Research on Agricultural Production Changes in Dianchi Lake Basin under Abnormal State

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Abstract: A period of abnormal state has changed the agricultural production and agricultural non-point source pollution condition in Dianchi Lake basin. How to control and prevent agricultural non-point source pollution under New Normal has become a popular topic. This paper makes a systematic investigation on agricultural production in Dianchi Lake basin from 2000 to 2014. The results show that agricultural acreage in the basin has shrunk substantially and become fragments. Sown area and crop output have also shrunk sharply. Agricultural means of production input was uneven. Crop farming layout in the basin has changed a lot. Although the number of livestock on hand at the end of the year has reduced sharply, output of livestock products has kept increasing. The paper also discusses major problems in the governance of agricultural non-point source pollution in Dianchi Lake basin. The overall governance idea was narrow and limited; pollution control was one-sided. The space for agricultural development in Dianchi Lake basin has shrunk and become fragments. The source of water diversion should be governed; the area of pollution treatment should be expand. Standards for the emission of agricultural pollution were not formulated. Investment on point source pollution control was not enough; the control methods were not efficient. Suggestions are provided accordingly.

1. Introduction

Dianchi is located in the southern suburb of Kunming, Yunnan province. The water area is 306km2. At the north end there is a lake embankment which separates Dianchi into two parts. The northern part which covers 12km2 is called Caihai; the southern part which covers 294km2 is called Waihai. The total water volume of Dianchi is 1 billion 570 million m3. [1-2] Dianchi locates at the lower water port of the city and belongs to the aging period in natural succession. It has been polluted since the late 1970. The pollution has obviously aggravated since 1990. The water body is in serious abnormal state of eutrophication, [3-5] which seriously affects and restricts the economic and social development of Kunming. There are many factors that cause the pollution of Dianchi environment. Besides city consumer pollution, agricultural non-point source pollution is one of the most important factors. Based on statistical yearbooks of Kunming and field survey data from county areas, the research group carries out this study through the forms of conference discussion, data collection, field survey, data arrangement as well as data analysis and induction. Combined with experimental study and governance practice, this paper analyzes the situations of agricultural production in Dianchi Lake basin. Changes in agricultural production after 2000 are analyzed, in order to provide scientific suggestions and theoretical support for the control of agricultural non-point source pollution in Dianchi Lake basin.

2. Changes of Agricultural Population in the Basin

The agricultural population in the Dianchi River basin decreased from 771.1 thousand in 2000 to 415.7 thousand, with the decrease amount of 355.4 thousand, the total decrease rate of 46.09%, and the annual decrease rate of 3.29%. (Figure 1) The decline from 2010 to 2010 was the largest. From 649.7 thousand in 2010 to 415.7 in 2014, the decline rate was 36.02%, indicating that the process of urbanization was accelerated after 2010.

