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Change of human activity intensity and its impact on lake water quality in Erhai Lake Basin

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Abstract: In recent years, the population around Erhai Lake has increased dramatically, and the rapid development of agriculture and tourism has caused the lake's water quality to face many problems and water ecological degradation is obvious, which seriously affects the sustainable utilization of the lake. The intensity of human activities in Erhai Lake Basin involves various aspects such as economy and society. At present, it is rare to use multi-source remote sensing data and a variety of social and economic data to establish an index system of human activity intensity, quantitatively evaluate the intensity of human activity and analyze its spatial and temporal distribution. The results showed that: during the study period, the emission of COD was the highest, followed by total nitrogen (TN), and total phosphorus (TP) was the least. The land use types in the basin showed the trend of increasing cultivated land and construction land, and decreasing woodland, grassland and water body. GDP and population are the highest around Erhai Lake and Dali City, and the increasing trend is the largest. Agriculture, industry and tourism will affect the water quality of the basin.

Keywords: Human activity; land use; lake water environment; Erhai Lake

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1. Introduction

As an important part of the natural ecosystem, lakes have many functions, such as regulating and storing runoff, water supply and irrigation, regulating climate and environment, and maintaining ecosystem balance, which has an important impact on human survival and development [1]. In recent decades, climate warming and human activities have made the lake water environment face many problems, such as water quality deterioration, eutrophication and so on, resulting in lake water ecological degradation, seriously affecting the sustainable utilization of Lake functions, and causing serious environmental problems in the world [2-5].The research of lake water environment is not only related to the sustainable development of Lake Basin, but also the strategic demand of realizing the sustainable development of regional ecological economy and national security and stability.

With the rapid development of China's economy and the acceleration of industrialization and urbanization, the contradiction between human and environment has become increasingly prominent. Human activities have become a factor that can not be ignored in the intervention of lake ecosystem.The results show that human activities such as changing land use pattern [6], economic development [7] and building water conservancy projects [8] can change the ecological environment of lakes in a short period of time. The intensity of human activities involves various aspects of economy and society, and each aspect is restricted by many factors, covering a wide range. However, due to the limitations of traditional statistical survey methods, the acquisition of socio-economic parameters often has the disadvantages of large error, time-consuming and lack of

spatial information. As an important data source that can measure the spatial and temporal characteristics of human activity intensity, remote sensing has shown great potential in the acquisition of land use information and ecological environment parameters [9-11]. At present, how to use multi-source remote sensing data and other types of eco-economic-social development data to establish the indicator system of human activity intensity in river basin, quantitatively measure the intensity of human activity and analyze its spatial and temporal distribution law is still rare.

Erhai Lake is the core of China's national nature reserves and scenic spots, and also the main drinking water source of Dali city. It has many functions, such as regulating climate, providing water for industrial and agricultural production, and maintaining aquatic biodiversity. It is an important basis for the sustainable economic and social development of the whole basin and even Dali Prefecture.At the end of the 19th century, the Erhai Lake regional climate developed towards aridification as a whole, which prolonged the retention time of the Erhai Lake, increased the nitrogen and phosphorus organic matter content in the sediments, increased nutrients in the water body, and gradually decreased water quality [12]; In recent years, human activities have gradually become an important factor affecting the quality of Erhai Lake. Studies have shown that the impact of human activities on the Erhai Lake environment is mainly manifested in: agricultural non-point source pollution caused by human irrational farming methods and excessive fertilization [13-14]; environmental damage and pollution caused by tourism activities and development [15]; Changes in land use types caused by economic development [16-17], etc. Comprehensive use of multi-source and multi-scale information to construct a human activity intensity index system and conduct quantitative analysis to reveal the temporal and spatial distribution of human activity intensity in the watershed, as well as the mechanism of human activity intensity changes in the watershed on the quality of the Erhai Lake need to be further studied. Based on the data of land use type, social economy and other factors, this study establishes a human activity intensity model to evaluate the human activity intensity and its spatiotemporal change of each administrative unit in Erhai Lake Basin and its different sub basins; on this basis, combined with water quality data, it analyzes the impact of human activity intensity on Erhai Lake environment It provides theoretical support for the sustainable development of Erhai Lake Basin.

