Analysis of Influencing Factors of Ecological Suitability in Shendong Mining Area

Rigen Mo[1,a], Rong Meng[1,b] and Yangnan Guo[2,c]

[1]Desert Science and Engineering College, Inner Mongolia Agricultural University, Hohhot, 010018, China;

[2]Technology Research Institute, Shenhua Shendong Coal Group Co., Ltd., Yulin 719315, China.

[a]morigen71@emails.imau.edu.c.n, [b]mengrong@imau.edu.cn, [c]21608003@mail.imu.edu.cn

Abstract

Select the Shendong mining area as the research object, select the 2000 Landsat 5TM and 2015 Landsat 8OLI_TIRS remote sensing images, use ARCGIS software to process the Shendong mining area remote sensing image map, distribute 150 random sample points on the remote sensing image map, and use the extraction The value to point function extracts the values of 8 impact factors in 2000 and 2015. For the purpose of optimizing the ecological system of the Shendong mining area, the ecological suitability analysis model system of the Shendong mining area is constructed from the data of the environmental factors, vegetation factors and soil erosion in the area. Based on GIS technology and principal component analysis method, the various ecological environment influencing factors are correlated and sorted, and the distribution of ecological suitability influencing factors in the area is analyzed, and a brief analysis is made to provide references for the area's ecological space planning opinion.

Keywords

Impact Factor, Suitability, Principal Component Analysis, Shendong Mining Area.

1. Introduction

While promoting the rapid economic development, long-term mining and utilization of coal resources have caused soil erosion and serious damage to the ecological environment, resulting in a large number of collapses, excavation and waste of land resources, and the contradiction between man and land has been increasing [1]. After mining, the surface of the mining area will undergo obvious changes. The surface collapses, roads are damaged, cultivated land is reduced, and some infrastructures are also destroyed to varying degrees. The production and life of the people in the mining area will be seriously affected. Therefore, environmental protection and ecological restoration in mining areas are one of the important indicators for the construction of national land ecological security [2-5]. A reasonable analysis of the ecological suitability of the mining area is useful for the ecological restoration of coal mining subsidence areas and comprehensive land reclamation management. Especially important [6]. The study area is located at the junction of the northern part of the northern Shaanxi Plateau and the southeastern part of the Ordos Plateau, in the transition zone of the Mu Us Desert and the eastern section of the northern edge of the Loess Plateau in northern Shaanxi. The terrain is low in the southeast and high in the northwest, low in the north and south, and high in the middle. The elevation is between 800-1385m. The ravines are vertical and horizontal, and soil erosion is serious. The stratum of the mining area belongs to the Ordos Basin in the stratigraphic belt of northern China. Quaternary sediments covered most of the surface, and the bottom rocks in the valley were exposed. The geographical coordinates are between 38°52'~39°41' north latitude and 109°51'~110°46' east longitude. It is 38~90km long from north to south, 35~55km wide from east to west, and covers an area of 3539km^2.

The climate of the mining area is arid and semi-arid continental climate. Different air masses have different effects on the regional climate. Due to the long-term control of the polar continental cold air masses, the continental climate is significant. It is also affected by ocean hot air for a relatively short time. As the mining area is located deep inland and still in a higher terrain, it seriously affects the thermal insulation and water retention of the underlying surface. Its main climatic characteristics are drought, less rain, and more wind and sand. The specific manifestations are severe cold and heat, relatively dry climate, frequent disasters, and large seasonal differences; long and cold winters, less rain and snow; short and hot summers, large temperature differences, and rainy seasons Relatively vigorous in May to July. Northwest wind is the most common in winter, with wind and sand. The northwest wind prevails in late autumn and winter and spring. The annual average wind speed is 2.5~3.6m/s, the maximum wind speed is 24m/s, and the average annual windy days are 42.2d. The evaporation is strong, and the annual average evaporation is 4.55-6.72 times the average annual rainfall [7]. In short, drought, less rain and more wind are the main characteristics of the climate in the mining area, and also the performance of the fragile ecological environment of the mining area.

2. Data and methods

2.1 Data Sources

This paper takes ecology as the core, feasibility as the leading factor, closely integrates the actual situation of the Shendong mining area and ecological construction goals, combines the comprehensive status of the Shendong mining area and the expert opinions of ecological planning, and refers to relevant research documents and "Eco-environmental status evaluation "Technical Specifications" (hereinafter referred to as "Specifications") screens the indicators of factors affecting the ecological suitability of the Shendong mining area. This paper explores the ecological suitability of Shendong mining area from three aspects: environmental factors, vegetation factors and soil erosion.

2.2 Research Method.

2.2.1. Literature analysis method

Search for relevant research literature on ecological suitability analysis of mining areas through databases such as CNKI, web of science and MDPI. The collected documents are sorted, analyzed and summarized by reading, so as to finally determine the research direction and content of this article based on the research status and development of ecological suitability analysis of mining areas at home and abroad.