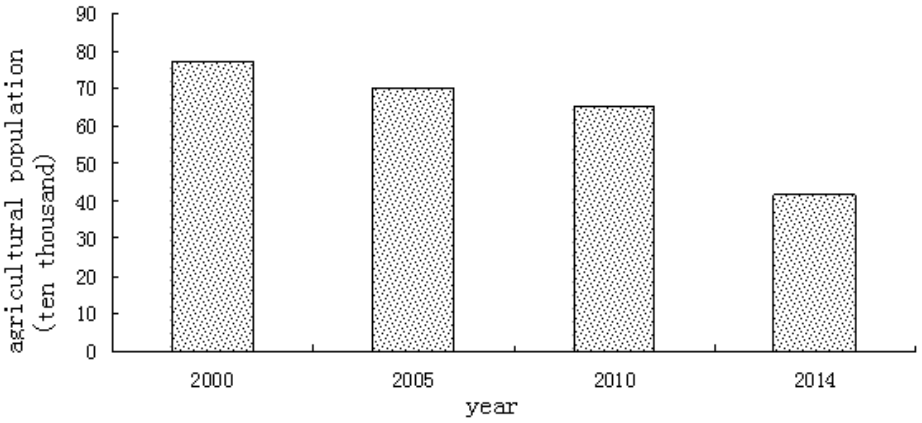

Figure.1 Changes in agricultural population in Dianchi Lake basin

3. Changes of Cultivated Land in the Basin

During the 14 years from 2000 to 2014, the area of cultivated land in the river basin greatly reduced; the distribution of cultivated land changed greatly. Most of the arable lands in the lakeside plain were divided and cut. The area of cultivated land was reduced greatly; lands became fragmented. The 12349 hm^2 slope farmland at 15-25° should be combined with the low yield farmlands to achieve the comprehensive management of mountains, rivers, forests, lands and lakes. The slope land should be transformed to terrace, in order to reduce the soil erosion and increase the yield. In mountain area, the 2812 hm^2 farmland in steep slopes which are greater than 25° has low productivity; soil erosion is serious in these areas. But the projects of reforestation of arable land and woodland protection have achieved remarkable results.

3.1 The area of cultivated land was greatly reduced

According to Kunming statistical yearbook and survey data, the area of arable land of each county in 2000, 2005, 2010 and 2014 was statistically analyzed. It can be seen that in the 14 years from 2000 to 2014, the area of cultivated land was reduced from 46070 hm^2 to 27539 hm^2, with the reduce amount of 18531 hm^2, the total decrease rate of 40.78%, and the annual decrease rate of 2.91%. In 2005, the number was reduced by 2812hm^2 compared with 2000, with the total decrease rate of 6.13% and average annual decrease of 1.22%. The decrease amount from 2005 to 2010 was 6771 hm^2, with the total decrease rate of 15.65% and the average annual decline of 3.13%. The decrease amount from 2010 to 2014 was 8942hm^2, with the total decrease rate of 24.51% and average annual decline 6.13% (table 1). This trend was similar to the change of agricultural population in river basin.

Table 1. Changes in agricultural acreage in Dianchi Lake basin

Year	agricultural acreage (hm^2)	crop planting area (hm^2)	cropping index
2000	46070	80957	1.93
2005	43252	81214	1.88
2010	36481	76752	2.10
2014	27539	62249	2.26

3.2 The distribution of cultivated land varied greatly in different counties and districts in 2014

In 2014, the area of cultivated land was reduced in four counties of the river basin. Among then, the reduce amount of Guandu District was the largest: 8727 hm^2. At the end of the year, Guandu District had 3513 hm^2 arable land. The area of arable land was reduced by 5658 hm^2 in Chenggong District; the cultivated land of Chenggong was 1040 hm^2 at the end of the year. The farmland of Xishan District was reduced by 3635 hm^2; the cultivated land of Xishan was 3533 hm^2 at the end of the year. 3332 hm^2 cultivated land was reduced in Jinning County. The cultivated land of Jinning was 11167 hm^2 at the end of the year. The area of arable land of the original city center, Panlong District and Wuhua District increased 5288 hm^2 and 1831 hm^2 respectively because of the adjustment of administrative divisions. In the basin, Jinning County and Panlong District had more concentrated cultivated lands, which covered 40% and 24% respectively. The cultivated lands of Guandu and Xishan were significantly reduced, accounted for 13%; the areas of cultivated land in Wuhua and Chenggong were the smallest, only accounted for 6% and 4%. (Figure 2)