2. Results

2.1. Land use change

Table 1. Land use transfer matrix of Erhai Lake Basin from 2000 to 2020 (km2)

		2020				
		Cultivated land	Forests	Grassland	Water	Construction land
2000	Cultivated land	499.92.	23.43	25.76	2.15	68.22
	Forests	36.66	1145.68	64.72	0.66	19.22
	Grassland	62.53	68.25	265.71	0.13	20.61
	Water	1.63	3.01	0.89	255.36	0.94
	Construction land	25.95	1.35	1.17	0.25	101.81

Table 1 shows the change of land use in Erhai Lake Basin from 2000 to 2020. The results show that the cultivated land and construction land increase, while the woodland, grassland and water area decrease in 21 years.The cultivated land and construction land increased by 7.21km2 and 80.26km2 respectively, while the woodland, grassland and water decreased by 25.22km2, 58.96km2 and 3.30km2 respectively.The increased cultivated land is mainly transformed from woodland and grassland; the increased construction land is mainly transformed from cultivated land and woodland.

2.2. Socio economic data

- GDP

Figure 1 shows the distribution of GDP in Erhai Lake Basin. It can be seen from the figure that the GDP distribution in the basin is low in the north and high in the south. The GDP value around Erhai Lake in the South and Dali city is the highest, and that of the northern basin is the lowest. During the study period, the GDP growth trend is significant, the growth rate is maintained at about 10%. In space, the areas with significant increase are located around Erhai Lake and Dali urban area, which is related to the growth of tourist number and the economic development of Dali City in recent years.

