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Classification of Environmental Management Types of Coal Development in China Based on Composite Ecosystem Theory

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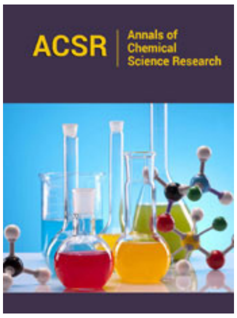

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Abstract

Energy is an important material basis for the survival and development of human society. Among them, coal resource is one of the important energy mineral resources. In terms of China's situation, energy development should focus on coal based thermal power production. But the development and utilization of coal will have a serious impact on the ecological environment. At present, China's total carbon emissions rank first in the world. Therefore, improving energy utilization technology, vigorously developing circular economy, improving energy utilization efficiency and optimizing energy structure are effective methods to solve the environmental problems caused by coal utilization. Coal development environment is a complex ecosystem of nature, society and economy. Based on the development of regional energy, economy, environment and energy economy environment system, this paper studies the theory and technology method system of coal development environment research. The "complex ecosystem theory" is applied to the study of environmental management of coal development. The principal component analysis method combined with fuzzy comprehensive evaluation method is used to comprehensively evaluate the coal development environment in China. The vulnerability types of coal development ecological environment in China are preliminarily divided, and a set of new theory and method system of regional energy and environment regulation based on coal is explored. The results show that the ecological environment of most provinces in China is very fragile. It is suggested that under the premise of doing a good job in project ecological environment impact assessment and ecological environment protection measures, we should try our best to tap the potential of resources and develop them moderately. The division results can provide a reference for China's ecological environment governance.

Keywords: Composite ecosystem; Coal development; Environmental management; Ecological vulnerability; Fuzzy comprehensive evaluation

Introduction

Energy is the material basis of economic and social development, among which coal is one of the important basic energies [1]. Coal development will have direct or indirect adverse effects on human health and ecological environment [2], such as depression and anxiety [3], and the emergence of a large number of organic pollutants in the environment of the industrial region [4]. The rational development and utilization of coal resources directly affect the sustainable development of coal industry and environment. The problems in the process of coal development, such as low utilization rate of coal resources, disorderly development, super-intensity mining, air and water pollution, have attracted widespread attention [5-7]. Coal environment is a composite ecosystem of three different properties, which is composed of society, economy and nature. The social ecological subsystem is dominated by human behavior. Economic subsystem is the production, circulation, consumption, reduction and regulation of human beings for their own survival and development. The natural subsystem is composed of water, gas, soil, and life, The environment on which human beings depend on survival and reproduction is formed by the relationship between minerals and their interrelations [8]. The evaluation of coal development complex ecosystem is one of the effective methods for environmental management and control. The energy value theory can be used to evaluate the adverse impact of coal mining on environment and human health [9-10].

British botanist Arthur George Tansley put forward the concept of ecosystem in 1935. He believed that ecosystem is a unity composed of biological community and its natural environment in a certain range of time and space [11]. Professor Ma Shijun, an outstanding ecologist in China, put forward the theory of compound ecosystem in 1981. He pointed out that the natural environment, society and economy on which human beings depend for survival are three different systems. Their survival and development are restricted by the structure and function of other systems. They must be regarded as a compound system, which we call social economic natural compound ecosystem [12]. Many scholars at home and abroad apply the theory of complex ecosystem to environmental research. Yang et al. [13] applied the theory of complex ecosystem to the comprehensive evaluation and management of rice ecosystem sustainability, and found that the anti-interference ability and stability of rice ecosystem in China weakened from 2009 to 2017, and the sustainability of rice ecosystem deteriorated. Wang et al. [14] studied the ecosystem functions of different geomorphic types in Beijing Tianjin Hebei region from 2000 to 2018. The results showed that three key ecosystem service factors: soil erosion, water yield and net primary productivity (NPP) had certain interaction. Pearson coefficient showed that soil erosion and water yield, water yield and NPP had a synergistic relationship, there is a compromise between soil erosion and NPP. The results can provide a reference for the comprehensive evaluation of ecosystem services and the management of ecosystem regionalization. Leijstera et al. [15] studied the ecosystem service function of agroforestry system in Columbia City in recent 40 years. The results showed that the aboveground carbon storage, habitat allocation, timber storage and coffee bean quality all followed a positive asymptotic trajectory. Agroforestry measures can be used to restore the development and sustainable supply of ecosystem services.

