* under four scenarios from 1998 to 2008, which indicated that changes of *K* show a downward trend under the four scenarios. The order of downward trend was scenarios 3 > 4 > 2 > 1(Figure 6 and Table 2). For the role of *Qi* and *a* factors, *a* was greater than *Qi* in making *K* downward trend. Only *a* factor was obvious in making *K* downward trend. Sudden-change points of *K* were 2004, 2005 and 2007 under four scenarios (Table 2), because the total grain outputs in 2004, 2005 and 2007 were higher than other years, as well as *Qi* was the greatest in 2004, 2005 and 2007 than others. This indicated that the effect of downward trend of *K* was significant by *Qi* more than *a* factor.

DISCUSSION

Scenarios 1 indicated that advances of science and technology increased higher land productivity through the application of more chemical fertilizer, pesticide, and covering polyethylene film (Tao, 2003). The activity in scenarios 1 therefore, reduced *K* value though values were kept at less than 1 unit. Influenced by farmland quality, population density, and natural conditions (Luo, 2005), there were high regional differences for the *K* values in the study counties. The extreme high values during 1998 to 2008 probably resulted from drought disaster in the counties (statistical yearbook of six counties). Cultivated land pressure index is one of the major factors reflecting land-bearing capacity.

The ecological construction projects, such as returning cropland for farming to forestry in ecological fragile region meet double challenges in terms of grain security and ecological security (Liu, 2006). The population, cultivated land and grain production are constrained by lots of factor. It is therefore necessary to implement complete set of policies, such as providing grain subsidy to the farms for their conversion of cropland to forest land or grassland, and shifting of surplus farm labors by training government organizations (Chen, 2009). The high pressure of population on cultivated land in the ecological fragile regions was the main reason for undue cultivated lands, also can be attributed to frequently irrational human activities. The birth control policy should be continually implemented in rural areas to improve population quality. In addition, typical dry farming characterizes the study counties, and farm land irrigation is very limited. Therefore, farmland protection and infrastructure construction are also required to resist drought for higher grain productivity capacity.

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