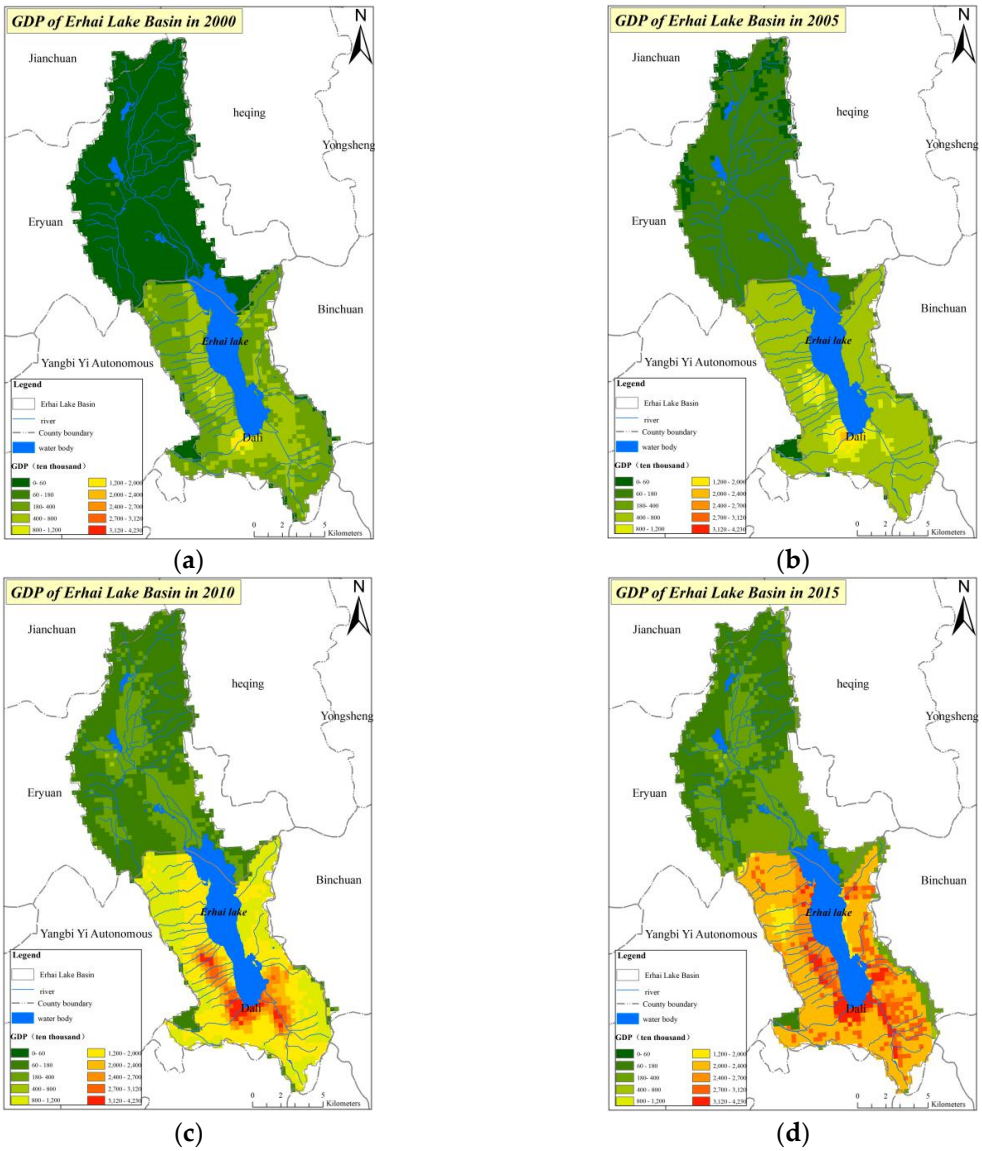

Figure 1. GDP spatial distribution data from 2000 to 2015

- Population

Figure 2 shows the distribution of population in Erhai Lake Basin. It can be seen from the figure that the distribution characteristics of population in the basin are similar to those of GDP, which are low in the north and high in the south. The population distribution on both sides of the river in the north is higher than that in other regions. Dali City in the South has the largest population, followed by Erhai Lake. During the study period, the northern part of the basin showed a decreasing trend, while the southern part showed an increasing trend.

