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Sustainable Development Capability Evaluation of Coal Resource-Based Cities Based on WEAP Model

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Abstract: From the perspective of my country and the world, the development of coal resource-based cities will inevitably lead to resource depletion. As the leading industry and economic pillar of urban development, coal resources will be fatal to the economic development of cities once the resources are exhausted. Therefore, how to realize the sustainable development(SD) of coal resource-based cities(CRBC) has become a long-term and urgent task in our country. M City is a city developed by relying on coal resources. Therefore, this paper takes M City as an example to analyze the economic development of M City from the perspectives of economic sustainability, social sustainability, resource sustainability and environmental sustainability, and uses the WEAP model to evaluate The average development efficiency of M city, and the ranking of M city's SD ability, and then put forward targeted improvement suggestions and measures to enhance the ability of SD. It is hoped that the research results of this paper can provide help and reference for the future development of CRBC.

1. Introduction

With the development of coal resources, for a long time, due to the lack of scientific and rational planning and the exhaustion of resources, these cities have accumulated many problems and contradictions in the development process. Problems such as ecological destruction, gradual exhaustion of resources, lagging development of successive alternative industries, increase of unemployed population, and single economic structure. These problems seriously restrict the SD of the city's economy.

At present, many scholars have carried out in-depth research on the evaluation of the SD capability of CRBC. For example, some researchers use the DEA method to model, select the energy data of prefecture-level administrative regions with proven coal reserves of more than 1 billion tons, and obtain the SD capacity of this CRBC. Then, the influencing factors of SD are analyzed by regression [1]. A scholar constructed an index system for SD of coal resource-based cities. There are four index layers. The first-level indicators are sustainability coefficient and coordination coefficient. The second-level indicators are divided into three groups, namely social progress, environmental support, economic development, and three. The high-level indicators include 14 indicators such as the quality of life index, the ecological construction index, and the economic scale benefit index, analyze the factors affecting the SD of the city, and give reasonable suggestions [2]. In the process of my country's development, many contradictions such as unbalanced regional development, extensive economic development, and lack of reasonable planning and guidance have led to great challenges in the SD of CRBC. A SD evaluation system has been established for the city-type city, and the index system can reflect the overall performance and comprehensive development status of the urban SD system, and then evaluate the reliability of the system through the analytic hierarchy process and the WEAP method [3-4]. Although the research results on the SD capacity of CRBC are good, the methods used to evaluate the SD capacity still need to be improved.

This paper first analyzes the characteristics of CRBC, and proposes to evaluate the SD capacity of cities from economic and environmental perspectives. Therefore, this paper selects the economic and industrial structure data of M city according to the four levels of the SD system. , social development data, "three wastes" emission data and coal resource data, and then evaluate the SD capability of M city through the WEAP model, and finally put forward suggestions for improving the SD capability of CRBC.

2. Theory

2.1. Coal Resource-based Cities

The characteristics of CRBC are: (1) The industrial structure is relatively simple, the continuous replacement industry is weak, and the dependence on coal and other resources is relatively large, so the evaluation of the urban industrial structure should be reflected; The enterprise is in short supply and the situation is not optimistic, so it should reflect the economic evaluation; ③ the environmental damage is more serious, especially the air pollution and water pollution, so there should be an environmental evaluation; ④ the resource consumption is huge, especially in the mining process. The consumption of coal resources is relatively large, so there should be an evaluation of resources [5-6].

2.2. The Principle of WEAP Model

WEAP is a comprehensive planning tool. WEAP can simulate the impact of future population and economic changes of a city, a watershed or a system on the demand and supply of local resources [7]. WEAP can assess how resources are used, developed, selected, managed, and the impact.

$$U=\left\{\frac{f(m)\cdot g(n)}{\left[\frac{\alpha f(m)+\beta g(n)}{2}\right]^{2}}\right\}^{x} \tag{1}$$

$$\begin{cases} f(m)=\sum_{i=1} p_i m_i \\ g(n)=\sum_{j=1} q_j n_j \end{cases} \tag{2}$$

Among them, M is the coordination degree, m_i is the i-th city feature, n_j is the j-th economic feature, and p and q are the weights describing the features. f(m) is a comprehensive environmental function, and g(n) is a comprehensive economic function.

