Study on Farmland Use Change and Driving Force in the High and Cold Areas in Northwest Yunnan——A Case Study of Ninglang Yi Autonomous County

LUO Li[1*], YANG Zi-sheng[1], KANG Yun-hai[1,2]

1. Land Resources and Sustainable Development Institute, Yunnan University of Finance and Economics, Kunming 650221, China; 2. Yunnan Academy of Social Sciences, Kunming 650034, China

Abstract On the basis of overview of the study area, by analyzing the dynamic change of farmland in Ninglang County, we can find that the farmland area in this county tended to decrease from 1996 to 2008. According to the investigation data concerning land change provided by Bureau of Land and Resources in Ninglang County and socio-economic data provided by Bureau of Statistics in Ninglang County, we select 11 indices, such as total population, GDP, total output value of county and so on, coupled with SPSS statistical method, we adopt principal component analysis method to analyze driving force factors of farmland use change in the high and cold areas in Northwest Yunnan. The results show that the two factors of economic development and population growth are the dominant driving factors impacting farmland use change, and the policy factors, such as "returning farmland to forests", are also the important driving factors impacting Ninglang County.

Key words Changes of farmland, Driving force, Principal component analysis, Ninglang County, China

Along with the outstanding problems of "population-resources-environment" and quickened process of urbanization, land use and land-cover change (LUCC) become the research focus and hot topic of scholars at home and abroad increasingly[1-3]. Farmland is the most important type of regional land use change, whose dynamic change impacts directly existence and development of human[4]. At present, there are many LUCC and the driving factors and processes, and some scholars are conducting exploratory work and achieve beneficial results on the basis of theoretical basis and research method[5-6]. From different perspective, China's scholars also conduct profound research on farmland change. For example, Yang Guishan researches the process and driving mechanism of farmland amount change over 5 decades in Yangtze River delta; Zhang Fengrong conducts analysis on quantity and quality change of China's farmland; Wang Jianlin researches relevant analysis on farmland and population change in Tibet over 2 decades.

Northwest Yunnan is the typical cold and high area with mountain and valley. Due to scanty farmland resources, increasing development of society and economy in the recent years, sharp mushrooming of population, urban construction and policy of returning farmland to forests, plenty of farmland resources are occupied. In addition, the soil erosion deteriorates increasingly and farmland decreases incessantly. Taking Ninglang Yi Autonomous County in cold and high area as an example, the thesis conducts quantitative analysis on dynamic change and driving force of farmland in this area, which is not only conducive to fathoming relationship between farmland change and human activity in Ninglang Yi Autonomous County, realizing sustainable use of farmland, and coordinating the relationship between farmland protection and socio-economic development.

Received: February 6, 2011 Accepted: March 26, 2011
Supported by The National Natural Science Foundation of China (40861014).
* Corresponding author. E-mail: lili65430@yahoo.com.cn

1 Overview of study area

Ninglang Yi Autonomous County, located in the conjunction of Northwest Yunnan and Sichuan, adjacent to Yanbian County and Yanyuan County of Sichuan Province on the east, facing each other across the river with Yulong County westerly, adjacent to Yongsheng County and Huaping County on the south, bordering on Muli County of Sichuan Province on the north, spanning 100°21′ -101°16′ E, 26°35′ -27°56′ N, is the typical mountain landscape with topography of high northwest and low southeast. The highest altitude is 4 510.3 m, the lowest altitude is 1 350 m, and the difference of the highest altitude and the lowest altitude reaches 3 160.3 m. The climate of this county is low-latitude plateau monsoon climate, with distinct dry season and wet season. Impacted by the topography of plateau, mountain and valley, the three-dimensional climate is outstanding.

Ninglang Yi Autonomous County is agricultural county in cold and high area with few people and considerable land. The whole county has 15 villages, 1 town, 86 village committees, 5 communities, 1122 villager groups, 32 resident groups. It has 12 ethnic groups, such as Yi, Han, Mosuo and so on, and the population of minorities accounts for 78% of total population. In 2008, the total population in this county reached 0.256 million, with population density of 42 people/km^2 and population natural growth rate of 4.20%. the agricultural population is 0.23 million, accounting for 89.84% of total population. In 2008, the per capita grain output in whole county was merely 277.4 kg, and farmers' per capita net income was 1 614 yuan, far below the average of

Yunnan Province and China, so it is state poverty county.