2.2.2. Principal component analysis method

Principal component analysis, also known as principal component analysis, is a simplified method of processing dimensions in mathematics, and it is also a statistical analysis method with multiple variables. Through linear transformation, multiple variables are used to select a small number of more important variables. The core idea of principal component analysis is to reduce the number of variables, including many interconnected variables, and to keep as many useful variables as possible [9].

2.2.3. GIS technology

By processing the remote sensing image map of the Shendong mining area, a geospatial database of the ecological suitability of the Shendong mining area is established, and 150 random samples are randomly distributed on the image map of each impact factor, and the value extracted by GIS technology is used to point, The values of 8 impact factors in the 2000 and 2015 are extracted. Process the remote sensing image map of each impact factor to obtain the spatial distribution map of 8 impact factors.

3. Results and Analysis

3.1 Spatial dynamic analysis of impact factors

The temperature in the Shendong mining area from 2000 to 2015 showed fluctuation characteristics. In 2000, the temperature in some parts of the southwest was between 30°C and 35°C, and the temperature in the rest of the area remained between 35°C and 40°C. In 2015, the temperature from northwest to southwest remained almost above 35°C, while the temperature from northeast to southeast was 25℃-30℃. It can be clearly seen that the temperature in the west is higher than that in the east. Compared with 2000, the temperature in the eastern region dropped significantly in 2015, and the temperature in some parts of the southwest increased.

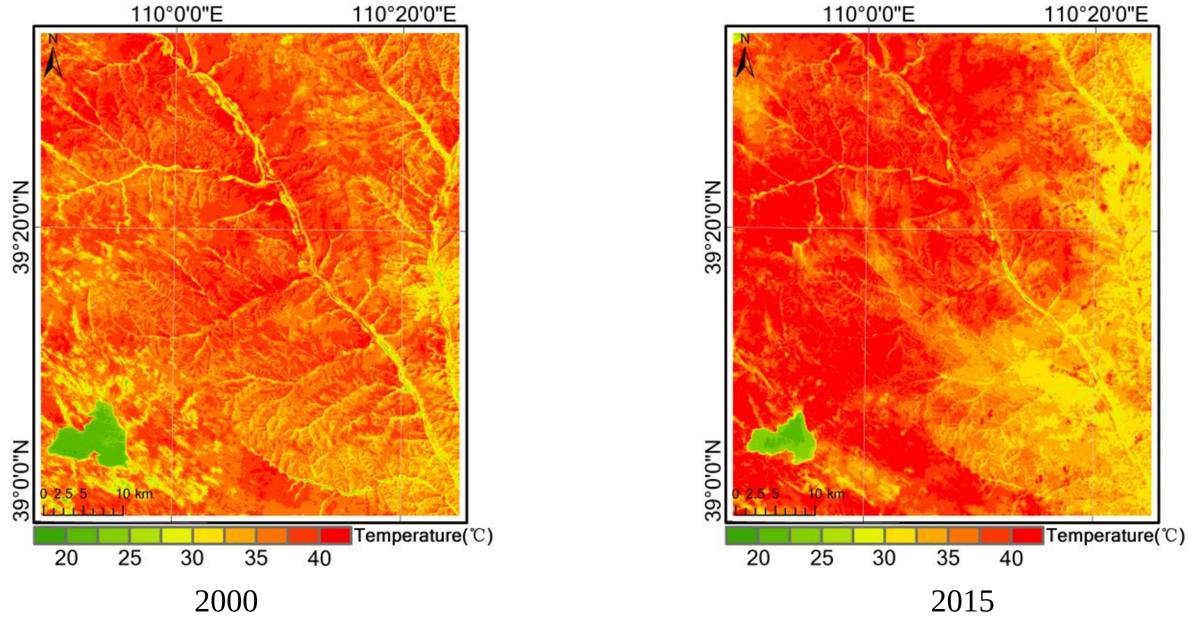


Fig.1. Temperature distribution map of Shendong mining area from 2000 to 2015

The drought degree of Shendong mining area from 2000 to 2015 showed fluctuating characteristics. In 2000, except for water bodies and river courses, the drought index was generally higher in other places, and a small part of the southeast had a relatively low drought index. In 2015, the drought index from northwest to southwest was higher, and the drought index from northeast to southeast was lower. Compared with 2000, the drought index from northeast to southeast in 2015 decreased significantly.