However, there are few reports on the theory and method of energy environment complex ecosystem regulation at home and abroad. Heuvel et al. [16] studied the ecosystem services in the relationship of water energy food land climate in Sweden: the interaction of human pressure and physics, focusing on the synergistic effect of Biophysics, socio-economic and social interaction among water, land, energy, food and climate in the level of Biophysics, socio-economic and governance The trade-off between conflict and relevance. Agus et al. [17] studied the organic carbon storage and its dynamics in the ecological restoration area after the open-pit coal mining in the tropical rainforest. The study found that in the tropical rainforest forest ecosystem, the mining of open-pit coal mining is leading to land degradation and destruction, and the extremely degraded area can be restored by reconstructing the fast-growing species and vegetation, It is expected to recover its biomass and organic carbon storage rapidly. Li et al. [18] studied the evolution characteristics of forest spatial pattern in China's northern coal energy province in the past 30 years, and found that the change of forest spatial pattern is a key process of landscape dynamics, which has an important impact on the changes of forest ecosystem biodiversity, habitat quality and even the overall function. Aggregation index (AI), maximum patch index (LPI), patch density (PD) and shape index (SI) are the four main landscape indicators.

It is of great significance to study the dynamic mechanism and cybernetic method of energy environment complex ecosystem for the sustainable development of China. At present, the research on the evaluation of coordinated development of economy environment society complex ecosystem has gradually changed from qualitative and static analysis to quantitative and dynamic trend evaluation. The evaluation models mainly include input-output model [19], EKC econometric model [20], grey system model [21], comprehensive evaluation model of coordinated scheduling and coordinated development degree [22], etc. These models have their own advantages and disadvantages and application scope, which promote the research progress in this field to a certain extent. Composite system is an open, nonlinear, dynamic and complex large-scale system, which involves many objectives and is easily affected by external factors. Different factors also directly affect the results of empirical analysis. According to the above analysis of game and coordination of economic and environmental development, the state or degree of system coordination can be reflected by mathematical model or quantitative method. Based on the principles of comprehensiveness, representativeness, quantification, operability and scientificity, this paper selects appropriate indicators to build an energy environment composite ecosystem evaluation index system.

The research on vulnerable areas of ecosystems can be traced back to 1905, when Clements, an American ecologist, introduced the concept of ecological transition zone into ecological research [23]. Ecosystem vulnerability is the process of any natural and man-made action on the ecological vulnerable zone, which occurs in a certain space and time range [24]. Cao [25] constructed the evaluation index system of ecological vulnerability, constructed the poverty evaluation index system of county level from the social and economic aspects, quantitatively analyzed and discussed the coupling relationship between the two, in order to provide decision-making basis for the study area to strengthen the ecological environment protection. Zhang [26] pointed out that the selection of ecological vulnerability evaluation indicators should be combined with the vulnerability characterization of the study area, and should be scientifically selected from the leading factors leading to vulnerability. Generally, topography, geomorphology, climate, hydrology, soil and geology can be used as potential vulnerability factors. When the degradation of ecological environment exceeds the current level of human utilization and development, we call it fragile ecological environment. The fragile ecological environment seriously restricts the development of regional economy and society, and poses a serious threat to the sustainable development of the region. Therefore, it is of great significance to evaluate the vulnerability of China's coal development ecological environment concretely and objectively.