3. Selection of SD Data

The overall goal of the SD system in this paper is the SD of coal resource-based cities, and SD should take into account the following four aspects of balanced SD:

(1) Economic SD data: Economic SD is the link for the SD of the entire city. Only with healthy and sustainable economic growth, optimizing the industrial structure, and driving good employment and consumption can society be stabilized, people's material living standards can be improved, and education, medical care, and environmental protection can be guaranteed by funds. Specifically, it should pursue a stable economic growth rate, sufficient economic scale, a reasonable industrial structure, and a moderate degree of economic export [8-9].

(2) Social SD data: Social SD is the goal of urban development. Only by guaranteeing various livelihood issues in society can society be harmonious and stable. Specifically, it should achieve a livable living environment, good education and medical resources, convenient transportation facilities, and a perfect security system [10-11].

(3) SD of resources and energy: The SD of resources and energy is the driving force of urban development. If resources are exhausted, cities cannot continue to grow. Improve the efficiency of resource use and avoid extensive development methods [12]. The use of science and technology and innovative power to develop new environmentally friendly energy, such as the development of solar cars, can reduce the consumption of oil. Nuclear power plants, hydropower plants, and wind power plants are more environmentally friendly and energy-saving than coal power plants [13].

(4) Data on SD of the ecological environment: The SD of the ecological environment is the premise of urban development. Without a good ecological environment, human beings will not be able to survive. Our human existence is inseparable from clean water sources, fertile soil, fresh air, and a balanced natural food chain [14]. Today, due to the savage way of human development of the economy, the brutal plunder and destruction of the natural world, leading to species extinction and ecological imbalance, our cities are full of smog, sewage, heavy metal pollution, mountains of garbage, oil spills, melting glaciers, and ozone holes. Etc., the harsh environment has already caused respiratory diseases, cancer, etc. that threaten human survival [15].

4. Analysis of Results

4.1. M City SD Data Processing

(1) Research on economic system data

M City is a resource-based city developed by relying on coal resources. The coal-based industry constitutes the main growth point of the output value of the secondary industry. Coal-related coal mining, coal washing, power generation, coal chemical industry and other extended industries account for a large proportion of the industrial structure. Judging from the information in Figure 1, the output value of the primary industry and the output value of the tertiary industry have increased each year, but the proportion of the total output value in the tertiary industry has been declining, while the output value of the secondary industry in the total output value has been accounted for. has been steadily rising. The proportion of the output value of the secondary industry will increase from 57.5% in 2015 to 66.5% in 2021. The proportion of the output value of the primary industry in GDP will only be 6.5% in 2021, and the largest proportion will be 13.1% from 2015 to 2021. The proportion of the output value of the tertiary industry in GDP will rebound between 2016 and 2017, or from 16 The proportion of 32.8% in 2021 dropped to 27% in 2021. This clearly shows that the secondary industry has made a great contribution to the development of the national economy in M city.