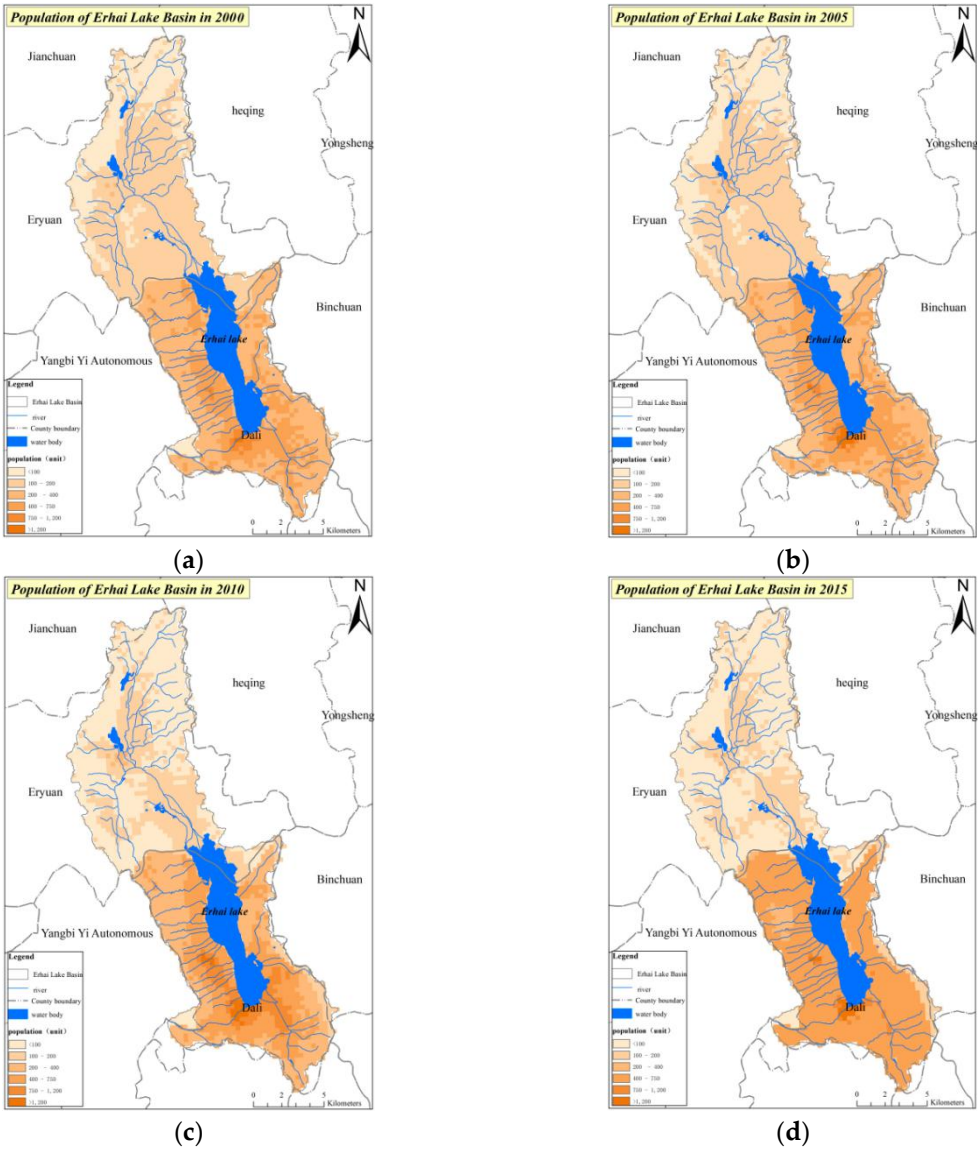

Figure 2. Population spatial distribution data from 2000 to 2015

3. Discussion

During the study period, the emission of COD was the highest, followed by TN and TP. The emission of chemical oxygen demand (COD) is related to industrial production, but it shows an obvious downward trend in 21 years, which indicates that the technical progress of industrial production makes the emission intensity of COD decrease. But the decrease of TN and TP was not obvious. Non point source pollution is an important factor affecting the water quality of Erhai Lake, and it is mainly livestock and poultry breeding pollution and farmland non-point source pollution. Adjusting agricultural production structure and scientifically standardizing livestock and poultry breeding is the key to environmental governance of Erhai Lake.In recent years, the GDP of the Erhai Lake Basin has changed significantly, mainly distributed in the surrounding Erhai Lake and Dali City. This is related to the development of economy and tourism, and the population of the northern part of the basin is decreasing, while the southern part is increasing, indicating that the development center of the basin is Migration to the south is also an important factor affecting water quality changes.

With the rapid development of the three major industries in Erhai Lake Basin, agriculture, industry and tourism all have a good development prospect. According to the production scale and sewage discharge of local industries, different policies are implemented, either encouraging

development or restricting development.For example, excessive use of chemical fertilizer in agriculture and sewage produced by aquaculture will lead to poor water quality into the lake. We should encourage the development of low pollution agriculture, restrict the development of high pollution agriculture, and readjust the layout to reduce the pressure of water environment.The development mode of "high pollution and high emission" should be changed in the development of industry. The location layout of heavy industry should be reasonably adjusted to be far away from Erhai Lake. The production mode of clean production should be carried out, the industrial development of "low pollution and low emission" should be encouraged, and technological innovation should be strengthened.The rapid development of tourism should pay special attention to environmental protection. Strict admittance system should be implemented for farmhouse entertainment and catering industry around Erhai Lake Basin, and the development of tourism and eco-tourism should be standardized to control the pollution level while improving the tourism benefits.