Based on the development of regional energy, economy, environment and energy economy environment system, this paper studies the theory and technology method system of coal development environment research. The "complex ecosystem theory" is applied to the study of environmental management of coal development, and an integrated index system of regional energy, environment and economy (3e) regulation is initially established. The principal component analysis combined with fuzzy comprehensive evaluation method is used to comprehensively evaluate China's coal development environment, and the vulnerability types of China's coal development ecological environment are preliminarily divided, A new theory and method system of regional energy and environment regulation based on coal is explored.

Research Methods

Research data sources

The data in this paper involve economic, ecological and social systems. The data range is 2010-2020, and the data are mainly from meteorological statistics, forestry statistics yearbook, China Statistics Yearbook, China Energy Yearbook, coal industry statistics yearbook and relevant statistical data of various provinces.

Construction of index system of composite ecosystem

It is very important to build a composite ecosystem evaluation index system for the evaluation of ecological environment vulnerability in China. Based on the availability of data, with reference to the research of Liu et al. [27-29] and combined with the actual situation of the research area in China, from the four dimensions of energy, economy, environment and ecology, this paper selects energy production, energy consumption, economic structure, economic growth, ecological scale, ecological protection and other indicators (Table 1) to build a composite ecosystem evaluation index system.

Table 1: Evaluation index system for regulation and control of regional energy and environment composite ecosystem.

Target layer	Criterion layer	Index layer
Evaluation index system of ecological vulnerability of coal development in China	energy production	C_{11}: per capita energy production / T standard coal
		C_{12}: raw coal output per capita / T
		C_{13}: power generation per capita / (K·wh)
	energy consumption	C_{14}: per capita energy consumption / T
		C_{15}: elasticity coefficient of energy consumption /%
	energy utilization	C_{16}: 10000yuan GDP energy consumption / T standard coal / 10000 yuan
		C_{17}: energy processing and conversion efficiency /%
	economic scale	C_{21}: per capita GDP / yuan
	economic structure	C_{22}: proportion of tertiary industry in GDP /%
	economic growth	C_{23}: GDP growth rate /%
		C_{24}: growth rate of added value of tertiary industry /%
	economic performance	C_{25}: per capita income of urban residents / yuan
		C_{26}: per capita net operating income of rural households / yuan
		C_{27}: per capita education expenditure / yuan
	environmental pollution	C_{31}: SO_2 emission / 10000 t
		C_{32}: PM_{10} / μ g/m^3
		C_{33}: domestic waste per capita / T
	environmental governance	C_{34}: comprehensive utilization rate of industrial solid waste /%
		C_{35}: harmless treatment rate of domestic waste /%
	environmental investment	C_{36}: proportion of environmental pollution investment in GDP /%
	ecological scale	C_{41}: water resources per capita / m^3
		C_{42}: plantation area / hm^2
		C_{43}: per capita cultivated land area / mu
	ecological quality	C_{44}: forest coverage /%
		C_{45}: urban green coverage rate /%
	ecological protection	C_{46}: proportion of nature reserves in land area /%

Evaluation model and method

Coordination degree analysis of complex ecosystem

Coordination degree is a measure of the degree of harmony between the system or the internal elements of the system in the development process, reflecting the trend of the system from disorder to order. It is a quantitative indicator of the coordination of energy, economy, environment and ecosystem. Referring to the capacity coupling coefficient model in physics, the coupling coordination degree formula of China's economy ecology environment composite ecosystem is constructed:

$$C=\left[\frac{U_1\times U_2\times U_3}{(U_1+U_2)\times(U_1+U_3)\times(U_2+U_3)}\right]^{\frac{1}{3}} \quad (1)$$

Among them, C is the coupling degree, and U1, U2 and U3 are the development indexes of ecological subsystem, economic subsystem and environmental subsystem respectively. The higher the C is, the closer the relationship between the systems is and the stronger the coupling strength is.