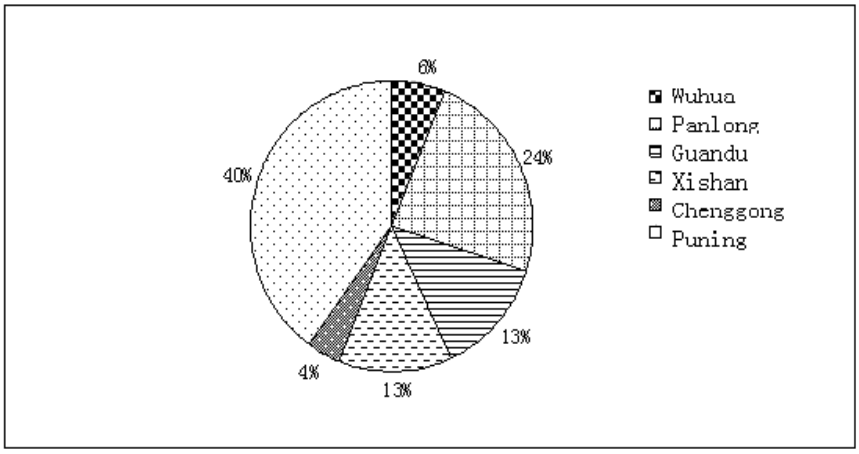

Figure. 2 Comparison of agricultural acreage in different counties in Dianchi Lake basin in 2014

4. Planting Industry in the Basin

4.1 Crop planting area in the basin

From 2000 to 2014, the crop sown area decreased from 89057 hm^2 to 62249 hm^2, with the total decrease rate of 26.39% and annual decrease rate of 1.89%. From 2000 to 2005, the decrease amount was 7382 hm^2, with the total decrease rate of 8.73% and average annual decrease rate of 1.75%. From 2005 to 2010, the decrease amount was 5462 hm^2, with the total decrease rate of 17.48% and average annual decrease rate of 7.08%. From 2010 to 2014, the decrease amount was 9469 hm^2, with the total decrease rate of 13.20% and average annual decrease rate of 3.30%. The multiple cropping index of the river basin showed an upward trend. With the decrease of cultivated land area, the utilization rate of cultivated land increased gradually; the structure of cultivated crops was also changing.

4.2 Crop planting structure in the basin

Gain crop planting in the basin. The sown area of grain crops in the basin was greatly reduced. From 2000 to 2014, the crop sown area decreased from 53192hm^2 to 24881hm^2, with the decrease amount of 28311hm^2, the total decrease rate of 53.22% and annual decrease rate of 3.80%. From 2000 to 2005, the decrease amount was 17815hm^2, with the total decrease rate of 33.49% and average annual decrease rate of 6.70%. From 2005 to 2010, the decrease amount was 2383hm^2, with the total decrease rate of 6.74% and average annual decrease rate of 1.35%. From 2010 to 2014, the decrease amount was 8113hm^2, with the total decrease rate of 24.59% and average annual decrease rate of 6.15 %.

The output of main grain crops greatly reduced, and the grain supply was slightly inadequate. From 2000 to 2014, the yield of grain crop decreased from 281062t to 123261t, with the total

decrease rate of 56.14% and annual decrease rate of 4.01%. The decrease rate was higher than the decrease of grain sown area, which might be related to the grain productivity and land decline or the adjustment of crop planting structure. From 2000 to 2005, the decrease amount was 127267t, with the total decrease rate of 45.28% and average annual decrease rate of 4.01%. From 2005 to 2010, the decrease amount was 30931t, with the total decrease rate of 20.11% and average annual decrease rate of 4.02%. From 2010 to 2014, the increase amount was 595t, with the total decrease rate of 0.48% and average annual decrease rate of 0.12%: basically unchanged.

Vegetable planting in the basin. The area of vegetable planting increased slowly first and then decreased slightly, and reached the peak in 2010. From 2000 to 2014, the vegetable planting area increased from 22787 hm^2 to 28343 hm^2, with the total increase rate of 24.38% and annual increase rate of 1.74%. From 2000 to 2010, the vegetable planting area increased rapidly. The area increased by 7285hm^2, with the total increase rate of 31.97% and annual increase rate of 3.20%; the number reached the historical peak of 30072 hm^2. After 2010, the planting area of vegetables began to decrease. Until 2014, the planting area of vegetables was reduced to 28343 hm^2.

