Green Development Evaluation System of Tuojiang River Basin

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Abstract. This paper analyzes the green development level of five key cities in the Tuojiang River Basin, which are Zigong, Luzhou, Deyang, Neijiang and Ziyang. Through relevant literature analysis method and data query method, the green development evaluation system indicators are integrated with the economic-social-natural-resource system. On this basis, we choose a variety of representative indicators for comparison, and sum up the green development indicator system which is suitable for the Tuojiang River Basin. The evaluation model is established by the method of grey correlation analysis, and the model is applied to the analysis of correlation degree. Finally, based on the calculation results, the paper put forward opinions and suggestions for the green development of the Tuojiang River Basin.

1. Introduction

The concept of green development is to pursue the harmonious coexistence of man and nature as well as to achieve the goal of sustainable development through constructing green low-carbon cycle system and an ecological civilized society [1]. Currently, the new development concept of green development is gradually popularized and it also becomes an essential development trend in the world. The majority of countries and nations have widely integrated green development into various economic fields and more and more countries try to implement the new concept of green development to achieve national economic development transformation and adjustment.

The Tuojiang River is a tributary of the upper reaches of the Yangtze River in Sichuan, which runs from the southern foothills of Juding Mountain and passes through Ziyang City, Neijiang City, Zigong City, Deyang City, to the intersection of Luzhou City and the Yangtze River. There are 19 cities in Tuojiang River Basin including Chengdu, Chongqing, Suining, etc. There are thousands of industrial chemical plants, and it is one of the largest cotton and sugarcane producing area in Sichuan. However, the Tuojiang River, as one of the most important river in Sichuan Province, has serious water pollution [2]. At the same time, many obstacles appeared in the process of promoting pollution prevention. For example, the water quality compliance rate is not enough high. The long-term impact of internal source pollution in river channels and the poor fluidity of many river sections cause serious environmental pollution issues. The large funding gap for water pollution prevention by encouraging various types of investment is an urgent issue [3]; the system of watershed prevention is lack of...
systematic problem diagnosis and comprehensive pollution control. The situation is contrary to the requirements of economic, social, natural development and resource protection. To realize the imagination of the 19th National Congress of the Communist Party of China, it is crucial to promote the green development of the Tuojiang River Basin.

2. Green development evaluation system of Tuojiang River Basin

2.1. Grey relational analysis

The paper applies the Grey relational analysis method [4] and the application of the method can be beneficial to evaluating the green development basing on the trend. Thus, the requirement of the data is not so high and the calculation method is relatively simple and the research result is more consistent with the qualitative analysis result. The degree of green development is mainly reflected from the four aspects of economy, society, resources and nature. What’s more, the green development system is established by the grey association analysis method to evaluate the green development of the Tuojiang River basin city, and the correlation degree of the four factors is analyzed. The evaluation results of green development can eventually be conducive for the improvement countermeasures and suggestions.

The following are the steps of the grey association analysis:

1. Determine the analysis index system according to the purpose of analysis, and collect the analysis data.

2. The data is dimensionless, because the meaning of each index of the system is different, the unit is different, and the data dimension is different. After dimensionless, it is convenient to make comparison, and then obtain the correct conclusion. Therefore, in the Grey relational analysis generally must carry on the dimensionless data processing. The dimensionless method includes initial value method, mean value method and interval method.

3. Determine the reference series and calculate the absolute value of the difference between the reference series and the comparison series. The formula is \( \Delta = \left| x_0(k) - x_i(k) \right| \) \( (k=1, 2, \ldots, n, i=1, 2, \ldots, m, m \) is the number of evaluation objects and \( n \) is the number of indicators).

4. Determination \( \xi_i(k) = \frac{\min \min \left| x_0(k) - x_i(k) \right| + \rho \max \max \left| x_0(k) - x_i(k) \right|}{\left| x_0(k) - x_i(k) \right| + \rho} \).

5. Calculate the average value of the correlation degree of the evaluation object index to get the result and analyze it.

2.2. Construction of index system

The construction of index system can be conducive to make evaluation to green development in Tuojiang River Basin and further support the research result. The green development plan can be communized in various places and can be summarized as economic structure transformation, life style transformation, energy structure optimization and ecological environment protection, which perfectly integrates with the four evaluation indexes of economy society resource nature constructed, combines the current characteristics and the development status of the flowing area.