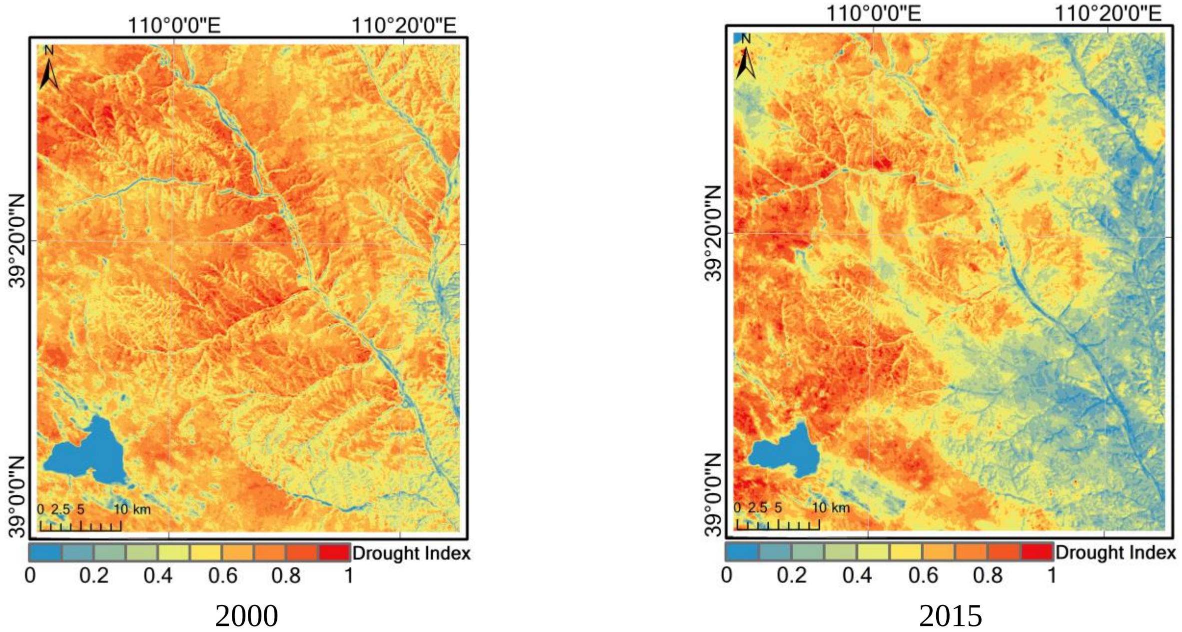
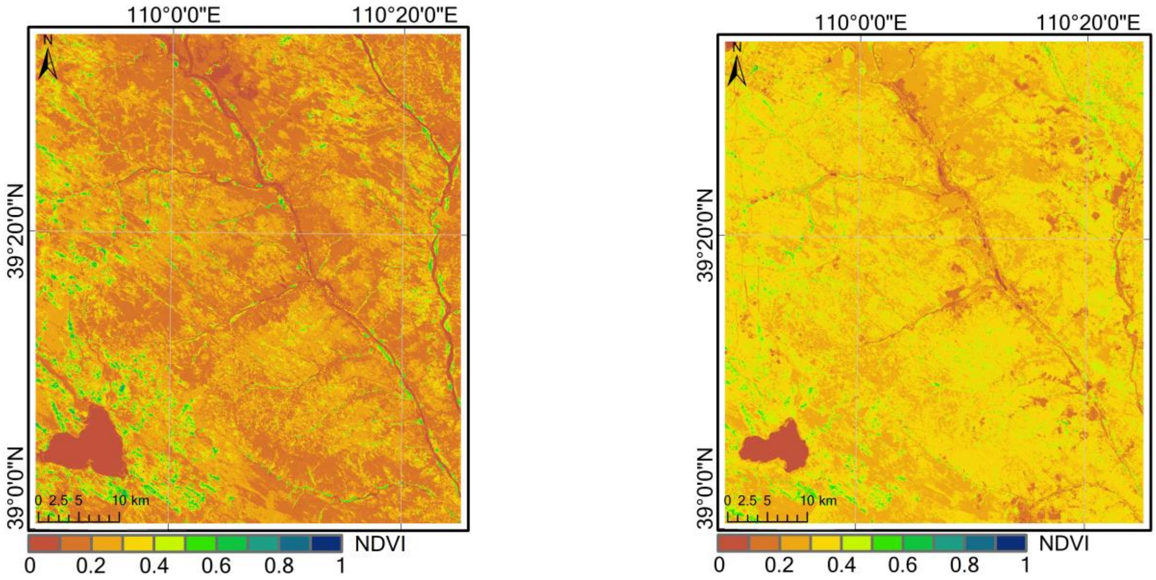