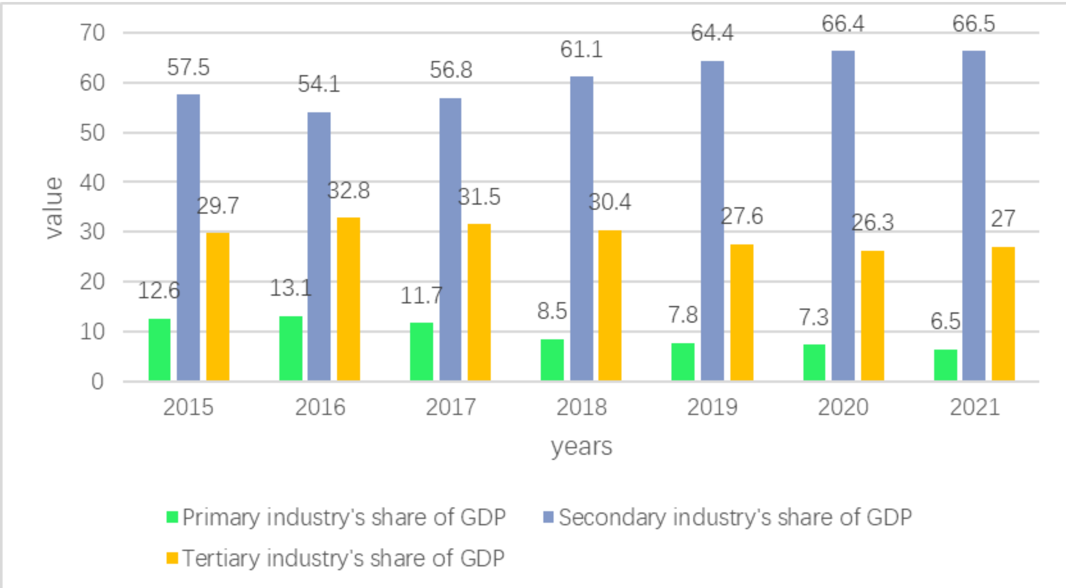

Figure 1. Industrial structure data

(2) Research on social system data

As shown in Table 1, the per capita income of urban residents and rural residents in M City will increase by about 1.5 times in 2021 compared with 2015, indicating that the income level of the people is increasing, which is related to the development of the industrial and coal industries in M City. However, comparing the Engel coefficient between urban and rural areas, the difference is very small, indicating that the consumption level of urban and rural people's investment in food is not much different, but from the perspective of per capita income, urban per capita income is much higher than rural per capita income, which shows that other materials and Spiritual construction and other aspects of rural areas should be strengthened, and urban and rural construction should be combined to drive rural economic growth.

Table 1. Social development data

	2015	2016	2017	2018	2019	2020	2021
Urban per capita income (yuan)	3627	4246	4518	5329	4873	4721	5156
Engel's coefficient of towns (%)	44.58	43.65	42.13	40.73	41.67	39.40	41.45
Rural per capita income (yuan)	1875	2041	2194	2576	2803	3252	3347
Rural sigel's coefficient (%)	46.95	45.37	45.26	42.19	41.47	40.68	40.43

(3) Environmental system data research

Along with the exploitation of natural resources, some by-products are also produced, such as coal mining, a large amount of dust accumulation, floating dust deposition affects the air quality and causes damage to the environment, and a large amount of coal mining causes the surface to sink and the land to collapse. The environmental carrying capacity of resource-based cities is relatively under pressure, and the analysis of environmental indicators directly reflects the degree of SD of M city. Figure 2 shows the emission of "three wastes" in M city. The discharge of industrial waste gas was the highest in 2016, the discharge of industrial wastewater showed a trend of increasing first and then decreasing, and the discharge of solid waste increased year by year, with the largest increase in 2017.

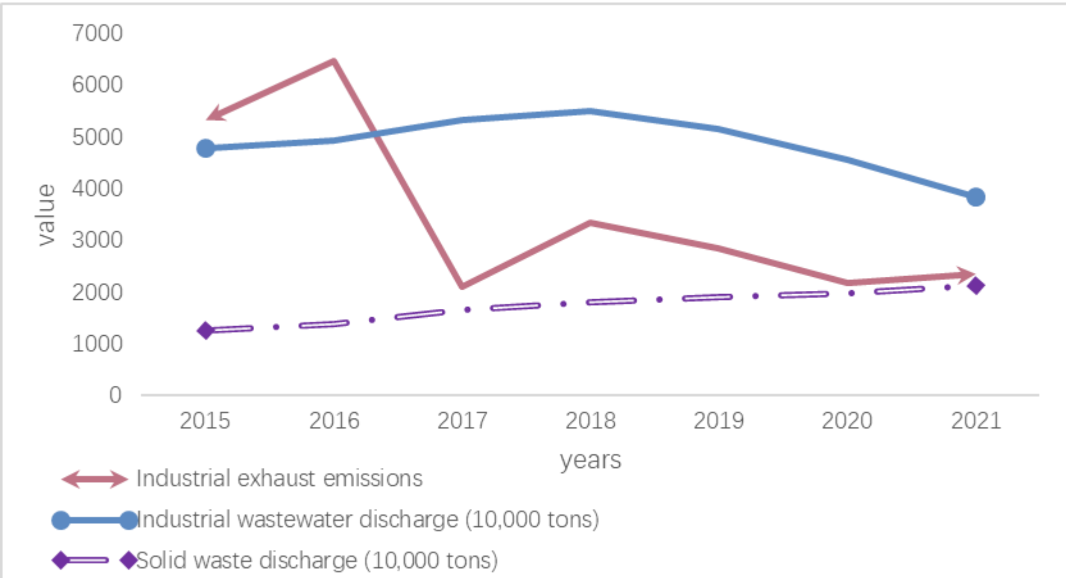

Figure 2. "Three Wastes" emissions

(4) Research on resource system data

As shown in Table 2, the coal reserves of M City in 2021 are 794 million tons, and the mining-reserve ratio is calculated based on this. middle. The exploitation and utilization of these resources has promoted the economic development of M city, but at the same time, we should realize that the non-renewable resources will inevitably be exhausted.

