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Analysis of the correlation between ecology and economy in Dianchi Lake Basin

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Abstract. Whether the ecological environment of Dianchi Lake Basin can run well or not is directly related to the smooth implementation of the sustainable development of Kunming City and even Yunnan Province. Without a benign ecosystem in the Dianchi Basin, there would be no rapid socio-economic development in Kunming. This paper analyses the relationship between social and economic development and ecological environment in Dianchi Lake Basin, and explores the relationship between them, which will be helpful to the theory and practice of economic development and ecological construction in Dianchi Lake Basin.

1. Introduction

Since the emergence of human beings, the interdependence and interaction between human social progress and ecological environment have emerged. The development of this relationship reflects the deepening process of human society's exploitation and utilization of the surrounding ecological resources. Its basic motivation comes from human's desire and efforts to improve their own survival and development. Despite the rapid development of human society and the increasing ability to transform the ecological environment, human dependence on ecological resources has not weakened at all. With the increase of population and the change of consumption structure, the dependence on ecological resources becomes stronger and stronger, and the impact on the ecological environment is greater. After the 1950s, with the development of urbanization in the Dianchi Basin, the rapid growth of population in the basin, the continuous expansion of urban areas, the rapid development of industry and the rapid expansion of economic scale, the conflict between the carrying capacity of ecological environment and social and economic development in the Dianchi Basin has become an important factor restricting the development of Kunming City. In the 1990s, due to the fragility of the ecosystem and the excessive consumption of ecological resources by economic development, the carrying capacity of the ecological environment in the Dianchi Lake Basin has reached its limit, resulting in the deterioration of the water quality in the Dianchi Lake and seriously affecting the life of the people of Kunming and the development of social economy.

2. Selection of Eco-economic Indicators

As a complex system, the ecological economic system of Dianchi Lake Basin is characterized by multivariate, dynamic and complex characteristics. It is closely related to economic, social and ecological environment. It is also influenced by policy orientation, history, culture, natural climate and



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other factors, and involves many indicators. But too many indicators are not conducive to the analysis of the problem. Therefore, only according to the principles of scientificity, operability and comparability, can we select indicators that not only reflect the ecological environment and socio-economic development of Dianchi Lake Basin, but also have strong practical operability.

2.1. Main Indicators of Social and Economic Development in Dianchi Basin

In the interactive process of social and economic development, the ecological environment change of Dianchi Lake affects the ecological environment change of Dianchi Lake. Along with urbanization and industrialization, the population of Dianchi Lake Basin increases sharply and the total population expands continuously. The large population not only bring influence to economic development, threatens the sustainable utilization of resources and environment, but also causes many social problems, affecting the coordinated development of social economy and ecological environment in Dianchi Lake Basin. Therefore, the main index of social economy is the total population. Of course, the existing statistical data should be used as much as possible in the calculation. The total population should use the total resident population, referred to as the permanent population.

At the same time, there are still many indicators reflecting the social and economic development of Dianchi Lake Basin, but they strive to be simple, clear in concept and easy to compare. At the same time, the convenience and accuracy of data acquisition are fully considered, and it is easy to collect and calculate. Per capita gross domestic product (GDP per capita) is undoubtedly the most widely used economic indicator in the world, and is considered as the main indicator to measure the level of economic development. Therefore, in addition to the permanent population, the main socio-economic indicators are the per capita GDP.

2.2. Main Indicators of Water Pollution in Dianchi Lake

Dianchi Lake is the core of the ecological environment in the Dianchi Lake basin. The key problem of Dianchi Lake is water pollution. The pollution structure of Dianchi Basin can be divided into urban living pollution, industrial point source pollution, rural agricultural non-point source pollution and Dianchi Lake endogenous pollution and so on. At present, the pollution load of Dianchi Lake mainly comes from urban production and living. Among them, the total nitrogen, total phosphorus and chemical oxygen demand account for more than 70% of the total pollution of Dianchi Lake [1]. Therefore, total phosphorus, total nitrogen and chemical oxygen demand are selected as the indices for the ecological environment analysis of Dianchi Lake. At the same time, Dianchi Lake is one of the lakes with the most serious eutrophication in China. In order to analyze it more comprehensively, besides total phosphorus, total nitrogen and chemical oxygen demand, the comprehensive nutritional status index is selected as the comprehensive index of Dianchi Lake ecological environment analysis.