There are more than 1000 factories and large-scale cotton production bases in Tuojiang River Basin. To some extent, it has a rapid development so that it is of great importance to measure and evaluate its economic development. Many economic indicators showed the development status and level of the five cities in this area, the economic development and scale were measured by per capita GDP and GNP, while the resource utilization and environmental protection were measured by the tertiary industry added value index, the proportion of energy conservation and environmental protection investment [5].
Among the social indicators, education and living standards are also a direct reflection of the development level of a region. Education can be the policy of rejuvenating the country and education expenditure reflects the importance of a region.

Tuojiang River Basin is abundant in resources, but the per capita resource is not high enough. Thus, making full uses of resources as possible is the top priority. The water and energy consumption of GDP in the index can be the reflection for the utilization rate and green level of resources. However, the forest coverage and green coverage of Tuojiang River Basin are very unbalanced so that the forest and green coverage reflect the investment in environmental protection.

The green development of economy, society or ecology, the environmental quality and pollution control ability under the natural indicators determine the green development level of a region. Generally speaking, it is of great importance to construct the system to further study the utilization of resources and the protection level of ecological environment.

Table 1. Analysis of Green Development Indicators in the Tuojiang River Basin.

| First-level indexes | Second-level indexes | Specific indicators |
|---------------------|----------------------|---------------------|
| economic-indicators | size of the economy  | GDP                 |
|                     |                      | gross value of production |
|                     | industrial structure | Value added index of tertiary industry |
|                     |                      | Investment in energy conservation and environmental protection as a share of GDP |
|                     |                      | The growth rate of total industrial added value for the whole year |
|                     |                      | fixed-asset investment |
| social-indicators   | educational level    | Education expenditure accounts for the proportion of government expenditure |
|                     |                      | University degree or above |
|                     | living level         | Urban per capita disposable income |
|                     |                      | urbanization rate |
| resource-indicators | resource utilization | Daily domestic water consumption per capita |
|                     |                      | forest coverage rate |
|                     |                      | Green coverage rate of built-up area |
|                     |                      | Energy consumption of gross regional product |
| nature-indicators   | environmental quality | Annual average concentration of PM2.5 |
|                     | The ability of the pollution treatment | City air quality good or equal to 2 standard days |
|                     |                      | treatment rate of domestic sewage |
|                     |                      | Municipal solid waste disposal rate |

3. Numerical experiment
Through the 2018 Sichuan provincial yearbook and local bulletins, the paper analyzed the data of 18 evaluation indicators of 5 cities, as shown in the table below.
Table 2. Data Table of Typical City Indicators.

| First-level indexes | Second-level indexes | Specific indicators | Zigong | Luzhou | Deyang | Neijiang | Ziyang | Index properties |
|---------------------|---------------------|---------------------|--------|--------|--------|----------|--------|------------------|
|                     | economic-indicators | GDP                 | 46182  | 37020  | 55607  | 35521    | 40137  | positive correlation |
|                     |                     | gross value of production | 1312.07 | 1596.21 | 1960.55 | 1332.09  | 1022.21 | positive correlation |
|                     |                     | Value added index of tertiary industry | 109.5 | 109.5 | 110 | 109 | 108.6 | positive correlation |
|                     |                     | Investment in energy conservation and environmental protection as a share of GDP | 0.01149 | 0.03243 | 0.03338 | 0.01623 | 0.0107 | positive correlation |
|                     |                     | The growth rate of total industrial added value for the whole year | 9.40 | 9.7 | 9.7 | 7.1 | 9.20 | positive correlation |
|                     |                     | fixed-asset investment | 832.24 | 2042.11 | 1311.4 | 860.18 | 594.1 | positive correlation |
|                     | social-indicators  | educational level    | Education expenditure accounts for the proportion of government expenditure | 16.31% | 18.80% | 15.08% | 18.19% | 18.82% | positive correlation |
|                     |                     | University degree or above | 1808 | 6173 | 3142 | 1530 | 185 | positive correlation |
|                     |                     | living level          | Urban per capita disposable income | 31016 | 31449 | 31609 | 30393 | 30867 | positive correlation |
|                     |                     | urbanization rate     | 50.92% | 48.95% | 50.98% | 47.90% | 41.34% | positive correlation |
|                     | resource-indicators | resource utilization  | Daily domestic water consumption per capita | 119.25 | 127.09 | 123.84 | 144.09 | 134.75 | negative correlation |
|                     |                     | forest coverage rate  | 35.01 | 50.4 | 24.5 | 34.13 | 39.8 | positive correlation |
|                     |                     | Green coverage rate of built-up area | 41.4 | 40.75 | 42 | 32.87 | 36.82 | positive correlation |
|                     |                     | Energy consumption of gross regional product | 0.531 | 0.705 | 0.560 | 0.972 | 0.391 | negative correlation |
|                     | nature-indicators  | environmental quality | Annual average concentration of PM2.5 | 66 | 52.6 | 54 | 46 | 36.1 | negative correlation |
|                     |                     | City air quality good or equal to 2 standard days | 229 | 273 | 247 | 277 | 303 | positive correlation |
|                     |                     | The ability of the pollution treatment | treatment rate of domestic sewage | 93.19 | 93.06 | 91.19 | 90.01 | 85.37 | positive correlation |
|                     |                     | Municipal solid waste disposal rate | 96.5 | 100 | 100 | 100 | 100 | positive correlation |