Coupling degree can reflect the closeness of each subsystem, but it cannot represent the coordinated development level of complex ecosystem. In order to characterize whether the functional systems are in a high-level promotion state or a low-level constraint state, this paper introduces a coupling coordinated development model. The improved coupling coordination model is as follows:

$$D=(C\times X)^{\frac{1}{3}} \quad (2)$$

$$X=\alpha U_1+\beta U_2+\gamma U_3 \quad (3)$$

Where D is the coupling co scheduling, C is the coupling degree, and X is the comprehensive development index of the composite functional system. α, β, γ. For the weight parameters of each subsystem, this paper considers that the ecological subsystem, economic subsystem and environmental subsystem are equally important, so the ecological subsystem is the most important, α=β=γ=1/3, That is, D reflects the development level of complex ecosystem, the higher the better.

Classification of coal reserves

Referring to the relevant statistical data, the statistics of coal reserves in China's provinces in 2010 are shown in Table 2. At present, there is no unified international classification of coal reserves. Some reserves classifications adopted now are developed on the basis of the three-level classification proposed by Goodwell in 1909 and in combination with their own characteristics.

Table 2: Index weight of regional energy environment composite ecosystem.

Target layer	Weight
Beijing	0.035
Hebei province	0.029
Shan xi province	0.029
Tianjing city	0.032
Liaoning province	0.033
Neimenggu	0.038
Shanghai city	0.031
Hunan city	0.031
Xizang	0.058
Jilin province	0.032
Xin Jiang	0.03
Heilong province	0.035
Zhejiang province	0.035
Jiangxi province	0.03
Anhui province	0.027
Sichuan province	0.032
Fujian province	0.033
Shan dong province	0.032
Ningxia	0.029
Jiangsu province	0.031
Hubei province	0.028
Guangdong province	0.038
Hainan province	0.031
Chong qing city	0.028
Guizhou province	0.031
Guangxi province	0.028
Yunnan province	0.033
Shanxi province	0.031
Gansu province	0.03
Qinghai province	0.027

Assessment and prediction of ecological environment vulnerability

Ecological environment vulnerability assessment and prediction [30-31]. Ecological vulnerability assessment includes static assessment and dynamic assessment. The evaluation indexes of ecological vulnerability mainly include productivity index, carrying capacity index and ecological sensitivity index. The main evaluation methods include analytic hierarchy process, principal analytic hierarchy process, fuzzy comprehensive evaluation method, landscape pattern index method, grey relational analysis method, evaluation method based on remote sensing GIS, neural network method, matter-element extension model, etc., and have the trend of diversification, complexity and integration; After the evaluation, they were graded according to the evaluation results. Ecological vulnerability classification is one of the key links to intuitively express the results of ecological vulnerability assessment. The classification is based on ecological threshold and combined with the actual situation of ecological vulnerable areas. The common methods include natural break point method and equal spacing classification method. The main methods of ecological vulnerability prediction include ecological footprint method, scenario analysis method, system dynamics simulation model, 3S technology and so on.

At present, the classification standard of ecological environment vulnerability has not been unified. In this study, the eco-environmental vulnerability assessment is divided into three levels: target level, criterion level and index level; The criteria layer is used to reflect the internal coordination of China's eco-environmental vulnerability, which is composed of four parts: energy, economy, environment and ecology; The index layer reflects the specific indicators of each criterion layer in the evaluation of ecological environment vulnerability, and is composed of 30 specific evaluation indicators reflecting the ecological vulnerability of the study area, which is the basis of the evaluation of ecological environment vulnerability.

Determination of index factor weight

In the evaluation of ecological vulnerability, the selected index factors have different influence and importance on the ecosystem. In order to ensure the scientificity of the analysis, the weight is usually used to express the importance of the indicators. In this paper, the principal component analysis method is used to determine the weight of each indicator. The results are shown in Table 2. From Table 2, it can be seen that the weight value of Xizang in 31 comments is the highest, which is 0.058.

1) Principal component analysis (PCA): Principal component analysis (PCA) is based on the relationship between the various indicators, using the method of dimensionality reduction to convert multiple indicators into a few unrelated indicators, so that the next step of research becomes a simple statistical method. After standardized operation, the data are dimensionless and can be evaluated and analyzed.