Total nitrogen: The amount of inorganic and organic nitrogen in water. Including inorganic nitrogen such as NO_3^- , NO_2^- and NH_4^+ and organic nitrogen such as protein, amino acids and organic amines, calculated in milligrams of nitrogen per liter of water. The English name of total nitrogen is Total Nitrogen, abbreviated as TN.

Total phosphorus: The results of determination of phosphorus in water samples after digestion and transformation of various forms of phosphorus into orthophosphate are measured in milligrams of phosphorus per liter of water sample. The English name of COD is Total Phosphorus, or TP for short.

Chemical oxygen demand: Chemically measure the amount of reductive substances that need to be oxidized in water samples. Chemical Oxygen Demand (COD) is the English name of COD.

Comprehensive Nutrition Status Index: An Index for Eutrophication Assessment of Lakes. The English name of COD.

With the Haigeng Dam as the demarcation line, the north side is called Caohai, and the south side is called Outer Sea.

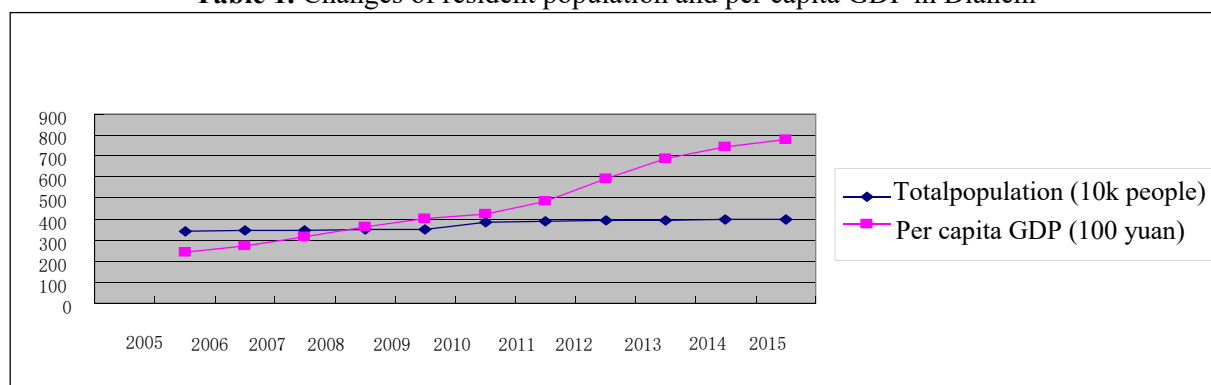
3. Social and Economic Development and Water Pollution Trend in Dianchi Lake Basin

Before analyzing the correlation between ecological environment and socio-economy, the changes of resident population and per capita GDP, total phosphorus, total nitrogen, oxygen demand and comprehensive nutritional status index were analyzed in order to grasp the changing trend of water quality in Dianchi Lake.

3.1. Permanent Resident Population and Per Capita GDP Change

Through data collection and statistical calculation, the permanent population and per capita GDP increased year by year from 2005 to 2015, but the growth rate was different. As can be seen from Table 1, the growth rate of per capita GDP is obviously faster than that of permanent population. The permanent population increased from 34338,000 in 2005 to 3993,000 in 2015, with an average of 372.79, with an annual growth rate of 1.52%. Per capita GDP increased from 243,054 yuan in 2005 to 778,242 yuan in 2015, with an average value of 48310, an increase of 3.2 times that of 12.34%.

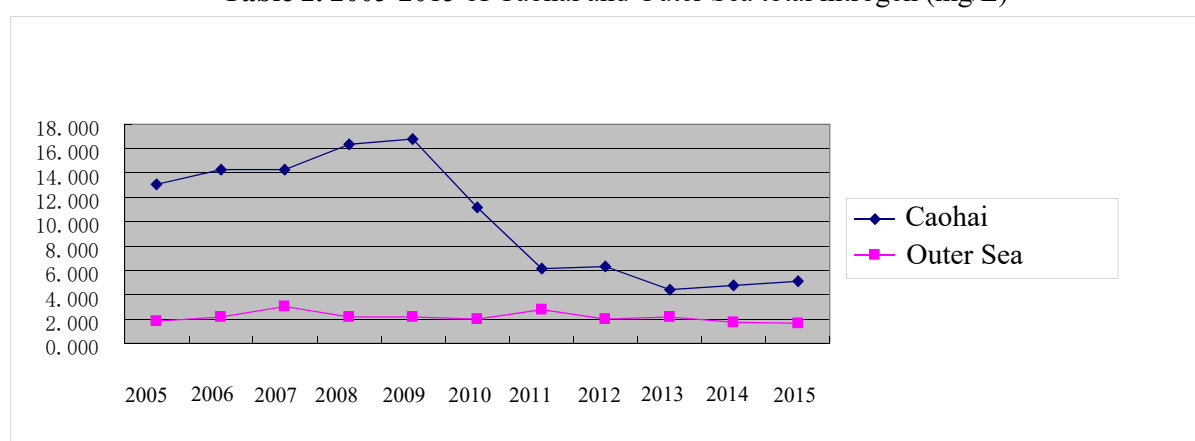
Table 1. Changes of resident population and per capita GDP in Dianchi



