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Analysis of Carbon Sequestration based on Ecosystem Value Service Model

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Abstract

This paper combined with the national land use, ecological environment and the desert in northern ningxia selecting distribution GIS map data biome, mathematical model is established as a case study of yinchuan, we collected 2006-2015 in yinchuan carbon oxygen consumption, land utilization, GDP, population, urbanization rate, gross industrial production. First through the carbon and oxygen balance factor analysis and the analysis of decoupling relationship between carbon and oxygen consumption, it is concluded that the relationship between economic system and ecological system of yinchuan, yinchuan judged by Pearson carbon oxygen consumption coefficient method and the correlation of other related, choose one of the strong correlation indicators, multiple linear regression equation to establish carbon oxygen consumption. Through the analysis of land use in Yinchuan by ecosystem value service model, the carbon sequestration and oxygen release of each type of land are calculated, and the difference between carbon sequestration and oxygen consumption is analyzed. The grey system prediction model is used to predict the GDP, population, urbanization rate, industrial GDP and other indicators of Yinchuan in 2022, so as to conclude that the carbon emission in 2022 is 20.716,600 t and the oxygen consumption is 2.4065,400 t. According to the GIS map of desertification, biology and reservoir of Yinchuan city, the ecological area was planned and the land type was planned. After calculation, the planned carbon sequestration was 29.1586 million T and the oxygen release was 2.406539 million T. After planning, the carbon sequestration was 8.445 million T and the oxygen release was 7.7016 million T.

Keywords

Carbon-oxygen Balance Coefficient; Pearson Coefficient Method; Grey System Prediction; Soil Sequesters Carbon and Releases Oxygen.

1. Establishment of Ecosystem Model

1.1 Carbon Oxygen Balance Model

Plants absorb CO2 and H2O through photosynthesis and solar energy to produce O2 and glucose Its respiration is opposite to photosynthesis. The chemical equation is as follows:

$$CO_2 + H_2O \rightarrow \text{glucose} + 0_2 \tag{1}$$

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The dry matter produced by plant growth needs to be absorbed and released. The carbohydrate consumed by plants is the reverse process of photosynthesis. The demand is the amount produced by photosynthesis, and the excretion is absorbed during photosynthesis, so as to make the and in the biosphere relatively balanced. With human activities, ecosystems become more complex, and the process of carbon and oxygen balance becomes more complex. Based on this condition, the balance of carbon and oxygen can be understood as: the absorption and release of green plants in the growth process and the consumption produced and consumed in the process of human production and living activities reach a balance of revenue and expenditure. The carbon and oxygen balance model includes two parts: emission and consumption, fixation and release The former is mainly caused by the energy consumption of production and life, and the latter refers to the photosynthesis and self-regulation ability of regional ecosystem The carbon oxygen balance model is shown below:

$$\begin{aligned} BC_c &= C_E / C_S \\ BC_o &= O_E / O_S \end{aligned} \tag{2}$$

In formula (2), it refers to the carbon balance coefficient and the oxygen balance coefficient, which respectively represent the ratio of emissions and fixed amounts, and the ratio of consumption and release in the regional composite ecosystem If it is less than or equal to 1, it means that the urban emissions can be fully absorbed by the regional natural ecosystem, the net output of the regional ecosystem can meet the local demand, and the regional ecological economic system is in a state of sustainable development; On the contrary, if the and are greater than 1, it indicates that the regional eco - economic system is in the state of unsustainable development.

1.2 Tapio Decoupling Analysis

Decoupling refers to breaking the link between environmental hazards and economic development, or breaking the link between environmental pressure and economic benefits. The research on the relationship between regional economic growth and resources and environment is a core research content of decoupling. Decoupling index analysis method is an important method to study decoupling. Tapio decoupling model analyzes the relationship between carbon and oxygen consumption and economic development. The calculation formula of carbon and oxygen consumption decoupling is as follows:

$$R_c = \frac{\Delta C_E / C_E}{\Delta GDP / GDP} and R_c = \frac{\Delta O_c / O_c}{\Delta GDP / GDP} \tag{3}$$

Where: R_c represents decoupling index, which represents the change of carbon emission and oxygen consumption with the development of economy; ΔC_E represents the growth of CO2 emissions relative to the previous year; ΔGDP represents the growth of GDP relative to the previous year; ΔO_c represents the growth of oxygen consumption relative to the previous year.