2) Spss19 statistical analysis software was used to conduct principal component analysis on the above 30 evaluation factors. The results are shown in Table 3.

Table 3: Characteristic value, contribution rate and cumulative contribution rate of each component in fragile ecosystem of coal development in China.

Principal Component	Explained Variance (%)	Cumulative Explained Variance (%)	Characteristic Value
1	89.641	89.621	28.679
2	4.476	94.098	1.432
3	3.740	97.838	1.197
4	2.115	99.954	0.677
5	0.044	99.997	0.014
6	0.003	100.0	0.001

The above table analyzes the situation of principal component extraction and the information amount of principal component extraction. It can be seen from Table 3 that three principal components were extracted by principal component analysis, and the eigenvalue values were all greater than 1. The variance interpretation rates of these three principal components were 89.621%, 94.098%, 97.838% respectively, and the cumulative variance interpretation rate was 97.838%. In addition, three principal components were extracted in this analysis and their corresponding weights were 89.621/97.838=91.60%; 4.476/97.838 = 4.58%; 3.740/97.838=3.82%; This shows that 97.838% of the information provided by the ecological vulnerability evaluation index can be reflected, which summarizes the main information of the original index, and also conforms to the principle of principal component extraction with the cumulative variance contribution rate of more than 80%; At the same time, it also shows that the principal component analysis method is reliable to evaluate the environmental ecological vulnerability of China's coal development.

3) Table 4 shows the initial factor load matrix, that is, the factor load coefficient divided by the square root of the corresponding characteristic root.

Table 4: Factor load matrix analysis results.

Name	Load Factor			Common Factor Variance
	Principal component 1	Principal component 2	Principal component 3	
Beijing city	0.989	0.141	-0.021	0.998
Tianjing city	0.792	0.578	-0.026	0.0962
Shanxi province	0.998	-0.053	-0.018	1.000
Hebei province	0.997	-0.066	-0.018	1.000
Neimenggu	0.997	-0.069	-0.017	1.000
Xinjiang	0.999	-0.036	-0.011	1.000
Qinghai province	0.880	0.419	0.207	0.992
Jilin province	0.998	-0.058	-0.17	1.000
Ningxia	0.977	0.199	-0.019	0.994
Gansu province	0.998	-0.057	-0.017	1.000
Guangdong province	0.997	-0.071	-0.017	1.000

Liaoning province	0.998	-0.065	-0.017	1.000
Shanxi province	0.998	-0.065	-0.017	1.000
Hainan province	0.998	-0.065	-0.017	1.000
Hubei province	0.998	-0062	-0.017	1.000
Zhejiang province	0.998	-0.060	-0.017	1.000
Shandong province	0.998	-0.063	-0.018	1.000
Heilongjiang	0.998	-0.068	-0.017	1.000
Jiangsu province	0.998	-0.028	-0.018	1.000
Henan province	0.997	-0.068	-0.017	1.000
Fujian province	0.997	-0.068	-0.017	1.000
Sichuan province	0.997	-0.075	-0.017	1.000
Xizang	0.177	0.212	0.843	0.786
Guangxi province	0.997	-0.076	-0.017	1.000
Yunnan province	0.997	-0.074	-0.016	1.000
Guizhou province	0.997	-0.072	-0.016	1.000
Chongqing city	0.999	-0.040	-0.016	1.000
Hunan province	0.997	-0.075	-0.017	1.000
Anhui province	0.997	-0.070	-0.017	1.000
Jiangxi province	0.997	-0.072	-0.016	1.000
Shanghai city	0.612	0.754	-0.021	0.944

4) The comprehensive score coefficient is calculated, that is, the linear combination coefficient is multiplied by the variance interpretation rate and then accumulated and divided by the cumulative variance interpretation rate; Calculate the weight and normalize the comprehensive score coefficient to get the weight value of each index. The calculation results are shown in Table 5.

Table 5: Comprehensive evaluation results of ecological vulnerability of coal development in China.