3.2. Changes in total nitrogen

From 2005 to 2015, the range of total nitrogen in Caohai ranged from 4.44 mg/L to 16.79 mg/L, with an average value of 10.244 and a standard deviation of 4.9435. The range of total nitrogen in Outer Sea ranged from 1.61 mg/L to 3.01 mg/L, with an average value of 2.1421 and a standard deviation of 0.42465. The changes of total nitrogen in the Caohai and Outer Sea in 2005-2015 are shown in Table 2.

Table 2. 2005-2015 of Caohai and Outer Sea total nitrogen (mg/L)



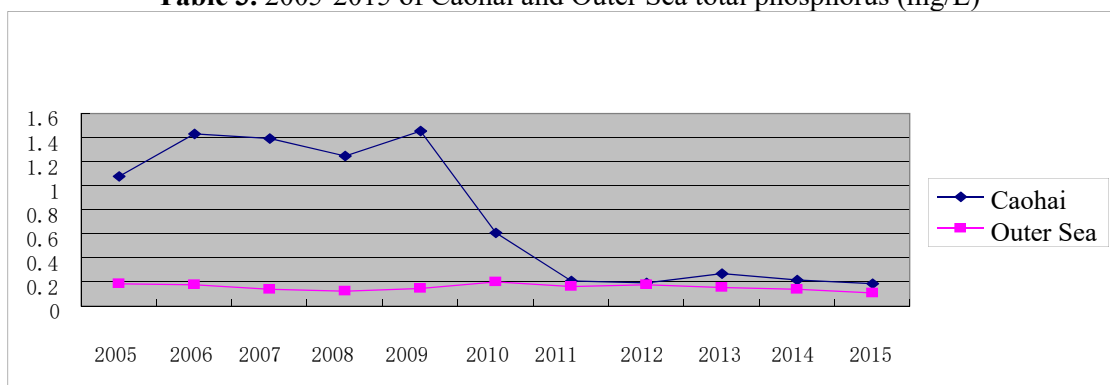
Combined with Table 2, we can draw the following conclusions: First, the total nitrogen in Caohai is larger than that in the open sea. Secondly, the total nitrogen content in Caohai decreased rapidly, which indicated that the total nitrogen content in Caohai decreased significantly. Thirdly, the standard

deviation of total nitrogen in Outer Sea is small, which indicates that the fluctuation of total nitrogen in Outer Sea is small and the content of total nitrogen is relatively stable.

3.3. Changes in total phosphorus

From 2005 to 2015, the variation range of total phosphorus in Caohai was 0.18-1.46 mg/L, with an average value of 0.7525 and a standard deviation of 0.56488. The variation range of total phosphorus in the Outer Sea of Dianchi Lake was 0.11-0.20 mg/L, with an average value of 0.1545 and a standard deviation of 0.02824. From 2005 to 2015, the changes of total phosphorus in Caohai and Outer Sea are shown in Table 3.

Table 3. 2005-2015 of Caohai and Outer Sea total phosphorus (mg/L)