2 Analysis of farmland area change

According to the survey data of farmland change from 1996 to 2008 in Ninglang Yi Autonomous County, at the end of 1996, the farmland area in Ninglang Yi Autonomous County was 71 120.7 hm^2, while at the end of 2008, the farmland area decreased to 65 545.3 hm^2. During the years from 1996 to 2008, the farmland area decreased by 5 575.38 hm^2 and decreased by 7.8% in the aggregate. In this period, the biggest change is from 2002. It decreases gradually from 69 710.03 hm^2. As of 2008, it decreased by 4 164.75 hm^2 and decreased by 6% in the aggregate. The land types with relatively prominent decrease of farmland area are mainly terrace land and dry land (Table 1). From 1996 to 2008, the terrace land decreased by 121.79 hm^2, while dry land decreased by 5 437.95 hm^2. The sloping field and swidden decreased and the terrace land increased. In the light of the analysis of gradual decrease of farmland area and amount, the reason lies in that the project of returning farmland to forests from 2002 makes the farmland area decrease accordingly; in addition, the deterioration of ecological environment factors is one of the important reasons. In cold and high area of Ninglang, the farmland is mainly sloping farmland. In the recent years, the frequent rainstorm and heavy rain in county deteriorate the phenomenon of soil erosion in this county and destroy considerable farmland.

Table 1 Increase or decrease amount of various types of land in from 1996 to 2008 hm^2

Year	Level farmland	Terrace	Fields on hill tops which depend on rains for water	Irrigable land	Dry land				Vegetable plot
					Level dry land	Sloping fields	Terrace land	Swidden	
1996	2 493.5	2 449.7	31.9	2 077.7	745.5	35 388	2 836	25 087.2	11.7
2008	2 485.2	2 328	31.5	2 071.2	742.7	34 994	3 475	19 407	11.3
Net Increase or decrease	−8.3	−121.7	−0.4	−6.5	−2.7	−394	639	−5 680.2	−0.4

Note: " +" is net increase, and " −" is net decrease.

3 The driving factors analysis of farmland use change

3.1 Data source, research method and index selection

3.1.1 Data source. The statistical data of land area is the survey data of land change provided by Land Resources Bureau of Ninglang County, and the socio-economic data is provided by Statistical Bureau of Ninglang County.

3.1.2 Index selection. According to the existing data of Ninglang County, 11 influencing factors are selected: X_1 is total population of whole county, X_2 is GDP, X_3 is total output value of industry of whole county, X_4 is total output value of agriculture, forestry, husbandry and fishing, X_5 is the total output value of tertiary industry, X_6 is total output of grain, X_7 is urbanization rate(%), X_8 is per capita farmers' net income, X_9 is total fixed assets in whole society, X_{10} is per capita grain output, and X_{11} is natural growth rate of population.

3.1.3 Research method. In order to know the dynamic change of farmland in Ninglang County and analyze driving factors of farmland change, we conduct analysis on temporal-spatial change characteristics of farmland from 1996 to 2008, use relevant model to discuss temporal-spatial change degree of farmland, and use principal component analysis method to analyze driving factors of farmland change.

3.2 The analysis of farmland use change based on principal component analysis Farmland is the complex integrating nature, society and economy. Certain land use type is related with change of natural and socio-economic factors[7−9]. The relatively stable natural factors have little impact on farmland change, while due to the rapid change and development, the socio-economic factors have strong impact on farmland change. In the light of the impact of socio-economic factors on amount of farmland, it is divided into factors of increasing farmland (such as reclamation) and factors of decreasing farmland (such as urbanization, basic construction and returning farmland to forests). As these factors have coupling relations, if we use simple correlation analysis, it is bound to have certain redundance error[10]. The principal component analysis method can transform many former indices into several indices. These indices not only can reflect the information of former indices as much as possible while they are independent from each other, but also can condense several independent variables into several independent components so as to abate the mutual interference among independent variables[11−12]. Using principal component analysis method is suitable for analyzing driving force of farmland change.