Name	Principal Component 1	Principal Component 2	Principal Component 3	Comprehensive Score Coefficient	Weight	Vulnerability Intensity
Characteristic root	28.679	1.432	1.197			
Variance interpretation rate	89.62%	4.48%	3.74%			
Beijing city	0.1846	0.1176	-0.0190	0.1738	3.39%	strength
Tianjing city	0.1479	0.4829	-0.0242	0.1567	3.06%	strength
Shanxi province	0.1864	-0.0446	-0.0161	0.1681	3.27%	strength
Hebei province	0.1863	-0.0551	-0.0162	0.1675	3.27%	strength
Neimenggu	0.1862	-0.0575	-0.0158	0.1673	3.27%	strength
Xinjiang	0.1866	-0.0301	-0.0102	0.1691	3.30%	strength
Qinghai province	0.1643	0.3497	0.1894	0.1737	3.39%	strength
Jilin province	0.1864	-0.0486	-0.0151	0.1679	3.28%	strength
Ningxia	0.1824	0.1660	-0.0177	0.1740	3.40%	strength
Gansu province	0.1864	-0.0476	-0.0153	0.1680	3.28%	strength
Guangdong province	0.1862	-0.0593	-0.0159	0.1672	3.27%	strength
Liaoning province	0.1863	-0.0544	-0.0159	0.1675	3.27%	strength
Shanxi province	0.1863	-0.0541	-0.0156	0.1676	3.27%	strength
Hainan province	0.1864	-0.0496	-0.0128	0.1679	3.28%	strength
Hubei province	0.1863	-0.0519	-0.0153	0.1677	3.28%	strength
Zhejiang province	0.1863	-0.0500	-0.0156	0.1678	3.28%	strength
Shandong province	0.1863	-0.0526	-0.0162	0.1676	3.27%	strength

Heilongjiang	0.1862	-0.0570	-0.0155	0.1674	3.27%	strength
Jiangsu province	0.1866	-0.0236	-0.0165	0.1692	3.31%	strength
Henan province	0.1862	-0.0568	-0.0160	0.1674	3.27%	strength
Fujian province	0.1862	-0.0570	-0.0152	0.1674	3.27%	strength
Sichuan province	0.1861	-0.0623	-0.0155	0.1671	3.26%	strength
Xizang	0.0330	0.1771	0.7740	0.0678	1,32%	light
Guangxi province	0.1862	-0.0633	-0.0155	0.1670	3.26%	strength
Yunnan province	0.1861	-0.0621	-0.0150	0.1671	3.26%	strength
Guizhou province	0.1861	-0.0602	-0.0150	0.1672	3.27%	strength
Chongqing city	0.1865	-0.0332	-0.0148	0.1688	3.30%	strength
Hunan province	0.1861	-0.0623	-0.0156	0.1671	3.26%	strength
Anhui province	0.1862	-0.0582	-0.0156	0.1673	3.27%	strength
Jiangxi province	0.1862	-0.0603	-0.0148	0.1672	3.27%	strength
Shanghai city	0.1143	0.6300	-0.0191	0.1328	2.59%	moderate

5) Fuzzy comprehensive evaluation: This study mainly adopts fuzzy comprehensive evaluation method [32], which transforms qualitative evaluation into quantitative evaluation according to the membership theory of fuzzy mathematics, that is, to make an overall evaluation of things or objects restricted by many factors with fuzzy mathematics. The fuzzy comprehensive evaluation of the results of principal component analysis is carried out, and the evaluation results are realized with the help of statistical analysis software spss19.0.

In the quantitative evaluation of fragile ecological environment, the index system is established and weighted to calculate the vulnerability g of each province. In this paper, based on the principal component analysis method to determine the weight of each index, the fuzzy comprehensive evaluation method is used to analyze the ecological environment vulnerability of China's coal development. Referring to Hu et al. [33-34] on the classification method of ecological environment vulnerability evaluation in Weifang City, the evaluation grade standard is divided. According to the results of principal component analysis, 31 provinces and cities are divided into three categories according to the degree of vulnerability; The area with G greater than 0.10 and less than 0.15 is moderately vulnerable; The area with g less than 0.10 is considered to be slightly vulnerable. The results are shown in Table 6.