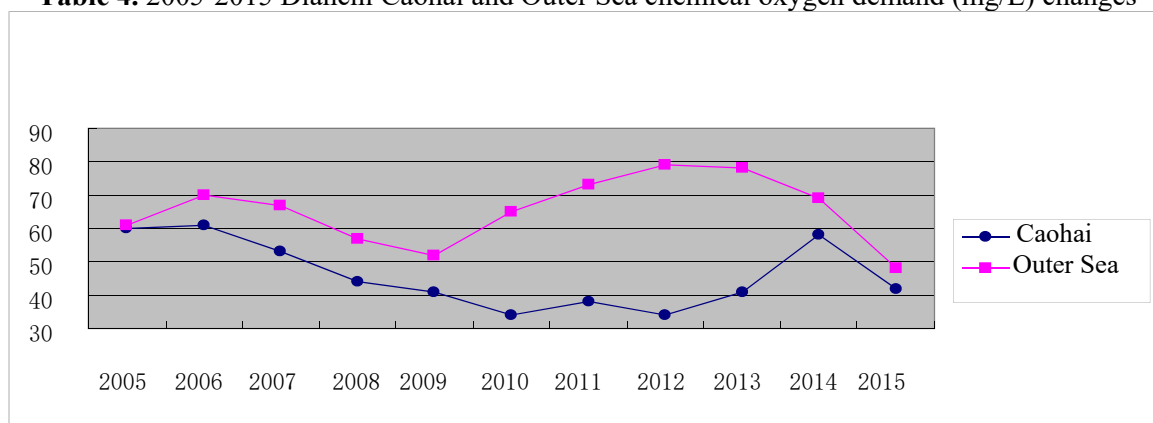


Combined with Table 3, it can be concluded that the changes of total phosphorus and total nitrogen are similar. Firstly, the total phosphorus in Caohai of Dianchi Lake is larger than that in Outer Sea. Secondly, the total phosphorus content in Caohai decreased rapidly, which indicated that the total phosphorus content in Caohai decreased significantly. Thirdly, the standard deviation of total phosphorus in the Outer Sea is small, which indicates that the fluctuation of total phosphorus in the Outer Sea is small and the content of total phosphorus is relatively stable.

3.4. Changes in Chemical oxygen demand

From 2005 to 2015, COD of Caohai ranged from 34 to 61 mg/L, with an average value of 46 and a standard of 10.17841; COD of Outer Sea ranged from 48 to 79 mg/L, with an average value of 65.3636 and a standard deviation of 10.05259. From 2005 to 2015, the changes of COD in Caohai and Outer Sea of Dianchi Lake are shown in Table 4.

Table 4. 2005-2015 Dianchi Caohai and Outer Sea chemical oxygen demand (mg/L) changes

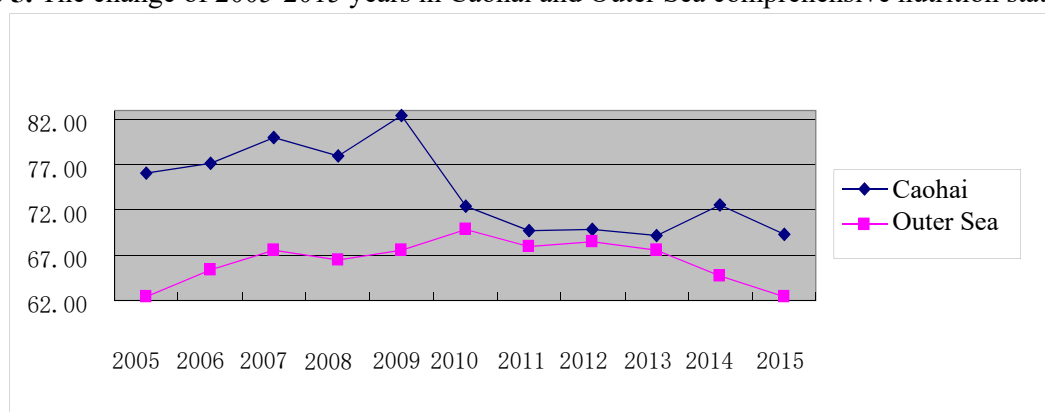


Combined with Table 4, we can see that: first, COD is greater in the Outer Sea than in the Caohai. Secondly, the standard deviation of COD in the Caohai and Outer Sea sea is large, which indicates that the COD fluctuates greatly in the whole Dianchi Lake.

3.5. Changes in comprehensive nutritional status index

From 2005 to 2015, the range of the comprehensive nutrient status index of Caohai ranged from 69.12 to 82.44, with an average value of 74.2509 and a standard deviation of 4.71027. The range of the comprehensive nutrient status index of the Outer Sea ranged from 62.40 to 69.83, with an average value of 66.3918 and a standard deviation of 2.4048. From 2005 to 2015, the changes of comprehensive nutrient status index between Caohai and Outer Sea are shown in Table 5.

Table 5. The change of 2005-2015 years in Caohai and Outer Sea comprehensive nutrition state index



From Table 5, we can see that: First, the comprehensive nutritional status index of Caohai is larger than that of the Outer Sea. Secondly, the comprehensive nutrient status of Outer Sea means that it rises first and then decreases. In recent years, the quality of Outer Sea has improved significantly. Thirdly, the comprehensive nutrient status index of Caohai declined greatly, indicating that the quality of Caohai improved obviously.

