Spatial Pressure Distribution of Cultivated Land and the Analysis of Food Safety in Kunming City, China

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Abstract The social and economical condition, cultivated land resources and general situation of grain production of research area are introduced. According to relevant data of cultivated land of Kunming City in 2006, taking the minimum per capita cultivated land and index model of cultivated land pressure, and combining with two conditions of per capita grain demand which are 300 kg and 400 kg, the comparative research method was used to calculate and analyze the minimum per capita cultivated land and index model of cultivated land pressure. The results show that when per capita grain demand-Gr is 300 kg, the per capita cultivated land in Kunming City has regional differences, reflects different regular patterns of spatial distribution, and presents obvious and typical radial distribution. Urban area of Kunming has the lowest point and be taken as the center, per capita cultivated land decreases progressively from suburban to the periphery; when per capita grain demand-Gr is 400 kg, under the same consumption level, cultivated land pressures of each county in Kunming City are different, and so are the driven factors; when per capita grain demand-Gr is 300 kg or 400 kg, the indexes of cultivated land pressure in Kunming are all greater than 1, cultivated land pressure is enormous, the indexes of cultivated land pressure of each county (district) have two conditions-greater than 1 and less than 2, and the reasons differ from one another. Combining with the spatial distribution characteristics of the cultivated land and food and the situation of industrial development, the countermeasures and suggestions are put forwarded to make full use of back-up cultivated land, to plan the distribution of industrial structure in each county (district) of Kunming City as a whole, to dispose cultivated land resources reasonably and so on.

Key words Food safety, Index model of cultivated land pressure, Minimum per capita cultivated land, Regular pattern of spatial distribution, China

China is being in a transformation period that is from planned economy to market economy and from agricultural society to industrial society. Just like many great turning points in history are related to land issues, many present social contradictions are reflected by land issues, and particularly focus on non-agricultural land use will further increase inevitably due to rapid development of economy and progress of urbanization and industrialization[1]. Consequently, we are in a dilemma between "grain demand" and "cultivated land protection". As a matter of fact, not only state grain safety, ecological safety, and ensuring land demand for construction are related to cultivated land, a series of social issues are reflected in the process of cultivated land transformation[1]. Grain safety is the important guarantee of economic safety and political safety, and also the important guarantee of achieving leapfrog development of national economy and society. The great problem at the present stage is how to adjust measures to local conditions aimed at the particular case of a certain district so as to resolve the contradiction between food and construction, that is, neither let the urbanization and industrialization occupy farmland endlessly nor absolutely protect cultivated land which may influence the progress of urbanization, industrialization and ecological reconstruction[2-3]. Therefore, through analyzing the change of population, cultivated land and grain and the features of per capita resource in Kunming City, the paper uses minimum per capita cultivated land and cultivated land pressure index to fix the threshold of cultivated land protection, analyzes and discusses the factors of cultivated land change in Kunming City and its influence to grain safety, so as to explore the effective way of "guarantee cultivated land and construction both".

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1 General situation of research area

1.1 Social and economic condition In 2006, Kunming City had 5 municipal districts—Wuhua, Panlong, Guandu, Xishan and Dongchuan, 8 counties—Chenggong, Jinning, Fumin, Yiliang, Songming, Shilin Yi nationality autonomous county, Luquan Yi and Miao nationality autonomous county, Xundian Hui and Yi nationality autonomous county, 99 townships (towns), 38 street offices. The total area was 21 011 km^2. Permanent resident population of the city was 6.193 3 million, registered permanent resident population is 5.177 0 million, and non-agricultural population took 41.56% of the total population; the population of minorities took 13.48% of total permanent resident population. The natural growth rate of population is 6.02‰. By the end of 2006, total employed persons were 3.959 4 million, the gross output value of farming, forestry, animal husbandry and fishery of the whole city is 14.644 billion yuan RMB.

1.2 Cultivated land resources and general situation of grain production in Kunming City In 2006, the total cultivated land area of Kunming City was 175 036 hm^2, the cultivated land in common use was 165 907 hm^2, temporary cultivated land was 9 129 hm^2; Among them, paddy field was 64 778

hm^2, irrigated land was 28 132 hm^2, and cultivated land on steep slope more than 25 degree was 7 742 hm^2. The total sown area of crops was 387 985.6 hm^2, mainly cultivated grain crops such as paddy rice, corn, wheat, soybean and potato, etc, and signature crops such as peanut, oil plants, flowers, tobacco leaf and so on.