Table 6: Evaluation results of ecological vulnerability.

Vulnerability Assessment Level	Name of District
Weak strength ($x \geq 0.15$)	Beijing city、Tianjin city、Shanxi province、Hebei province, Inner Mongolia, Xinjiang, Qinghai province, Jilin province, Ningxia, Gansu province, Guangdong province, Liaoning province, Shaanxi province, Hainan province, Hubei province, Zhejiang province, Shandong province, Heilongjiang, Jiangsu province, Henan province, Fujian province, Sichuan province, Guangxi province, Yunnan province, Guizhou province, Chongqing, Hunan province, Anhui province, Jiangxi province
Moderate vulnerability ($0.15 > x \geq 0.10$)	Shanghai city
Mild vulnerability ($x < 0.10$)	Xizang

Data standardization

Because the dimension and magnitude of the original data are non-uniform, the original data must be standardized. After data standardization, the index value is between 0 and 1.

Results and Analysis

Coordination degree analysis of complex ecosystem

Coordination degree is a measure of the degree of harmony between the system or the internal elements of the system in the development process, reflecting the trend of the system from disorder to order. It is a quantitative indicator of the coordination of energy, economy, environment and ecosystem. Referring to the capacity coupling coefficient model in physics, the coupling coordination degree formula of China's economy ecology environment composite ecosystem is constructed. The coordination coupling degree of 21 provinces and cities in China is calculated, and the results are shown in Table 7. The larger the C value of coupling degree in different regions, the greater the interaction between the systems; The larger the D value of coupling coordination degree is, the higher the coordination degree is. As can be seen from Table 7, the coupling coordination level of China's economy society environment composite ecosystem is high, which is high quality coordination.

Table 7: calculation results of coupling coordination degree of different regions in 2010.

Term	C Value of Coupling Degree	Coordination Index t Value	D Value of Coupling Coordination Degree	Coordination Level	Coupling Coordination Degree
Item 1	0.991	2.355	1.528	16	–
Item 2	0.999	2.545	1.595	16	–
Item3	0.996	2.478	1.571	16	–
Item 4	0.931	1.311	1.105	12	–
Item 5	0.717	31912.065	151.224	1513	–
Item 6	0.961	41.119	6.287	63	–
Item 7	0.99	13.316	3.632	37	–
Item 8	0.982	11.509	3.362	34	–
Item9	0.797	19267.312	123.898	1239	–
Item 10	0.826	2701.622	47.226	473	–
Item 11	0.857	1202.225	32.094	321	–
Item 12	0.686	68.599	6.862	69	–
Item 13	0.186	0.717	0.365	4	Mild maladjustment
Item 14	0.879	65.781	7.603	77	–
Item 15	0	74.167	0	1	Extreme maladjustment
Item 16	0.64	2.007	1.134	12	–
Item 17	0.185	7079.637	36.218	363	–
Item 18	0.414	1932513.25	894.011	8941	–
Item 19	0.591	2.291	1.163	12	–
Item 20	0.799	31.308	5.003	51	–
Item 21	0.786	10.025	2.807	29	–

Classification of coal reserves

With reference to the relevant statistical data, the statistics of coal reserves of China's provinces in 2010 are shown in Table 8. According to the degree of investigation and research, China's coal reserves can be divided into a, B, C and D levels. Among them, Grade A and B are called advanced reserves. In this paper, according to 100 ~ 6.5 billion tons, 2.5 ~ 6.5 billion tons, 0 ~ 2.5 billion tons of coal reserves are classified into high, medium and low reserves.

Table 8: Coal resource reserves of China's provinces.