3.2.1 The relevant matrix of driving factors. According to the existing data of all indices in Ninglang County from 1996 to 2008, we use SPSS17.0 to conduct analysis and calculation, so that we get relevant matrix, eigen value, contribution rate of principal component, cumulative contribution rate and matrix of principal component of driving factors of farmland change in Ninglang County (Table 2). From Table 2, there is correlation with different degree among selected indices. For example, X_1 has high degree correlation with X_2, X_5 and X_8, and the relevant coefficient is 0.967, 0.978 and 0.952 respectively; so, in order to quantitatively research contribution of all factors and mutual relations, it is necessary to conduct principal component analysis on these influencing factors.

3.2.2 The eigen value, contribution rate of principal component and matrix of principal component. From Table 3, in the variable correlation matrix, there are two characteristic roots bigger than 1, namely 8.076 and 1.577, and the corresponding cumulative contribution rate of first principal component and second principal component reaches 87.752%, bigger than cumulative contribution rate of 85% the principal component requires, which can fully summarize the information expressed by most of data. From the matrix of principal component (Table 4), we can find that X_1, X_2, X_3, X_4, X_5, X_6 and X_7 have great correlation with the first principal component, and the factor

load is above 0.9. These factors represent total population in whole county, GDP, total output value of industry in whole county, total output value of agriculture, forestry, husbandry, and fishing, total output value of the tertiary industry, total output of grain and urbanization rate respectively, indicating that the first principal component mainly concentrates on indices of economic development level, which can be generalized as economic development factors; the second principal component has big load on X_{10} and X_{11}, while they represent per capita grain output and natural growth rate of population respectively. The second principal component mainly reflects that population factor is one of the driving factors of farmland area change. So, economic development and population factor are the dominant factors impacting farmland change in Ninglang County.

Table 2 Correlation matrix of driving force factors regarding farmland change

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X9	X_{10}	X_{11}
X_1	1.000										
X_2	0.967	1.000									
X_3	0.926	0.982	1.000								
X_4	0.912	0.983	0.980	1.000							
X_5	0.978	0.996	0.972	0.966	1.000						
X_6	0.569	0.582	0.574	0.621	0.568	1.000					
X_7	0.418	0.460	0.520	0.519	0.409	0.254	1.000				
X_8	0.952	0.988	0.976	0.965	0.992	0.530	0.397	1.000			
X_9	0.795	0.915	0.926	0.954	0.892	0.525	0.488	0.916	1.000		
X_{10}	0.111	0.145	0.159	0.223	0.122	0.881	0.068	0.091	0.173	1.000	
X_{11}	−0.906	−0.854	−0.775	−0.790	−0.869	−0.601	−0.193	−0.842	−0.649	−0.203	1.000

Table 3 The eigen value and contribution rate of principal component of all factors

Principal component	The eigen value	Contribution rate//%	Cumulative contribution rate//%
1	8.076	73.418	73.418
2	1.577	14.334	87.752
3	0.894	8.126	95.878
4	0.340	3.089	98.967
5	0.072	0.655	99.622
6	0.023	0.213	99.835
7	0.013	0.120	99.955
8	0.004	0.039	99.994
9	0.000	0.004	99.998
10	0.000	0.002	100.000
11	2.320E-05	0.000	100.000

Table 4 The matrix of principal component

Variable	The first principal component	The second principal component
X_1	0.984	0.170
X_2	0.982	0.116
X_3	0.980	0.153
X_4	0.969	0.170
X_5	0.959	0.233
X_6	0.951	0.155
X_7	0.905	0.165
X_8	−0.816	−0.267
X_9	0.503	0.024
X_{10}	−0.021	0.995
X_{11}	0.437	0.897