Fig.2. Distribution of drought index in Shendong mining area from 2000 to 2015

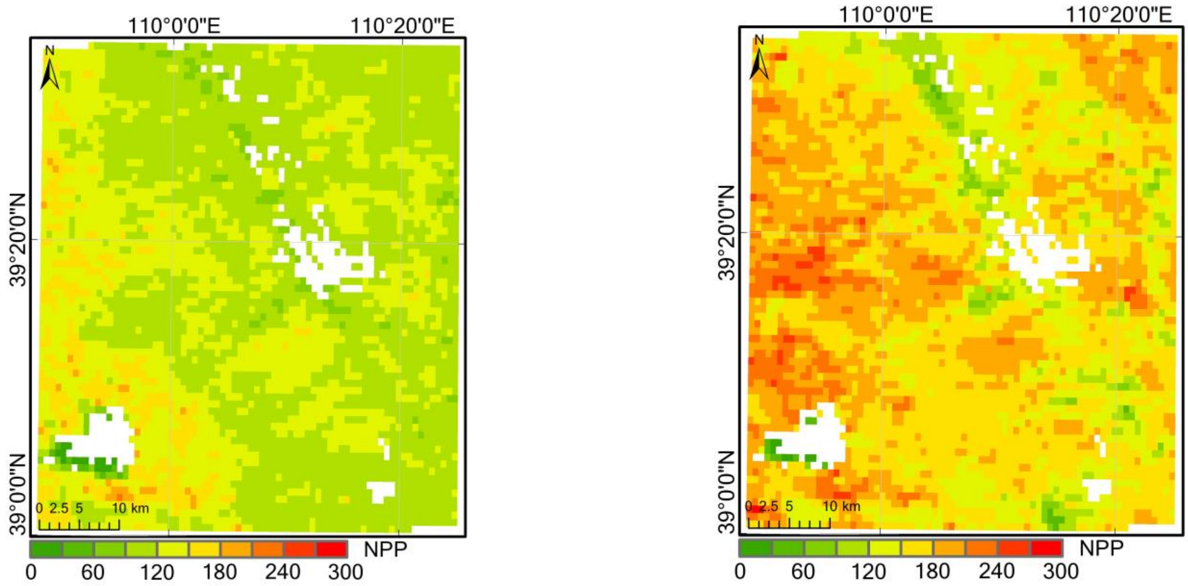
From 2000 to 2015, the NDVI of Shendong mining area showed an increase and change characteristics. In 2000, the NDVI value was higher in a small part of the southwest, and generally lower in the rest. In 2005, the NDVI value was relatively high in a small part of the southwest, and generally low in other places. In 2015, NDVI was higher in a small part of the northeast and southwest. Compared with 2000, NDVI increased significantly in 2015.



2000 2015

Fig.3. NDVI distribution map of Shendong mining area from 2000 to 2015

From 2000 to 2015, the NPP of Shendong mining area showed an increase and change characteristic. In 2000, NPP was relatively high in a small part of the northwest to southwest. The rest is generally lower. In 2015, except for a small part of the northern part of the country where NPP was low, the NPP was generally high in other places, especially from the northwest to the southwest. Compared with 2000, the overall NPP increased significantly in 2015, especially from the northwest to the southwest.

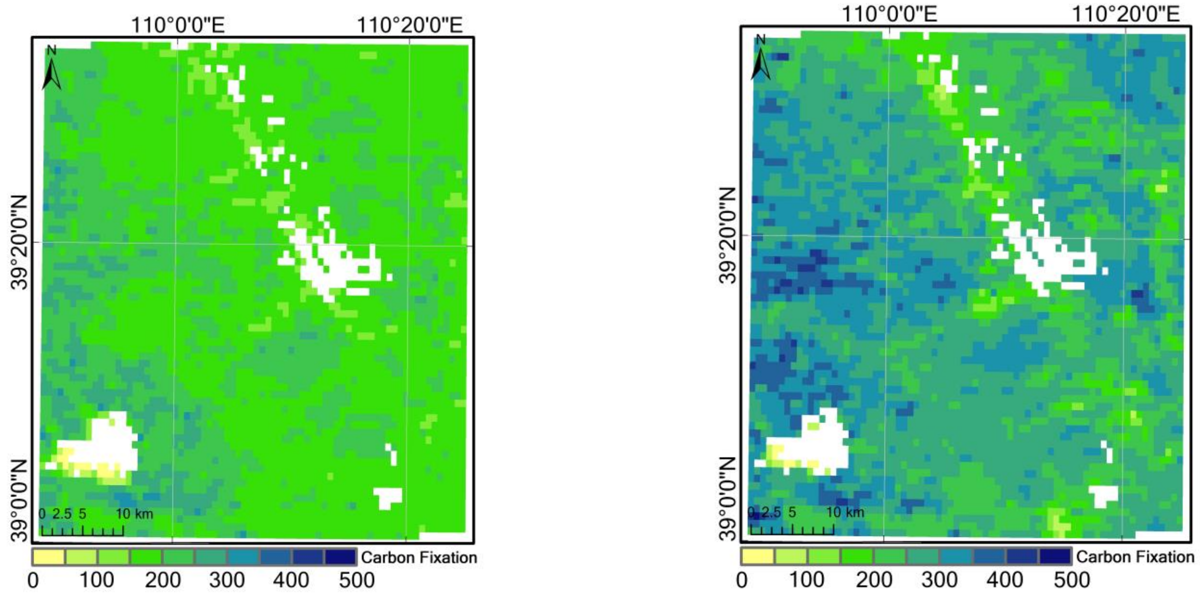


2000 2015

Fig.4. NPP distribution map of Shendong mining area from 2000 to 2015

The carbon sequestration function of Shendong mining area from 2000 to 2015 showed an increase and change characteristic. In 2000, a small part of the northwest to southwest has a higher carbon sequestration function. The rest is generally lower. In 2015, except for a small part of the northern part of the area where the carbon sequestration function was low, the carbon sequestration function was generally higher in other places, especially from the northwest to southwest. Compared with