Name of Province (City, District)	Coal Reserves / 100 million tons	Reserves Classification
Beijing city	3.79	low
Hebei	60.59	middle
Shanxi	844.01	high
Inner Mongolia	769.86	high
Liaoning	46.63	middle
Jilin	12.40	low
Heilongjiang	217.80	high
Jiangsu	14.23	low
Zhejiang	0.43	low
Anhui	81.93	high
Fujian	4.06	low
Jiangxi	6.74	low
Shandong	77.56	high
Henan	113.49	high
Hubei	3.30	low
Hunan	18.76	low
Guangdong	1.89	low

Guangxi	7.74	low
Hainan	0.9	low
Sichuan	54.37	middle
Chongqing	22.49	low
Guizhou	118.46	high
Yunnan	62.47	middle
Xizang	0.12	low
Shanxi	119.89	high
Gansu	58.05	middle
Qinghai	16.22	low
Ningxia	54.03	middle
Xinjiang	148.31	high
Tianjin	2.97	low
Shandong province	77.56	high
	2793.90	

Division of coal development environmental management type area

To improve China's ecological carrying capacity and ensure ecological security, based on the theory of composite ecosystem, this paper preliminarily divides China's coal development reserves and ecological environment vulnerability types, and puts forward differentiated environmental management requirements and suggestions for different ecological vulnerability control areas. The results are shown in Table 9.

Table 9: Environmental management zoning and control requirements for coal development.

Ecological Risk Control Area	Partition Name	Range	Key Points of Environmental Management
development	High reserves Strong vulnerable area	Shanxi, Inner Mongolia, Heilongjiang, Anhui, Shandong, Henan, Guizhou, Shaanxi, Xinjiang, Shandong	The coal reserves are rich and the ecological environment is very fragile. It is suggested that the potential of resources should be tapped as much as possible on the premise of doing a good job in the ecological environment impact assessment and ecological protection measures of the project.
Appropriate development	Medium reserves Strong vulnerable area	Hebei Province, Liaoning Province, Sichuan Province, Yunnan, Gansu, Ningxia	The coal reserves are in the middle level and the vulnerability of ecological environment is high. It is suggested that the coal should be properly developed in strict accordance with the reserves and ecological environment factors.
Prohibited / Light Development Zone	Low reserves Strong vulnerable area	Chongqing, Qinghai Province, Tianjin	The coal reserves are low and the ecological environment is very fragile. It is suggested that Qinghai and Tibet should not be developed, and other provinces should be slightly developed.
Overall development zone	Low reserves Light vulnerable area	Xizang	Due to the low coal reserves and the low vulnerability of ecological environment, it is necessary to make further development strategies.

Conclusion and Suggestion

The fragile ecological environment is the result of the long-term interaction between natural factors and human activities. In order to realize the sustainable development of social economy, it is necessary to coordinate the ecological environment protection and social economic development. Based on the theory of complex ecosystem, this paper divides the environmental management area of coal development in China. According to the types of eco-environmental vulnerability in different regions of China, a new theory and method system of regional energy and environmental regulation based on coal is explored. It is suggested that the prevention and control of environmental pollution should be carried out according to the goal of "taking improving environmental quality as the core". The following conclusions are drawn from the management of energy and environment in China

1) In view of the slowdown of China's economic growth and the reduction of energy consumption dependence on coal, considering the environmental carrying capacity of coal development, it is suggested to appropriately adjust the mining intensity of China's coal resources.

2) Sustainable development has increasingly become the ideal goal of development and environmental management, and the measurement or evaluation of sustainable development is one of the important issues.

3) In this paper, the "complex ecosystem theory" is applied to the study of environmental management of coal development. The principal component analysis combined with fuzzy comprehensive evaluation method is used to make a comprehensive evaluation of China's coal development environment, and the vulnerability types of China's coal development ecological environment are preliminarily divided.

4) According to the comprehensive evaluation results of the ecological environment vulnerability of the study area, aiming at the existing resources and environmental problems in the region, this paper puts forward the strategy of insisting on sustainable development and differentiated environmental management requirements, so as to protect China's ecological environment.

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