The output of main vegetable crops increased first and then decreased. The value reached its peak in 2005, and the supply of vegetables was obviously insufficient. From 2000 to 2014, the output of vegetable crops decreased by 17044t, with the total decrease rate of 2.10% and average annual decrease rate of 0.15%. The decrease of yield was opposite to the increase of planting area, which might be related to the productivity of vegetable and the decline of soil fertility. From 2000 to 2005, the increase amount was 81761t, with the total increase rate of 10.06% and average annual increase rate of 2.01%. From 2005 to 2010, the decrease amount was 42140t, with the total decrease rate of 4.71% and annual decrease rate of 0.94%. From 2010 to 2014, the decrease amount was 56665t, with the total decrease rate of 6.65% and annual decrease rate of 1.66%.

Flower planting in the basin. The area of flower planting increased rapidly and then decreased slowly. The number reached its peak in 2005. From 2000 to 2014, the flower planting area increased from 3000hm^2 to 3892hm^2, with the increase amount of 892hm^2, the total increase rate of 29.73% and annual increase rate of 2.12%. From 2000 to 2005, the planting area of flowers increased rapidly. The flower planting area increased by 1912hm^2 over the five years, with the total increase rate of 29.73% and annual increase rate of 12.75%, reaching a historical peak of 4912 hm^2. After 2005, the planting area of flowers began to decrease.

The production of flowers showed an increasing trend, and there were significant differences between various counties. From 2000 to 2014, the flower production increased from 2018.45 million to 3499.85 million, with the total increase rate of 73.39% and annual increase rate of 14.68%. From 2000 to 2005, it increased by 955.31 million, with the total increase rate of 47.33% and annual increase rate of 5.24%. It was which is the fastest growing period of flower production. The growth slowed down gradually. From 2005 to 2010, the number increased by 304 million 830 thousand, with the total increase rate of 10.25% and annual increase rate of 2.05%. From 2010 to 2014, the number increased by 221.26 million, with the total increase rate of 6.75% and annual increase rate of 1.69%.

4.3 Fertilizer usage in the basin

The amount of chemical fertilizer usage decreased first, then increased and then decreased again. Among fertilizers, the amount of nitrogen fertilizer was similar to that of chemical fertilizer; the amount of phosphate fertilizer was decreasing; the amount of compound fertilizer was increasing year by year. In the 14 years, the amount of chemical fertilizer application reduced from 42074t to 41622t, with the decrease amount of 452t and decrease rate of 1.07%. From 2000 to 2005, the decrease amount was 11196t, with the total decrease rate of 26.61% and average annual increase rate of 5.32%. From 2005 to 2010, the increase amount was 15944t, with the total increase rate of 51.64% and annual increase rate of 10.33%. From 2010 to 2014, the decrease amount was 5200t, with the total decrease rate of 11.11% and annual decrease rate of 2.78%.

The amount of nitrogen application decreased from 19911t to 18903t, with the decrease amount of 1008 tons and decrease rate of 5.06%. From 2000 to 2005, the amount reduced by 102t, the decrease rate was 0.51%. From 2005 to 2010, the increase amount was 3200t; the total increase rate was

16.15%, and the average annual increase was 3.23%. From 2010 to 2014, it was reduced by 4106t; the total decrease rate was 17.85%, and the annual decrease rate was 4.46%.

The application of phosphate fertilizer reduced from 10194t to 7142t, with the decrease amount of 3052t and decrease rate of 29.94%. From 2000 to 2005, the decrease amount was 2067t; the decrease rate was 20.28%. From 2005 to 2010, the decrease amount was 76t; the decrease rate was 0.9%. From 2010 to 2014, the decrease amount was 909t; the decrease rate was 11.29%.

The amount of compound fertilizer increased from 7714t to 11503t, with the increase amount of 3789t and increase rate of 49.12%. From 2000 to 2005, the increase amount was 352t; the increase rate was 4.56%. From 2005 to 2010, the increase amount was 3250t; the increase rate was 40.29%. From 2010 to 2014, the increase amount was 187t; the increase rate was 1.65%.