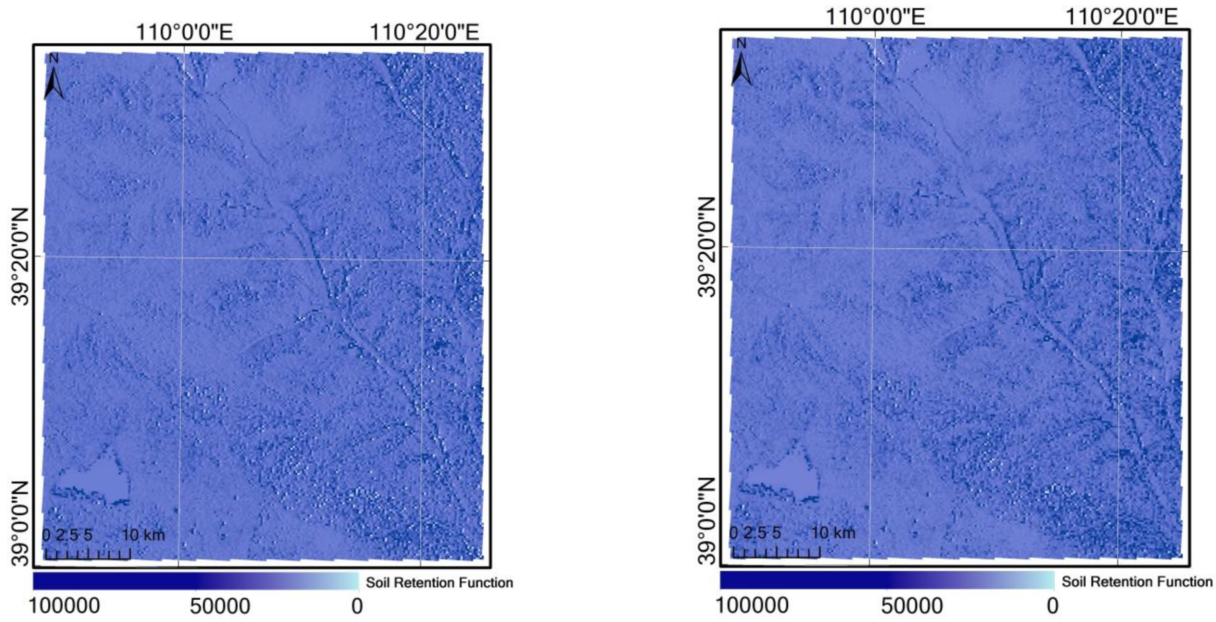
2010, the overall carbon sequestration function increased significantly in 2015, especially from the northwest to the southwest.



2000 2015

Fig 5. Carbon sequestration function distribution map of Shendong mining area from 2000 to 2015

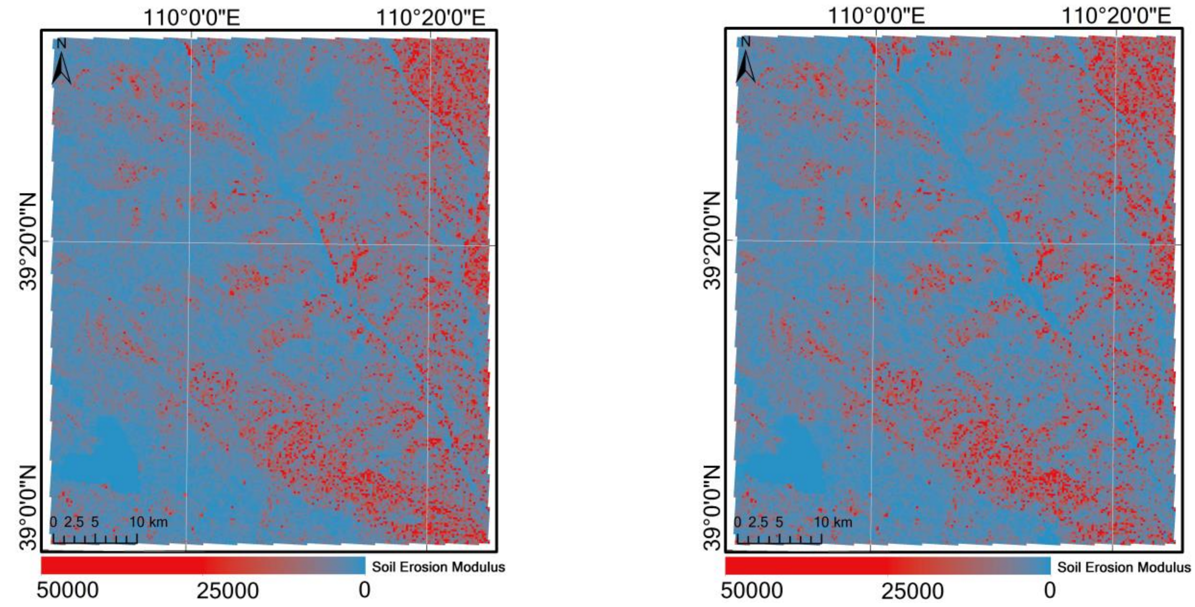
From 2000 to 2015, the soil conservation function of Shendong mining area showed an increase and change characteristic. In 2000, the soil conservation intensity from northeast to southeast was relatively high. In 2015, the soil conservation intensity from northeast to southeast was relatively high. Compared with 2000, the soil conservation intensity decreased slightly in 2015.