3.2.3 The analysis of calculation results. From the preceding analysis of data, economic development and population growth have significant impact on farmland change of Ninglang County. Since the 1980s, the economic strength of Ninglang County has grown rapidly, and the per capita GDP tends to increase in the recent years. Economic development and population increase is bound to increase land demand and make agricultural use land in the periphery of city change into construction use land, while the agricultural use land in the periphery of city is often the farmland with high quality; in addition, human is one of driving factors of land use and land-cover change with greatest vitality. The faster the population grows, the faster the land use changes, so population plays significant role in farmland change[9]. Increase of population will cause increased demand of people's residential use land and construction use land, while the demand, in a large measure, is answered by changing function of farmland.

Table 5 Information about returning farmland to forests

Year	2002	2003	2004
Area of farmland//hm^2	69 710.03	66 575.59	65 634.13
Area of returning farmland to forests//hm^2	1 000	2 800	1 333.3
The proportion in farmland area//%	1.43	4.21	2.03

Data source: Office of Returning Farmland to Forests, Forestry Bureau of Ninglang County.

In addition, apart from the foregoing two dominant driving factors, there are also important factors impacting farmland area change in Ninglang County (Table 5). Since 1999, China has implemented strategy of Development of the West Regions and policy of "returning farmland to forests", which exerts great influence on Ninglang County. At the end of 1996, the farmland area was 71 120.66 hm^2, while at the end of 2008, the farmland area decreased to 65 545.28 hm^2. It decreased by 5 575.38 hm^2 over 12 years. As can be seen in Table 5, in 2002, the area of returning farmland to forests was 1 000 hm^2, accounting for 1.43% of farmland area in 2002, while it increased to 2 800 hm^2 in 2003, accounting for 4.21% of farmland area in 2003. In 2004, the area of returning farmland to forests was 1 333.3 hm^2, accounting for 2.03% of farmland area in 2003. From farmland area decrease in Table 1, we can find that the decreased land types are terrace land, sloping land, and swidden, while the amount of planted land increases accordingly. So, the decreased land types in the recent years are mainly terrace land, sloping land and swidden.

4 Conclusion and discussion

Firstly, since a decade, the farmland area tends to decrease, and it decreased by 5 575.38 hm^2 in the aggregate and decreased by 7.8%. The period with biggest change was from 2002, and it began to decrease gradually from 69 710.03 hm^2. It decreased by 4 164.75 hm^2, and decreased by 6% in the aggregate as of 2008. In the light of annual change rate, the years from 1996 to 2002 are the period of slow decrease; the years from 2002 to 2003, it had the biggest decrease degree; in 2003, it was −0.491 6%, decreasing by 0.339 0%; after 2003, it tended to decrease slowly; in 2008, the dynamic degree of farmland was −0.603 0%.

Secondly, by principal component analysis, the driving forces impacting farmland use change in Ninglang County can be classified as factor of economic development and factor of population. Taking into single factor is in that population increase causes increased demand of farmland and impact on GDP, the secondary industry and the tertiary industry.

Thirdly, in addition to the analysis of driving mechanism of farmland use change in Ninglang County from the influencing factors of population, economic development and so on. The policy factor also has significant impact on farmland area change. For instance, the policy of returning farmland to forests in the recent years has significant influence on farmland area change in Ninglang County and even Yunnan Province, and this policy is the important reason of farmland decrease in this area.