4. Analysis of the correlation between socio-economic development and water pollution in Dianchi Lake Basin

From the above analysis, we know that the total phosphorus, total nitrogen and comprehensive nutrient status index are the largest in the vicinity of 2009. Therefore, with 2009 as the boundary, we can divide the existing data into two parts: 2005-2009 and 2010-2015, calculated by statistical software SPSS18.0, and finally get the correlation analysis table 6.

Table 6. Correlation Analysis of population, per capita GDP and Dianchi water quality in Dianchi River Basin

Permanent population	Particular year	Caohai				Outer Sea			
		TN	TP	COD	CNSI	TN	TP	COD	CNSI
	2005-2009	0.954	0.558	-0.958	0.849	0.239	0.484	-0.664	0.848
	2010-2015	-0.809	-0.711	0.631	-0.304	-0.612	-0.935	-0.428	-0.924
Per capita GDP	2005-2009	0.968	0.506	-0.973	0.823	0.154	-0.132	-0.722	0.798
	2010-2015	-0.808	-0.662	0.670	-0.246	-0.648	-0.876	-0.336	-0.865

According to Table 6, and referring to the changes of total phosphorus, total nitrogen, oxygen demand and comprehensive nutritional status index, the analysis is as follows:

The correlation coefficients of TP, TN and CNSI with permanent population and per capita GDP in Caohai are positive in 2005-2009 and negative in 2010-2015, indicating that the quality of Caohai was once the most polluted area, but it has improved significantly in recent years, and the ecological environment has improved significantly.

The correlation coefficients of TP, TN and CNSI with permanent population and GDP per capita are positive in 2005-2009 (except GDP per capita and TP), and negative in 2010-2015, which indicates that the quality of Outer Sea has been polluted, but in recent years, the situation has gradually improved and the ecological environment has improved.

Whether in Caohai or Outer Sea, COD fluctuates greatly and varies uncertainly. How to improve COD will become a key concern.

From the above, it can be concluded that the water quality of Dianchi Lake has improved in the past five years, especially that of Caohai. In recent ten years, although the water quality of Dianchi Lake fluctuates, it generally falls first and then rises, and the ecological environment has improved in recent years. In this sense, it verifies the "Environmental Kuznets Hypothesis". Firstly, changes in the ecological environment interact with the level of social and economic development, which may form a virtuous circle or a vicious circle. Secondly, the relationship between environmental change and national income level is inverted U-shaped, that is, the degree of environmental pollution before the peak is positively correlated with national income level, and the degree of environmental pollution after the peak is negatively correlated with national income level. Using SPSS18.0 statistical software, the curve estimation (1) of the per capita GDP of Dianchi Lake basin and the comprehensive nutrient status index of Dianchi Outer Sea in 2005-2015 is also illustrated, referring to Fig. 1.

$$y = 48.065 + 0.001x - 8.198 \times 10^{-9} x^2 \quad (1)$$

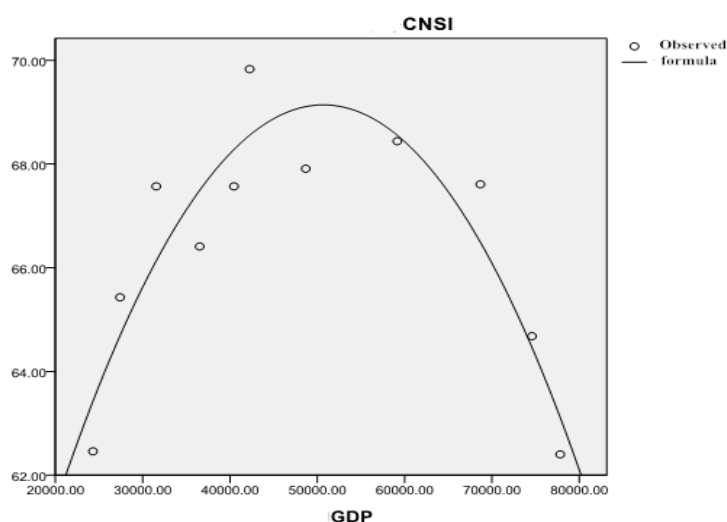


Fig. 1 Simulated curve of per capita GDP and comprehensive trophic state index of Dianchi Outer Sea in Dianchi Basin

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