2000 2015

Fig.6. Distribution map of soil conservation function in Shendong mining area from 2000 to 2015

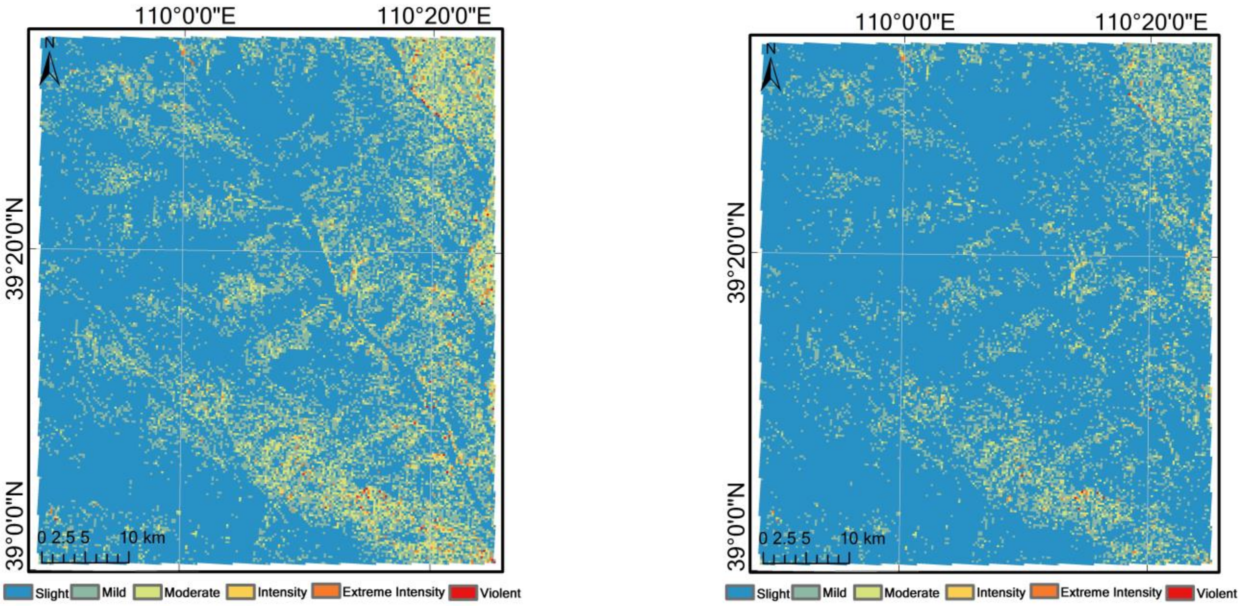
From 2000 to 2015, the soil erosion modulus of Shendong mining area showed a decreasing characteristic. In 2000, the soil erosion modulus was relatively high in the northeast to southeast, and central regions. In 2015, the soil erosion modulus from northeast to southeast was relatively high. Compared with 2000, the soil erosion modulus decreased slightly in 2015.



2000 2015

Fig.7. Distribution map of soil erosion modulus in Shendong mining area from 2000 to 2015

It can be seen from the distribution map of soil erosion grades in Shendong Mining Area from 2000 to 2015 that the overall soil erosion grades show decreasing characteristics. In 2000, the soil erosion intensity level from northeast to southeast was relatively high. In 2015, the soil erosion intensity level from northeast to southeast was relatively high. Compared with 2000, the level of soil erosion intensity decreased in 2015.



2000 2015

Fig.8. Distribution map of soil erosion grade in Shendong mining area from2000 to2015

3.2 Principal component analysis

Principal component analysis is a method of mathematical transformation of dimensionality reduction processing technology. It is used on the basis of research on the correlation between various variables to convert the original multiple variables into a few new variables of comprehensive indicators, and these new variables Keep as much information as possible from the original variables.