References

[1] WANG XL. A research on the change of agricultural land use and impact on rural sustainable agricultural development in Hulunbeier distract based on the remote sensed data[J]. Progress in Geography, 1999, 18(4): 322 −329. (in Chinese).
[2] GEIST H. An overview of research projects 1997 −2001[J]. LUCC Newsletter, 2001(6): 1 −3.
[3] XIE XP, ZHOU J. Study on prediction of land use/cover change: a case study in the Xi'an region[J]. Arid Zone Research, 2008, 25(1): 125 −130. (in Chinese).
[4] XU YQ, LI XB. Analysis of dynamic change and driving forces of farmland in Hebei Province[J]. Resources Science, 2001, 23(5): 29 −32. (in Chinese).
[5] TURNERII BL, SKOLE D, SANDERSON S, *et al*. Land-use and land cover change science/research plan[R]. Stockholm: IGBP, 1995.
[6] GU CL. Study on phenomena and mechanism of land-use/over change in Beijing[J]. Nature Resource, 1999, 14(4): 307 −312. (in Chinese).
[7] ZHOU BZ, ZHAO QG, YANG H. Study on the change of cultivated land and its regulation countermeasure in Jiangsu Province[J]. Acta Pedologica Sinica, 2003, 40(5): 665 −671. (in Chinese).
[8] SHAO XM, YANG QY, ZHANG HY. A study on trend and driving forces of cultivated land use change in Shandong Province[J]. Geographical Research, 2001, 20(3): 299 −306. (in Chinese).
[9] HUANG NS. Macro-driving mechanism for changes in cultivated land area in Guangdong Province, China[J]. Earth Science-Journal of China University of Geosciences, 1999, 24(4): 359 −362. (in Chinese).
[10] ZHANG Y, LIU SY, WANG J, *et al*. Study on the change of cultivated farmlands and its driving factors in Aksu Prefecture, Xinjiang [J]. Arid Land Geography, 2004, 27(2): 228 −233. (in Chinese).
[11] WEI HY, LIU X. The application of SPSS10. 0forWindOWS in the economic management[M]. Beijing: China Statistics Press, 2000: 245 −248. (in Chinese).
[12] LI CZ, LIU XN, CAO SL, *et al*. Contrastive research on relationship between ante −precipitation and sediment yield of watersheds with different sediment supply[J]. Journal of Soil and Water Conservation, 2001, 15(6): 37 −38. (in Chinese).

(From page 78)

between the two as follows: on one hand, China's farmland decreases rapidly, which makes the state formulate a series of farmland protection policies; on the other hand, due to the formulation of farmland protection policies, the tendency of farmland decrease is arrested to some extent. Although currently China's farmland tends to decrease, but the decrease speed and amplitude are allayed. The conclusion is basically consistent with the predecessor's research accomplishments, indicating that this method has high reliability and provides new theoretical instrument for future deep research.

3.2 Policy suggestions The conclusion of research indicates that in the system of "farmland quantity change-farmland protection policy", the interaction between farmland quantity and farmland protection policy is merely a part of system contradiction, and it cannot be neglected that the farmland quantity and farmland protection policy are impacted by their own brunt. Consequently, in order to solve contradiction between farmland quantity and farmland protection policy, we should formulate long-term strategy and adopt diverse measures. This means that strengthening research on farmland protection policy, reinforcing formulating degree of farmland protection policy, strengthening supervision of policy implementation and perfecting policy are also the important means to solve farmland problems.

References

[1] ZHU HB. Analysis on the effect and efficiency of policies operation to cultivated land protection in China[J]. Geography and Geo-Information Science, 2007, 23(6): 50 −53. (in Chinese).
[2] HUANG XH. Land management in new China[M]. Beijing: Contemporary China Publishing House, 2006. (in Chinese).
[3] ZHANG B. Study on the performance evaluation of farmland protection policy in China[D]. Nanjing: Nanjing University, 2005. (in Chinese).
[4] ZOU P. Financial econometrics[M]. Shanghai: Shanghai Finance and Economics University Pres, 2005: 120 −128. (in Chinese).
[5] GUJARATI. Basic econometrics[M]. 3rd ed. Translated by LIN SG. Beijing: Renmin University of China Press, 2000: 7 −8. (in Chinese).
[6] QU WX, HUANG XJ. Analysis on the effect of policies operation of cultivated land protection in China[J]. China Land Science, 2003, 17(2): 8 −13. (in Chinese).
[7] SUN Y, JIN XB, ZHANG YP, *et al*. Multi-time scale analysis on fluctuation of the acreage of cultivated land and its driving forces a case study of Jiangsu Province[J]. Acta Pedologica Sinica, 2008, 45(5): 964 −970. (in Chinese).