4. Study area and Methods

4.1. study area

Erhai Lake (25 ° 36 ′– 33 ° 58 ′ n; 100 ° 06 ′– 100 ° 18 ′ E) is the main drinking water source in Dali City, and is also the core component of Cangshan Erhai National Nature Reserve and scenic spot (Figure 1). Erhai Lake Basin is located in Northwest Yunnan Province, with high terrain around and low in the middle, with a drainage area of 2927.85km2 (Erhai Lake area of 252km2), with a total population of 883900 and GDP of 45.832 billion yuan. The main development of the basin is planting and animal husbandry. The water environment pollution caused by the development of agriculture is mainly manifested in the use of chemical fertilizer in planting industry and feces produced by livestock in animal husbandry. As one of the important tourist attractions in Yunnan, Erhai Lake Basin has rich tourism resources. In recent years, Dali tourism industry has developed rapidly, and the number of tourists has increased continuously, more than 10000. The output value of tourism industry has also greatly increased, which has become one of the important factors affecting the environment of Erhai Lake Basin.

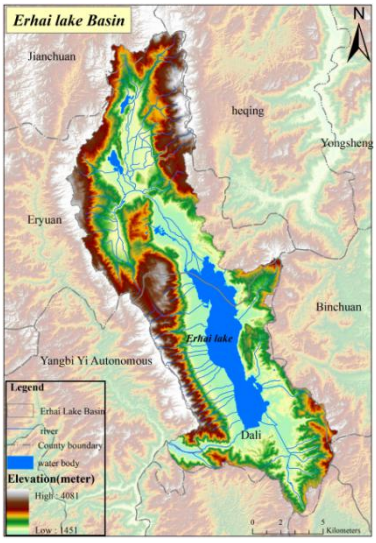

Figure 3. Location of Erhai Lake Basin

4.2. methods

- Trend analysis

In this paper, the slope of least square method (OLS) is used to establish the linear regression relationship between years and socio-economic factors.

$$\theta_{slop} = \frac{n \times \sum_{i=1}^{n} i \times X_i - \sum_{i=1}^{n} i \sum_{i=1}^{n} X_i}{n \times \sum_{i=1}^{n} i^2 - (\sum_{i=1}^{n} i)^2} \quad (1)$$

Where: the regression coefficient (y) represents the trend of the variable (Xi), i represents the year, Xi represents the GDP / population distribution data of the corresponding year in i year, and n is the study period. θslope > 0 indicates that GDP / population shows an increasing trend, and θ slope < 0 indicates a decreasing trend of GDP / population.

- Correlation analysis

In this study, correlation analysis is used to study the relationship between economic factors and lake water quality

$$r_{ab} = \frac{\sum_{i=0}^{n} (a_i - \bar{a})(b_i - \bar{b})}{\sqrt{\sum_{i=0}^{n} (a_i - \bar{a})^2 \sum_{i=0}^{n} (b_i - \bar{b})^2}} \quad (2)$$

- Estimation of non-point source pollution

Rainfall and topography are important factors affecting the transport of non-point source pollution, both of which play a key role in surface source pollution. We choose the output coefficient model to estimate the non-point source pollution. The structure of the model is as follows:

$$L = \alpha\beta \sum_{i=1}^{n} E[A_i(I_i)] + P \quad (3)$$

Where, L is the loss of nutrients; Ei is the output coefficient to i nutrient source; Ai is the area of land use type i or the number of livestock and population of type i;Ii is the nutrient input of the ith nutrient source; P is the nutrient input of precipitation. α is the rainfall impact factor, which is used to characterize the impact of rainfall on pollution; β is the terrain impact factor, which is used to characterize the impact of terrain on pollution.

4.3. Data

The land use data is derived from the global land cover data of 30 meters developed by China (http://www.globallandcover.com/defaults.html?src=/Scripts/map/defaults/download.html&head=download&type=data). In this study, the land cover type data of Erhai Lake Basin in 2000 and 2020 are selected for research.

The concentration data of TN, TP and COD are from China national environmental monitoring station (www.cnemc.cn). Is the monthly average data from June 2012 to July 2018.

Social and economic data are from China resource and environment science and data center （http://www.resdc.cn/Default.aspx）.GDP data is derived from China's GDP spatial distribution grid data set, with a resolution of 1km and data unit of 10000 yuan / km^2.The population distribution data is derived from the grid data set of China's population spatial distribution. The resolution is 1km, and the data unit is person / km^2. GDP and population distribution data are selected in 2000, 2005, 2010 and 2015.

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