The following table shows the average value of the relational coefficient of the five cities, which is the result of the grey correlation analysis of the Green Development Index.

Table 3. Results of average correlation coefficient of typical cities.

|         | Zigong | Luzhou | Deyang | Neijiang | Ziyang |
|---------|--------|--------|--------|----------|--------|
| Result  | 0.765  | 0.894  | 0.848  | 0.717    | 0.778  |

4. Discussion

In order to further improve the industrial system and accelerate and harmonious development of economy and environment, the five cities of Tuojiang River Basin must focus on the construction of ecological civilization and the protection of green resources. Therefore, it is imperative for Tuojiang River Basin to transform towards green development.

(1) According to the above calculations, the "value added index of tertiary industry" is obviously higher in other indicators, which shows that this index was closely related to the green development of the Tuojiang River Basin. The existence of the tertiary industry is conducive to the improvement of the social market, accelerate development, and improve the comprehensive national power and human living standards of our country.
(2) Human being is supposed to sustainably increase education spending under the premise of educational basic guarantee. On the one hand, in the process of management, it can further strengthen talent training through elevating education expending. On the other hand, education expenditure and the number of graduates of ordinary colleges are also important factors to attract foreign personnel, which provide the premise and potential for the green development of the basin.

(3) It is because that China is in the stage of rapid economic and industrial development and it means that China will inevitably be accompanied with a large amount of resource consumptions. Although China has abundant resources, it has a large population and its per-capita share of resources is below the world average. Therefore, the Tuojiang River basin should complete the transformation of economic development mode as soon as possible. Taking new energy, new materials, energy saving and emission reduction is the focus of the new round of economic development.

(4) The green development of any region can be correlated to the improvement of pollution control capacity. Through analyzing the pollution control capacity in the evaluation index, the pollution control of the Tuojiang River basin can still be improved, and the proper treatment of urban pollution can better protect the environmental resources. The improvement of pollution control capacity should install with the pollution control facilities. Only through studying the pollution control strategy of advanced countries and inventing more excellent mechanical equipment can our country's pollution control ability be further improved.

5. Conclusion
The green development level of the five cities is similar. The calculation results show that the order of green evaluation index of five major cities in Tuojiang River Basin is generally from high to low and respectively Luzhou, Deyang, Ziyang, Zigong, Neijiang, except Luzhou's green development index is close to 0.9, the other four cities' green development index is between 0.717-0.848, which shows the green development level is close, and the overall green development situation of the city still entail improvement. For example, the gap between the rich and the poor within the city is obvious, and the unbalanced development of the city is characterized significantly. Luzhou, for example, has a GDP of 159.621 billion yuan, the second largest of the five cities, but its per capita GDP is only 37,020 yuan, ranking fourth in the five cities. In addition, some cities pursue urban economic development one-sidedly and neglect green environment construction and protection, Deyang is a typical example, whose per capita GDP is 55607 yuan and its gross national product is 19.6055 billion yuan, both of which are the highest in five cities, but its forest cover is only 24.5 percent, the last in five cities.

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