The grain yield of Kunming City has reduced 119 400 t in all in the past ten years, a decrease of 10.07%. In 1996, Yiliang, Xundian, Luquan, Soming, Guandu and Shilin are all the main production area of Kunming City, annual grain output was more than 100 thousand tons, took 67.54% of the total grain output of the city. By 2006, the total grain output of Yiliang, Luquan, Songming and Xundian had increased, Xundian County had the maximum increment, increased from 159 000 t in 1966 to 189 500 t in 2006. The other counties are all in a declining trend. For instance, the grain output of Chenggong County in 1996 was 46 200 t, and only 4 200 t in 2006, just 9.10% of the grain output of ten years ago.

2 Research method and data collection

2.1 Data sources The population data in 2006 in this paper is quoted from *Yunnan Yearbook*; data of grain and cultivated land come from *Yunnan Agricultural Statistic Resource and Grain* (2006), food self-sufficient rate is 100%.

2.2 Research methods The paper uses comparative research method, minimum per capita cultivated land and index model of cultivated land pressure to analyze the data of grain output, population, the minimum per capita cultivated land and index model of cultivated land pressure, and then, puts forward countermeasures to lighten cultivated land pressure, guarantee grain production safety, and promote sustainable utilization of land[4-5]. Minimum per capita cultivated land is the cultivated land required to meet the food consumption of daily life in a certain region and at a certain level of food self-sufficient and productivity. The minimum per capita cultivated land is the function of factors such as food self-sufficient rate, food consumption level, productivity level of cultivated land and so on[6].

The formula is $S_{min} = \beta Gr/p.q.k.$

In the formula, S_{min} is the minimum per capita cultivated land area; β is food self-sufficient rate; Gr is per capita food demand; p is the unit grain yield, q is the proportion of sown area of grain in total sown area; k is the replant index, it is the proportion of actual sown area of each season in cultivated land area. Minimum per capita cultivated land provides a base line of cultivated land for ensuring the food safety in a certain region.

Index of cultivated land pressure is the proportion of minimum per capita cultivated land area in actual per capita cultivated land area. Express in following formula:

$K = S_{min}/Sa.$

In the formula, K is index of cultivated land pressure; Sa is actual per capita cultivated land area (hm^2) S_{min} is the minimun per capita cultivated land area. The function of total area of cultivable land and population in a certain region. Index of cultivated land pressure can judge the scarcity and conflict level of cultivated land resource in a region. The threshold of cultivated land protection is given, and it can be used as the regulation target of cultivated land protection.

3 Regional differences of per capita cultivated land area in Kunming City

According to the statistical data, using minimum cultivated land area per capita and index mathematical model of cultivated land pressure, with consideration of two conditions of per capita food demand which is 300 kg and 400 kg, we calculate the cultivated land area per capita, actual cultivated land area per capita and cultivated land pressure, in order to reveal the spatial distribution change of per capita cultivated land in Kunming City.

3.1 Distribution of per capita cultivated land area In 2006, Kunming City, as a whole, per capita cultivated land area is 0.034 hm^2, much less than 0.046 hm^2 or 0.062 hm^2 which is the per capita cultivated land area when the per capita food demand Gr is 300 kg or 400 kg. Relative to the integral change of cultivated land resource of Kunming City, per capita cultivated land area of Kunming shows the regional difference of cultivated land resource, embodies different regular pattern of spatial distribution. Under the same consumption level, cultivated land pressures of each county in Kunming City are different, and so are the driven factors; the spatial distribution of actual per capita cultivated land area presents obvious and typical radial distribution. Urban area of Kunming has the lowest point and is taken as the center, per capita cultivated land decreases progressively from suburban to the periphery. The minimum per capita cultivated land area of the main urban zone such as Panlong, Wuhua, Guandu, Xishan, Chenggong is much more than that of other suburban counties, but the actual per capita cultivated land is the minimum in Kunming City. For example, Chenggong is the maximum of Kunming City, respectively 0.325 hm^2 per capita and 0.433 hm^2 per capita, but the actual per capita cultivated land is only 0.037 hm^2 per capita, has a long distance to local cultivated land demand.

3.1.1 Per capita food demand-Gr is 300 kg. Fumin, Yiliang, Shilin, Songming, Luquan and Xundian are the counties that actual per capita cultivated land area is more than minimum per capita cultivated land area, and very close to minimum per capita cultivated land area. But, Panlong, Wuhua, Anning, Fumin, Chenggong are much more than the minimum cultivated land demand, cultivated land resources are difficult to ensure the local grain demand.