1.3 Multiple Linear Regression Model

Multiple linear regression model refers to a linear regression model with multiple explanatory variables, which is used to explain the linear relationship between the explained variables and other explanatory variables. Its mathematical model is:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p + \varepsilon \tag{4}$$

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The above formula represents a pary linear regression model, which can be seen that there are p explanatory variables. It indicates that the change of the explained variable y can be composed of two parts: the first part is the linear change of Y caused by the change of P explanatory variables X:

$$\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_p x_p \tag{5}$$

The second part is to explain the part of y change caused by random variables, which can be replaced by part, which can be called random error. The parameters in the formula are unknown quantities of the equation, which can be expressed as partial regression constant and regression constant, so the regression equation of the multiple linear regression model is:

$$E(y)=\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_p x_p \tag{6}$$

1.4 Grey Prediction Model

1.4.1 Data Inspection and Processing

In order to ensure the feasibility of GM (1,1) modeling method, it is necessary to test and process the known data. Set the original data column as X (0) = (x0 (1), x0 (2) x0(n))x(0)=(x0(1),x0(2),…. X0 (n)), calculate the order ratio of the sequence:

$$\lambda(k)=\frac{x^{(0)}(k-1)}{x^{(0)}(k)},k=2,3,\ldots,n \tag{7}$$

If all order ratios fall within the allowable coverage range, the series can establish GM (1,1) model and carry out grey prediction. Otherwise, the data shall be properly transformed, such as translation transformation:

$$y^0(k)=x(0)+c;k=2,3,\ldots,n \tag{8}$$

Take C so that the level ratio of the data column falls within the allowable coverage.

1.4.2 Establish GM (1,1) Model

Let's assume that the above requirements are met, take it as the data column to establish GM (1,1) model, and use regression analysis to obtain the estimated values of a and B, so the corresponding whitening model is:

$$\frac{dx^{(1)}(t)}{dt}+ax^{(1)}(t)=b \tag{9}$$

Solution:

$$x^{(1)}(t)=\left(x^{(0)}(1)-\frac{b}{a}\right)e^{-a(t-1)}+\frac{b}{a} \tag{10}$$

So the predicted value is obtained:

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$$\hat{x}^{(1)}(k+1)=\left(x^{(0)}(1)-\frac{b}{a}\right)e^{-ak}+\frac{b}{a},k=1,2,\ldots,n-1 \tag{11}$$

Thus, the predicted value is obtained accordingly:

$$\hat{x}^{(0)}(k+1)=\hat{x}^{(1)}(k+1)-\hat{x}^{(1)}(k+1),k=1,2,\ldots,n-1 \tag{12}$$

1.4.3 Inspection Prediction Value

Residual test: calculate the relative residual:

$$\varepsilon(k)=\frac{x^{(0)}(k)-\hat{x}^{(0)}(k)}{x^{(0)}(k)},k=2,3,\ldots,n \tag{13}$$

If for all| ε (k)|<0.1| ε (k) | < 0.1, it is considered to meet higher requirements; Otherwise, if all| ε (k)|<0.2| ε (k) | < 0.2, it is considered to meet the general requirements.

Level ratio deviation value inspection: Calculation:

$$\rho(k)=1-\frac{1-0.5\alpha}{1+0.5\alpha}\lambda(k) \tag{14}$$

If for all| ρ (k)|<0.1| ρ (k) | < 0.1, it is considered to meet higher requirements; Otherwise, if for all| ρ (k)|<0.2| ρ (k) | < 0.2, it is considered to meet the general requirements.

2. Solution of Ecosystem Model

2.1 Carbon and Oxygen Balance Calculation

The carbon emission and oxygen consumption of Yinchuan from 2006 to 2015 are collected as shown in the figure below:

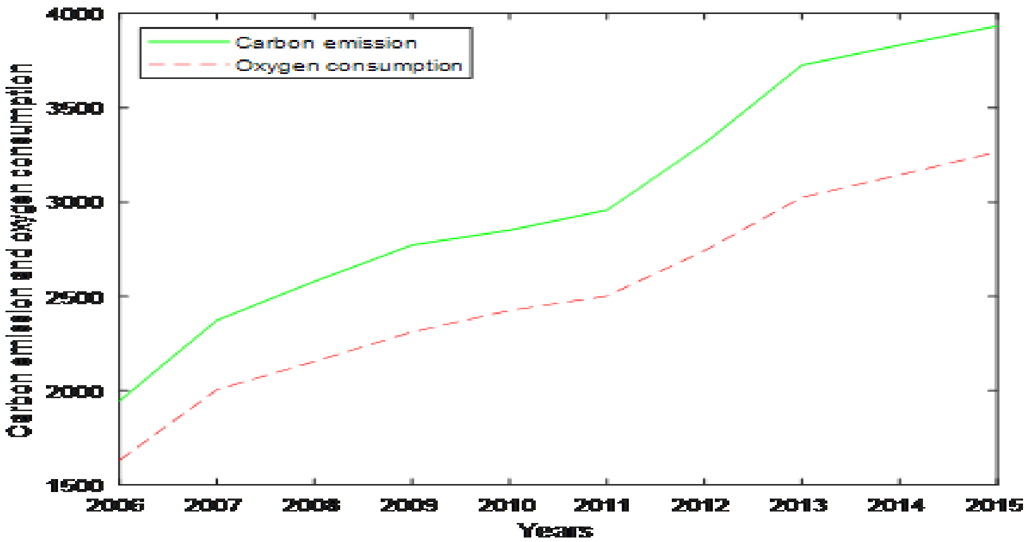

Figure 1. 2006-2015 Yinchuan city carbon emission and oxygen consumption

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From 2006 to 2015, the carbon and oxygen consumption of Yinchuan City showed an overall growth trend, and the total CO2 emission increased from 1945.21 million tons to 39.3307 million tons, an increase of 2.02 times; The total O2 consumption increased from 16.3063 million tons to 32.6533 million tons, an increase of 2.01 times. Compared with the past, the carbon and oxygen consumption has increased significantly, mainly due to the acceleration of economic growth and the great improvement of urbanization and industrialization, resulting in a significant increase in carbon and oxygen consumption; Secondly, the economic development of Yinchuan mainly depends on the increase of fossil energy use.

2.2 Calculation of Carbon Fixation and Oxygen Release

Extract the actual area of five types of natural ecosystems in Yinchuan, which are divided into cultivated land, garden land, forest land, grassland, water area and other agricultural land. The proportion of land distribution area in Yinchuan is shown in the figure below:

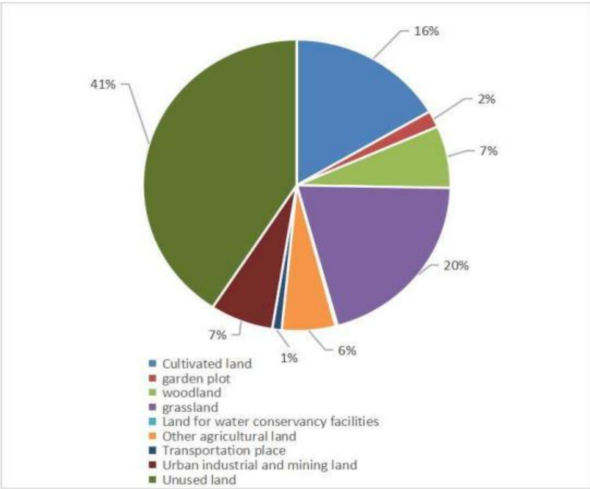

Figure 2. Land area distribution of natural ecosystem in Yinchuan city

Population, labor force, economic development, urban expansion, policy system and other factors drive the change of cultivated land area in Yinchuan, which leads to the decrease of carbon sequestration and oxygen release from cultivated land. Population, labor force and GDP are shown in the figure below:

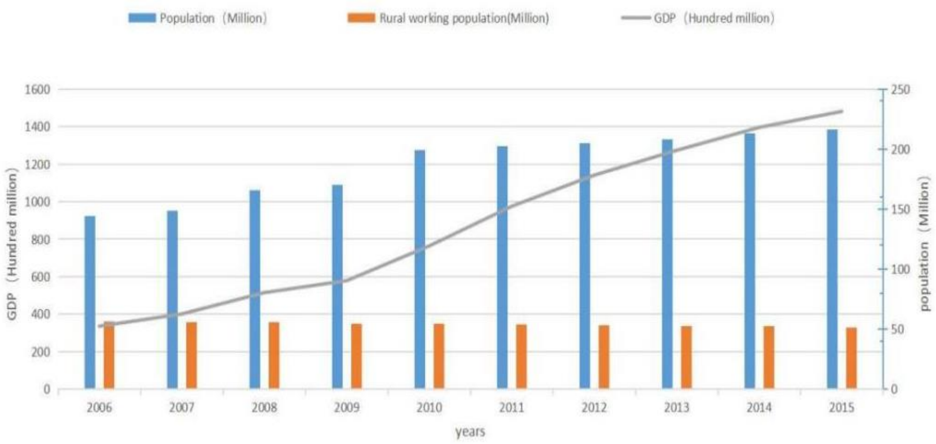

Figure 3. 2006-2025Changes of Population, labor force and GDP in Yinchuan

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From 2006 to 2015, the total population increased from 1442800 to 2164100. The rapidly growing population led to an increase in the demand for urban construction land and prompted the conversion of a large number of cultivated land in Yinchuan, most of which were converted to urban construction land. From 2006 to 2015, the number of agricultural labor force in Yinchuan has been in a downward trend. The city's agricultural population is obviously non-agricultural. A large number of young labor force enter the city and change into non-agricultural population, which leads to the change of agricultural production activities, and then relates to the conversion of cultivated land to other land. Since the reform and opening up, Yinchuan's GDP has increased from 33.5 billion yuan in 2006 to 148.073 billion yuan in 2015. With the continuous improvement of economic level and the continuous adjustment of industrial structure, the land use efficiency of urban land is higher than that of cultivated land. However, most of cultivated land is located in urban fringe areas, which are easy to be converted into urban construction land. Urban expansion accelerated

Using the calculation model of carbon fixation and oxygen release and relevant parameters, the total annual fixed amount of CO2 and total annual release amount of O2 in Yinchuan natural ecosystem from 2006 to 2015 are calculated.

Table 1. Carbon sequestration and oxygen release of cultivated land and forest land

Cultivated land						
Year	Cultivated land	Proportion	Carbon sequestration	Proportion	Oxygen release	Proportion
2006	159828.5	18.01%	401.9687	23.93%	592.0048	24.98%
2007	145697.6	16.42%	366.4295	21.78%	539.6639	22.76%
2008	145697.6	16.42%	366.4295	21.63%	539.6639	22.60%
2009	143894	16.21%	361.8934	21.30%	532.9834	22.26%
2010	147027	16.57%	369.7729	21.65%	544.588	22.62%
2011	145216.2	16.36%	365.2187	21.45%	537.8808	22.42%
2012	144415	16.27%	363.2037	21.24%	534.9132	22.20%
2013	142695.8	16.08%	358.8799	21.04%	528.5452	22.00%
2014	142328.7	16.04%	357.9567	21.03%	527.1855	21.99%
2015	142205.8	16.02%	357.6476	21.02%	526.7303	21.97%
Woodland						
Year	Cultivated land	Proportion	Carbon sequestration	Proportion	Oxygen release	Proportion
2006	54698.5	6.16%	236.8992	14.11%	327.2611	13.81%
2007	58945.9	6.64%	255.2947	15.17%	352.6733	14.87%
2008	58966.8	6.65%	255.3852	15.07%	352.7984	14.77%
2009	61152.6	6.89%	264.8519	15.59%	365.876	15.28%
2010	61048.6	6.88%	264.4015	15.48%	365.2538	15.17%
2011	61596.1	6.94%	266.7727	15.67%	368.5295	15.36%
2012	62567	7.05%	270.9777	15.85%	374.3384	15.54%
2013	62492.5	7.04%	270.655	15.87%	373.8926	15.56%
2014	62337.9	7.02%	269.9854	15.86%	372.9677	15.56%
2015	62432.3	7.03%	270.3943	15.89%	373.5325	15.58%

2.3 Carbon Oxygen Balance Analysis

Carbon oxygen balance coefficient is used to measure the relationship between the two. According to the model analysis results, 2006-2015 is shown in the figure below:

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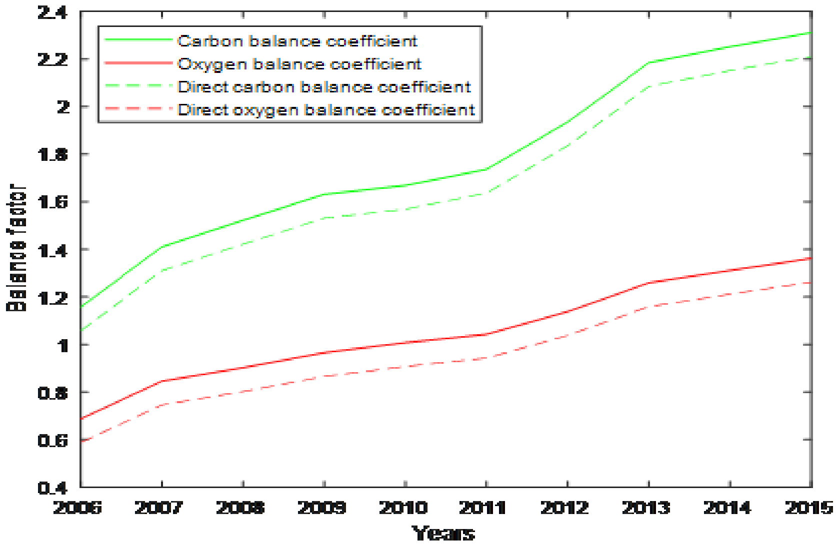