3.2.1 Correlation analysis of ecological suitability indicators in Shendong mining area

After standardizing the original data with SPSS 24.0 software, the correlation coefficient of each impact factor is calculated. As shown in Table 1. Correlation analysis shows (Table 1) that temperature and drought are significantly correlated ($P<0.05$); NDVI is significantly correlated with NPP and carbon fixation function ($P<0.05$); NPP is significantly correlated with carbon fixation function ($P<0.05$); The soil erosion modulus has a significant correlation with the soil erosion grade ($P<0.05$). Correlation analysis shows that the above seven statistical impact factors have a certain overlap of information, which is suitable for principal component analysis to further extract the main information.

Table.1. Correlation analysis results of ecological suitability indicators in Shendong mining area

Index	Temperature	Drought Index	NDVI	NPP	Carbon Fixation	Soil Retention Function	Soil Erosion Modulus	Soil Erosion Grade
Temperature	1							
Drought Index	0.882	1						
NDVI	-0.271	-0.277	1					
NPP	0.036	-0.193	0.598	1				
Carbon Fixation	0.036	-0.193	0.598	1	1			
Soil Retention Function	-0.143	-0.165	0.037	0.12	0.12	1		
Soil Erosion Modulus	-0.189	-0.13	-0.086	-0.122	-0.122	-0.125	1	
Soil Erosion Grade	-0.218	-0.168	0.065	-0.108	-0.108	-0.067	0.929	1

Calculate the eigenvalues and eigenvectors of the correlation coefficient matrix of the ecological suitability index of the Shendong mining area, and sort the eigenvalues in order of magnitude to find their individual contribution rate and cumulative contribution rate. The results are shown in Table 2. The first principal component has the largest eigenvalue, with a variance contribution rate of 33.705%, followed by the second principal component, with a variance contribution rate of28.466%, and the third principal component with a variance contribution rate of 18.479%, and the cumulative contribution rate of the three is 80.65 %, and the three principal components are not related to each other. This shows that the first to third principal components basically contain the comprehensive information of the ecological suitability influencing factors of the original eight Shendong mining areas, which can better reflect the ecological suitability trend represented by the changes in the original variables.

Table.2. Characteristic values and corresponding variance contribution rate and cumulative contribution rate

Composition	Initial Eigenvalue			Extract the Sum of Squared Loads		
	Total	variance proportion	Accumulation %	Total	variance proportion	Accumulation %
1	2.696	33.305	33.705	2.696	33.305	33.705
2	2.277	28.466	62.171	2.277	28.466	62.171
3	1.478	18.479	80.650	1.478	18.479	80.650
4	0.932	11.645	92.295			
5	0.475	5.940	98.235			
6	0.075	0.939	99.174			
7	0.066	0.826	100			
8	1.39E-16	1.74E-15	100			

Use F_i to represent the i-th principal component, and X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, respectively to represent temperature, drought index, NDVI, NPP, carbon sequestration function, soil conservation function, soil erosion modulus, Soil erosion level. According to the score coefficient matrix of the principal components, the first to third principal components can be expressed as the formula:

$$F_1 = 0.08X_1 + 0X_2 + 0.286X_3 + \cdots\cdots + 0.038X_8 \quad (1)$$
$$F_2 = 0.003X_1 + 0.01X_2 + 0.006X_3 + \cdots\cdots + 0.495X_8 \quad (2)$$
$$F_3 = 0.5X_1 + 0.471X_2 - 0.084X_3 + \cdots\cdots + 0.039X_8 \quad (3)$$

Table.3. Component score coefficient matrix

Index	Composition		
	1	2	3
Temperature	0.08	0.003	0.5
Drought Index	0	0.01	0.471
NDVI	0.286	0.006	-0.084
NPP	0.406	0.034	0.08
Carbon Fixation	0.406	0.034	0.08
Soil Retention Function	-0.018	-0.159	-0.206
Soil Erosion Modulus	0.037	0.503	0.063
Soil Erosion Grade	0.038	0.495	0.039

The principal component loading matrix reflects the closeness between each influencing factor and the principal component. It can be seen from the score coefficient of the principal component (Table 3) and the factor loading matrix (Table 4) that the first principal component is in the NDVI, NPP and carbon fixation functions. The scoring coefficients are all above 0.25, and the corresponding factor load is also as high as 0.75, indicating that the first principal component integrates the three influencing factors of NDVI, NPP and carbon sequestration function, reflecting the characteristics of the ecological suitability of the mining area, which can be called “vegetation "The impact on the environment" can represent the overall intensity of the impact of vegetation on the environment in qualitative considerations, and the impact is greater. The score coefficients of the second principal component on the two influencing factors of temperature and drought are significantly higher than other influencing factors. The temperature and drought in the factor loading matrix (Table 4) are as high as 0.5 or more, indicating that the second principal component is mainly affected by environmental factors. The third principal component has a higher score coefficient on the three influencing factors of temperature, soil erosion modulus and soil erosion grade, and the corresponding factor load is also higher. It shows that the higher the temperature of the area with lower vegetation coverage, the greater the evaporation, the greater the evaporation, the more drier the soil can not store water, vegetation is difficult to grow, so the soil erosion is more severe.