Table 2. Resource data

	2015	2016	2017	2018	2019	2020	2021
Proportion of coal mining and reserves	6.42	6.57	6.61	6.89	7.35	7.77	7.94
Raw coal output (10,000 tons)	4583	4792	5017	5429	6234	6542	6638

4.2. Evaluation of SD Efficiency Based on WEAP Model

Table 3. WEAP evaluation of SD capability of city M

	2015	2016	2017	2018	2019	2020	2021
Efficiency value	76.2%	73.5%	84.8%	91.7%	86.4%	93.5%	90.6%
Ranking	6	7	5	2	4	1	3

After standardizing the SD data of the above M city, the economic, social, environmental, resource and other data are entered into the WEAP model, and the EIS software is used to analyze the SD capability. The results of the development efficiency of M city in each year are shown in Table 3. . It can be seen from the table. Among the average development efficiency of M city from 2015 to 2021, the development efficiency in 2020 is the highest, reaching 93.5%. The SD capacity from 2016 to 2018 continued to increase, and it weakened in 2019.

4.3. Suggestions for the SD of CRBC

(1) Continuing and replacing industries with development advantages

We should keep up with the pace of the times, actively grasp the changes in market demand and the trend of technological progress, and strive to develop emerging industries and new pillar industries. For example, using the "Internet +" thinking, combining education, shopping, tourism, culture and other industries with the Internet, giving full play to the advantages and resources of the Internet era. Another example is to vigorously develop the service industry, and the rapid development of the tourism industry can add a lot of vitality to the city's economy. These emerging industries are not only low-carbon, environmentally friendly, and efficient, but also make a huge contribution to attracting employment [16].

(2) Promote scientific and technological innovation and improve management level

Enterprises use science and technology to vigorously develop new material industries, new clean energy, and renewable energy, such as nanomaterials, high-performance rare earth materials, and so on. Cities with resource advantages can actively develop new energy industries such as biomass energy, wind energy, geothermal energy, and ocean energy according to local conditions [17].

Environmental protection departments should increase management efforts to deal with the damage to the ecological environment during the mining of coal resources, and enterprises should also take precautions before pollution begins. In-depth analysis of many problems involved in coal resource mining, the establishment of strict environmental impact assessment, and the establishment of coal enterprises and the issuance of certificates are closely linked [18].

(3) Improve the environment and strengthen ecological protection

The government rationally guides energy conservation, environmental protection, and low-carbon green industries through policies, reforms and innovations. In addition, a series of support and guarantees such as the introduction of high-tech, the introduction of high-quality talents, and venture capital support are provided to some technological and environmental-friendly enterprises. For example, increasing taxes on high-polluting and energy-intensive industries, or tax relief and preferential policies for environmental protection and high-tech innovation industries. Give full play to the management functions of the government, guide the healthy and sound development of the industry, and allocate resources rationally [19].

(4) Improve the space of coal industry

Explore the potential of resource utilization and improve the utilization efficiency of coal resources. Updating excavation equipment and using new technologies to explore deep coal resources has formed a scientific and technological innovation system based on enterprises and the combination of research institutes and universities. Taking advantage of the inherent advantages of coal resources, we will actively explore new methods of coal-to-electricity conversion, study new methods of direct power supply, and develop high-level, high-quality, and high-capacity industries.

5. Conclusion

Based on the WEAP model, this paper analyzes the SD capacity of coal resource-based cities represented by M city, and finds that the SD capacity of M city is relatively higher in the past two years. In this paper, the suggestions for improving the SD capacity of CRBC are only a preliminary discussion, and they need to be further deepened and improved in future research. The selection of SD evaluation data in this paper and the evaluation method of WEAP model need to be enriched and gradually improved in the follow-up research.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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