Figure 4. Carbon and oxygen equilibrium coefficient

The carbon balance coefficient of Yinchuan city increased from 1.16 to 2.31, and the oxygen balance coefficient increased from 0.69 to 1.36 Indirect carbon and oxygen consumption mainly refers to the carbon and oxygen consumption of electricity and transportation. In the carbon and oxygen consumption of roads, railways and civil aviation, this part of carbon and oxygen consumption is generated outside the area, but it contributes to the GDP growth of Yinchuan city. The carbon balance coefficient is significantly higher than the oxygen balance coefficient regardless of indirect carbon and oxygen emission or direct carbon and oxygen emission. Therefore, it can be found that the relationship between the economic system and ecosystem in Yinchuan is uncoordinated, the carbon and oxygen balance has been seriously damaged, and the city is in a non-equilibrium state of carbon and oxygen.

The change value of carbon emission and oxygen consumption intensity per unit output value from 2006 to 2015 is shown in the figure below:

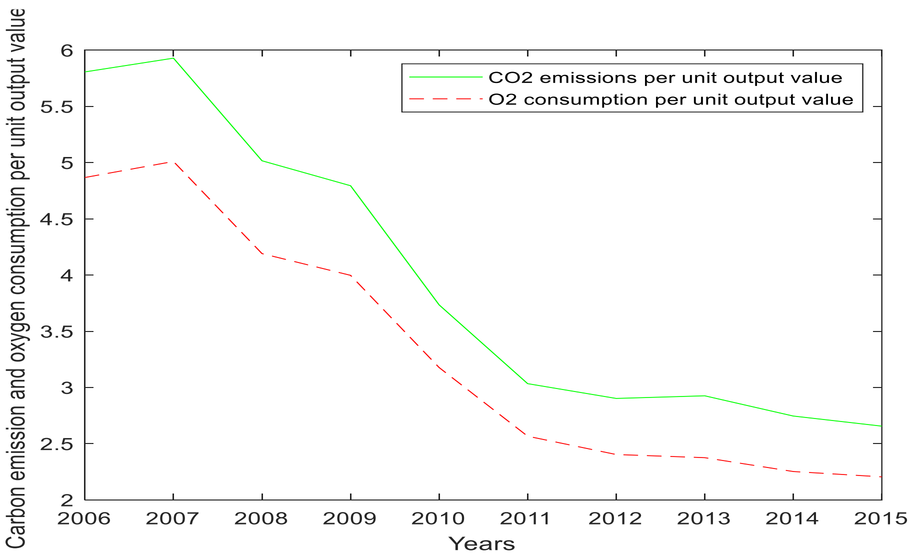

Figure 5. 2006-2015 change of carbon and oxygen emission intensity

From 2005 to 2016, the carbon and oxygen consumption per unit GDP of Yinchuan city was in a downward trend, indicating that with the improvement of economic development level and the

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continuous investment in science and technology, the energy utilization efficiency of Yinchuan city was in a rising trend.

2.4 Prediction of Carbon Emission and Oxygen Consumption

Using SPSS software, the linear regression analysis between CO2 emission, O2 consumption and GDP, total industrial output value, urbanization rate, population and construction land area from 2005 to 2061 is carried out. The R2 of CO2 emission and O2 consumption are 0.969 and 0.978 respectively, with a high degree of fitting, and the regression equation is established according to this:

Regression equation of CO2 emission: $y = 9.183x_1 - 12.904x_2 - 0.047x_3 - 4.59x_4 + 5538.47x_5 + 22516.73$.

The regression equation of O2 consumption is $y = 8.23x_1 - 12.03x_2 - 0.045x_3 - 2.32x_4 + 5279.78x_5 + 21010.55$.

According to the grey prediction model, the GDP, total industrial output value, urbanization rate, population and construction land area of Yinchuan City in 2022 are predicted. The results are as follows:

Table 2. forecast result

GDP	Gross industrial output value	City rate	population	land used for building
2293	1150	0.82	240.91	554127.2

Brought into the multiple linear regression equation:

In 2022, the CO2 emission is 61.25 million tons and the O2 consumption is 49.0915 million tons, of which two-thirds are absorbed by the ocean and one-third by the land. The land absorption is 20.7166 million tons of CO2 and 24.0654 million tons of O2.

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