4.4 Pesticide and mulching film usage in the basin

The usage of pesticide in the basin was basically stable. In the past 14 years, the amount of pesticide application reduced from 1513t to 1442t, with the decrease amount of 71t and total decrease rate of 4.69%; annual decrease rate was 0.34%. The low value of 1120t only appeared in 2005. The amount of mulching film first decreased, then increased and then decreased again, and reached a peak in 2010. From 2000 to 2014, the usage of mulching film increased from 2206t to 2367t, with the increasing amount of 161t and increase rate of 7.30%. (Table 2)

Table 2. Pesticide and mulching film usage in Dianchi Lake basin

Year	dosage of pesticide (t)	The amount of mulching film (t)
2000	1513	2206
2005	1120	2183
2010	1499	2452
2014	1442	2367

5. Breeding Industry in the Basin

5.1 Livestock breeding in the basin

From 2000 to 2014, livestock on hand at the end of the year decreased from 762465 to 468301, with the decrease amount of 294164 and the decrease rate of 38.58%; the average annual decline was 2.76%. From 2000 to 2005, the decrease amount was 104145; the total decrease rate was 13.66% while the annual decrease rate was 2.73%. From 2005 to 2010, the decrease amount was 110208; the total decrease rate was 16.74% while the annual decrease rate was 3.35%. From 2010 to 2014, the decrease amount was 79811; the total decrease rate was 14.56% while the annual decrease rate was 3.64%. (Table 3).

5.2 Production of livestock products in the basin

In 14 years, the meat production of the breeding industry increased from 52438t to 69723t, increased by 17285t; the total increase rate was 32.96%, and the annual increase rate was 2.35%. The production of dairy products greatly increased and gradually decreased, and reached the peak in 2005. From 2000 to 2014, dairy production increased from 16103t to 32887t, with the increase amount of 16784t, the total increase rate of 104.23%, and average annual increase rate of 7.44%. (Table 3) The production of meat and dairy products increased while the number of livestock decreased, which might be related to the improvement of local livestock breeding.

Table 3. Livestock breeding and livestock product output in Dianchi Lake basin

Year	livestock on hand	output of meat (t)	output of dairy products (t)
2000	762465	52438	16103
2005	658320	51934	67229
2010	548112	67166	36356
2014	468301	69723	32887

6. Problems in Control of Agricultural Non-point Source Pollution in the Basin

The comprehensive measures such as "returning cultivated lands and no breeding", "four retreats and three restorations" as well as "eastward and northward expansion" adopted in the abnormal period have made great achievements in the comprehensive control of water environment in Dianchi and the comprehensive prevention and control of agricultural non-point source pollution. 22867hm^2 farmlands have been returned; more than 3 million livestock and poultry have been decreased. But it has completely changed the "three rural" situations in Dianchi basin, and brought about some new problems, include the destruction of agricultural ecosystem, the extrusion of agricultural development space, the fragmentation of agricultural production, the drastically shrinking of agricultural industry, the rapid reduction of the natural villages, the loss of cultivated lands of farmers, the serious influence on urban food supply, and the rising product prices. Facing the new "three rural" situations, agricultural non-point source pollution treatment has shown many new characteristics, which need to be studied and analyzed.

6.1 The overall governance idea was narrow and limited; pollution control was one-sided

"Comprehensive management, three level control, combination of point and non-point, and the reduction of load" was the general idea of pollution treatment. Although it played a very good guiding role in the treatment of agricultural non-point source pollution at that time and achieved practical results, it could not adapt to the new issue of "innovation, coordination, green, open and sharing". The idea must be adjusted. The overall idea of pollution control should be "innovative transformation of modern agriculture and ecological civilization; control pollution and reduce emission to build beautiful countryside, to achieve green and clean production, to share development fruits and realize anonymous well-off society".