3.1.2 Per capita food demand-Gr is 400 kg. When the per capita food demand-Gr is 400 kg, actual per capita cultivated land area is a little more than minimum per capita cultivated land area in Shilin County which is in suburban area, and 78 km to the urban zone. Fumin, Yiliang and Songming are just equal in 2006. With the continuous growth of population, the cultivated land pressure will increase gradually. The other counties have already been difficult to realize grain self-sufficient. The cultivated land resource of Kunming has already been difficult to guarantee grain self-sufficient. Data analysis is shown in Table 2.

3.2 Distribution of cultivated land pressure

3.2.1 Per capita food demand-Gr is 300 kg. Analyzing cultivated land pressure in the condition of 300 kg per capita food demand, if the grain self-sufficiency of Kunming City is 100%, the cultivated land pressure is 1.35, much more than that of grain

self-sufficient condition when $K=1$. Relative to 330 kg per capita food demand in Kunming City, cultivated land resource presents great pressure.

Table 2 The cultivated land pressure index and maximum farmland area per capita in each county (district) of Kunming City in 2006

Administrative division	Unit yield of foods P kg/hm^2	Multiple cropping index K// %	Proportion of sowing grain area in total sowing area q	Actual farmland area per capita Sa// hm^2	Maximum farmland area per capita S_{min}// hm^2		Farmland pressure index K	
					Gr=300 kg	Gr=400 kg	Gr=300 kg	Gr=400 kg
Panlong	4 426.51	129	0.54	0.004	0.097	0.129	24.25	32.33
Wuhua	4 887.30	258	0.58	0.003	0.041	0.055	13.67	18.23
Guandu	4 947.36	169	0.38	0.014	0.092	0.123	6.57	8.78
Xishan	5 493.18	196	0.58	0.009	0.048	0.064	5.33	7.11
Chenggong	5 472.20	211	0.08	0.037	0.325	0.433	8.78	11.70
Jinning	5 208.84	218	0.47	0.050	0.056	0.075	1.12	1.50
Anning	6 367.61	220	0.47	0.030	0.046	0.061	1.53	2.02
Fumin	4 904.08	231	0.72	0.048	0.037	0.049	0.77	1.02
Yiliang	5 625.85	257	0.66	0.045	0.031	0.042	0.69	0.92
Shilin	4 560.05	263	0.60	0.070	0.041	0.056	0.58	0.78
Songming	4 641.21	209	0.72	0.058	0.043	0.057	0.74	0.99
Luquan	4 396.30	203	0.82	0.053	0.041	0.055	0.77	1.03
Dongchuan	3 961.11	186	0.68	0.042	0.060	0.080	1.43	1.90
Xundian	3 636.36	228	0.69	0.064	0.052	0.070	0.81	1.09
Kunming City	4 591.20	221	0.64	0.034	0.046	0.062	1.35	1.82

Cultivated land pressure-$K>1$: There are 8 districts (counties) Panlong, Wuhua, Guandu, Xishan, Chenggong, Jinlin, Anning and Dongchuan, which have a high cultivated land pressure which is higher than five. Cultivated land pressure of Panlong District is the highest, reaches 24.25, the reasons are differ from one another. Panlong and Wuhua previously are the main urban zone of Kunming, and have no agricultural land. According to new administrative division of Kunming City, after adjusting division and property of cultivated land with Guandu and Xishan, the four districts have own a little bit cultivated land respectively in 2004. Cultivated land pressure of Chenggong is 8.78, higher than those of Guandu and Xishan. The main reason is the overall arrangement of industry in Chenggong. The flower and vegetable have been the mainstay industry for many years. Only some of the cultivated land in mountain area with inconvenient transportation grows a few grain crop, per unit area yield reaches 609.7 kg, replant index is 211%, but the proportion of sown area is too little, only 0.08, which is the lowest of the city. It can be ignored when face the whole grain demand of the City. Dongchuan's cultivable land is little, cultivated land pressure is 1.43. The main reason is development of mineral resources takes a great deal of cultivated land, soil erosion is serious, debris flow disaster occurs frequently, and a great deal of cultivated land needs reclamation, these lead to oversize cultivated land pressure. Cultivated land pressure of Jinning and Anning are also more than 1. The main reason is that they are located in the zone joining city and suburb in Kunming City, and the development of new Kunming City drives the increase of land for construction, the replant index of the only cultivated land is more than 210%.

There are six counties with the cultivated land pressure-$K<1$, they are Fumin, Yiliang, Shilin, Songming, Luquan, Xundian. They are all main grain production area, annual grain output is more than 100 thousand tons. The proportion of grain sown area in cultivated land area of each county are all more than 60%, Songming and Luquan are respectively 72% and 82%, and the replant indexes are all more than 230%, cultivated land pressure is relatively small. But part of the mountain area in the six counties has a relative big slope degree, soil erosion is serious, and so is the drought and water shortage, agricultural infrastructure is weak. So, if we reform the relevant infrastructure of these areas, the productivity level of cultivated land still has a large potential. It can contribute the grain safety in Kunming City besides guarantee grain self-sufficiency of its own.