6.2 The space for agricultural development in Dianchi Lake basin has shrunk and become fragments

With the rapid development of urbanization, various buildings and infrastructures have occupied most of the farmlands in lakeside area of Dianchi Lake. Remaining farmlands are fragmented. At present, 9 counties in the basin have returned almost all cultivated lands (remaining 80hm^2 cultivated lands are used for vegetable planting in 67hm^2 and flower planting in 13hm^2). Only 191hm^2 cultivated lands are left in the Resort District (158hm^2 planting vegetables, 33hm^2 planting flowers). [6] For the growing of crops, Wuhua District had only 5hm^2 cultivated lands to plant rice, Chenggong District has 25hm^2 cultivated lands to plant potato, Guandu District has only 91hm^2 cultivated lands to plant corn, Panlong District has only 18hm^2 cultivated lands to plant flowers. In the area of "four retreats and three restorations", Guandu still has 40hm^2 cultivated lands in Fubao. Agricultural production has been fragmented in this area; it is difficult to develop modern agriculture and large-scale agriculture under that condition. The fragmentation also affects the effective governance of agricultural non-point source pollution.

6.3 The source area of water diversion should be governed; the area of pollution treatment should be expanded

Yunlong Reservoir, Qingshui Lake and Niulan River became the source of water diversion for Dianchi basin. The water source area of Niulan river includes 12 towns in 7 towns in Xundian County and Songming County. In 2014, the agricultural population there was 840 thousand people, which was more than 2 times of the 410 thousand of Dianchi basin. The cultivated land area was 51672hm^2, which was 1.88 times of the 27539hm^2 cultivated land of Dianchi basin; the crop sown area was 112837hm^2, which was 1.81 times of the crop sown area of Dianchi basin. The area had 1 million 260 thousand large livestock, which was 2.68 times of the 470 thousand of Dianchi Lake basin; it had 3 million 170 thousand poultry, which was 90% of the number of poultry of Dianchi Lake basin. The number of agricultural population, the area of cultivated land, the sown area of crops and the number of large livestock in that area were about 2 times compared with those of Dianchi Lake basin; the number of poultry was equal to that of Dianchi Lake basin. Pollution caused by agricultural

population such as living consumption and planting industry pollution, the loss of water and fertilizer in cultivated lands, and the pollution of the livestock and poultry manure in that area directly affected the water quality of water diversion, and required us to expand the treatment area.

6.4 Lack of standards for the emission of agricultural pollution

In the past, authorities formulated discharge standards for urban point source pollution and industrial point source pollution. But there were no standards for the emission of agricultural pollution. The agriculture industry had to ban planting and breeding activities totally to reach the target. Since there were no standards, there was no control for the emission of agricultural pollution

6.5 Insufficient investment and limited efficiency of non-point source pollution control

The pollution of Dianchi has been treated for 30 years. The period during Seventh and Eighth Five Year Plans was investigation and research. In the Ninth Five Year Plan, the investment on agricultural non-point source pollution control was 31 million yuan, which only accounted for 1.29% of the total input of 2 billion 405 million yuan in the pollution control of Dianchi. [7] In the Tenth Five Year Plan, the investment on agricultural non-point source pollution control was 435 million yuan, which only accounted for 5.58% of the total input of 7 billion 799 million yuan in the pollution control of Dianchi. [8] In the Eleventh Five Year Plan, the investment on agricultural non-point source pollution control was 134 million yuan, which only accounted for 1.45% of the total input of 9.227 billion yuan in the pollution control of Dianchi. [9] In the Twelfth Five Year Plan, the investment on agricultural non-point source pollution control was 945 million yuan, which only accounted for 2.25% of the total input of 42 billion 14 million yuan in the pollution control of Dianchi. [10] In the four five year plans, the total investment on agricultural non-point source pollution control was 1.545 billion yuan, which only accounted for 2.51% of the total input of 61 billion 445 million yuan in the pollution control of Dianchi. The contribution rate of agricultural non-point source pollution in this period was 21%-69%, but only 2.51% of the investment was used to control the pollution. It was difficult to obtain good control efficiency.

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