3.2.2 Per capita food demand-Gr is 400 kg. Analyzing cultivated land pressure in the condition of 400 kg per capita food demand, if the grain self-sufficiency of Kunming City is 100%, the cultivated land pressure is more serious, the index is 1.82. The situation of cultivated land protection and grain demand are more severe. Cultivated land pressure-$K>1$: Besides Panlong, Wuhua, Guandu, Xishan, Chenggong, Jinlin, Anning and Dongchuan, the cultivated land pressure in Fumin Luquan, Xundian are more than 1. The highest index of cultivated land pressure is 32.33, Panlong District.

There are only 3 counties that the cultivated land pressure-$K<1$, they are Yiliang, Shilin and Songming. And they are all close to 1, Shilin has the lowest index which is 0.78. That is to say, when per capita food demand is 400 kg, Kunming City can not realize grain self-sufficiency depend on its own cultivated land resource.

4 Countermeasures and suggestions

4.1 Making full use of back-up cultivated land, deploying cultivated land reasonably, ensuring grain safety Strictly implement new plan for land utilization in Kunming City, strengthen management of land acquisition of Kunming City, and stick to not break though the existing red-line standard of

land utilization. Increase the strength of reformation of urban villages. Fully exert the region division function of the zones joining city and suburb such as Chenggong, Jinning, Anning, Yiliang, Songming and so on. Strictly carry out land management and economical and intensive land utilization. Reduce land occupancy for agriculture in the process of urbanization as far as possible.

4.2 Solving the grain safety of Kunming City in the scope of whole province Kunming City is the economic, political, cultural, information and tourism center of Yunnan Province. The grain safety of Kunming is the core and key of grain safety of Yunnan. To ensure the grain gross output increase along with the increase of population, keep the level of 300 kg per capita, it is necessary to stand in the scope of the whole province to study and solve the way of grain safety in Kunming City. Solve the place of in sufficient grain gross output in poverty area in Yunnan Province. Put the work of increasing grain gross output continuously at the top of rural economy. Ensure the grain self-sufficiency of each city, county (district). The most important is to protect and improve the overall production capacity of grain in each area. It is necessary for each area to put the protection of high and stable yield farmland construction completed at the fundamental place. We should protect basic farmland legally, continuously increase infrastructure construction of irrigation and water conservancy, cultivate high and stable yield farmland, improve agricultural overall production capacity, and improve capability of resisting natural disaster, so as to ensure the grain safety of Yunnan Province.

4.3 Overall planning the structure distribution of industry in suburban counties (districts) of Kunming City From the perspective of grain safety, Kunming is suggested to be the center, scientifically and reasonably plan the structure distribution of industry of major grain producing areas of Kunming City such as Shilin, Yiliang, Luquan, Songming, Fuming and Fumin. And plan to townships (towns) combining with the local situation and developing features. The target is through improving unit yield, adjust the grain breed structure, develop high-quality and high-efficient grain production, ensure gross output as well as increase profit, fully use the distinct location advantage of suburban to develop signature, high-quality and high-efficient agriculture, guarantee the food sufficiency of Kunming as far as possible.

4.4 Increasing strength of utilization, management and regulation of cultivated land resource by government It is proved by facts that relying on increasing investment and scientific and technological progress to improve productivity of cultivated land is the foundation of cultivated land resource of ensuring grain safety and the basic way of meeting the land demand of industrialization and urbanization[7]. It is necessary to strengthen administrative regulation and restrict transformation from cultivated land resource to non-agricultural utilization. At the same time, increase investment of infrastructure construction, in particularly, increase land arrangement and reclamation of mountain area such as Luquan, Xundian, Fumin, Shilin and so on, and increase reformation of middle and low yield farmland. Improve productivity level of cultivated land as far as possible, so as to increase actual per capita cultivated land area. Under the precondition of improving productivity of cultivated land and ensuring grain production safety, reasonably and properly transfer the purpose of cultivated land, furthest exert the effectiveness of cultivated land resource.

4.5 Reducing per capita food demand With the improvement of urbanization of Kunming, the pressure of social and economic development and population growth is gradually increasing. Reducing per capita food demand is an important way to ensure grain safety. It can also effectively reduce minimum per capita cultivated land for food safety and pressure of grain safety by reasonably conducting consumption and properly reducing the level of food consumption, or increasing food export and reducing food self-sufficient rate[8].

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