Table.4. Factor loading matrix

Index	Composition		
	F1	F2	F3
Carbon Fixation	-0.311	0.731	0.553
NPP	-0.483	0.658	0.482
NDVI	0.785	-0.059	0.09
Soil Retention Function	0.898	0.156	0.351
Soil Erosion Grade	0.898	0.156	0.351
Soil Erosion Modulus	0.24	-0.02	-0.362
Temperature	-0.215	-0.783	0.541
Drought Index	-0.183	-0.803	0.51

3.2.2 Comprehensive score analysis

The ratio of the feature value corresponding to each principal component to the total feature value of the extracted principal component is used as the weight to calculate the principal component comprehensive model:

$$F = \frac{\lambda_1}{\lambda_1+\lambda_2+\lambda_3} F_1 + \frac{\lambda_2}{\lambda_1+\lambda_2+\lambda_3} F_2 + \frac{\lambda_3}{\lambda_1+\lambda_2+\lambda_3} F_3 \quad (4)$$

You can get the principal component synthesis model:

$$F=31.195\times F_1+24.876\times F_2+24.578\times F_3 \quad (5)$$

According to the comprehensive evaluation function, calculate the average comprehensive score of each year in 2000 and 2015. The results are shown in Table 5.

The overall score from 2000 to 2015 is ranked as 2015>2000. Judging from the average score of the first principal component, the score in 2015 was higher, indicating that NDVI, NPP and carbon sequestration were the main components in 2015; from the average score of the second principal component, the score in 2000 was higher, indicating that 2000 The year is dominated by temperature and drought, and the year is mainly affected by temperature and drought. From the average of the third principal component scores, the score in 2000 was higher, indicating that the soil erosion modulus and the The soil erosion grade is the main one, and the year is mainly affected by the soil erosion modulus and soil erosion grade. The overall ranking shows that the comprehensive score in 2015 was higher than that in 2000.

Table.5. 2000-2015 comprehensive score results

Rears	F1	Rank	F2	Rank	F3	Rank	Total Score	Rank
2000	-0.693	2	0.115	1	0.024	1	-18.167	2
2015	0.693	1	-0.115	2	-0.024	2	18.167	1

4. Conclusion

The choice of study area has limitations. So far, the specific location of the "Shendong coal mining subsidence area" has not been scientifically defined. Most studies use specific mining areas or experimental samples as the study area, and there are also "mining area groups" as the study area [13]. This paper selects the adjacent banner counties at the junction of the two provinces of Inner Mongolia and Shaanxi as the study area. The advantage of this is that it is convenient for data acquisition, but the disadvantage is that the consistency of the data in time and space is poor.

This study uses ArcGIS 10.6 software to establish a geospatial database for the ecological suitability of the Shendong mining area, randomly distributes 150 random sample points on the image map of each impact factor, and uses GIS technology to extract the value to the point. And the values of 8 impact factors in 2015. Process the remote sensing image map of each impact factor to obtain the spatial distribution map of 8 impact factors.

Enter the values of the eight impact factors into SPSS software for principal component analysis, and after standardizing the original data, the correlation coefficient of each impact factor is calculated. Correlation analysis shows (Table 1), temperature and drought degree are significantly correlated ($P<0.05$); NDVI is significantly correlated with NPP and carbon fixation function ($P<0.05$); NPP and carbon fixation function are significantly correlated ($P<0.05$); The soil erosion modulus is significantly correlated with the soil erosion grade ($P<0.05$). The cumulative contribution rate of the three is 80.65%, and the three principal components are not correlated with each other. The principal component loading matrix reflects the closeness between the influencing factors and the principal components. It is derived from the score coefficients of the principal components and the factor loading matrix. The first principal component reflects the characteristics of the ecological suitability of the mining area. "Environmental impact" can represent the overall intensity of vegetation's impact on the environment in qualitative considerations, and the impact is greater. The score coefficients of the second principal component on the two influencing factors of temperature and drought are significantly higher than other influencing factors. The temperature and drought in the factor loading matrix (Table 4) are as high as 0.5 or more, indicating that the second principal component is mainly affected by environmental factors. The third principal component has a higher score coefficient on the three influencing factors of temperature, soil erosion modulus and soil erosion grade, and the corresponding factor load is also higher. It shows that the higher the temperature of the area with lower vegetation coverage, the greater the evaporation, and the greater the evaporation, the more drier the soil can not store water. It is difficult for vegetation to grow, so the soil erosion is more severe.

The overall score from 2000 to 2015 is ranked as 2015>2000. In 2015, the first principal component ranked first, and the year was mainly affected by vegetation; in 2000, the second principal component ranked first, and the year was mainly affected by temperature and drought; in 2000, the third principal component ranked first 1. The year was mainly affected by temperature, soil erosion modulus and soil erosion grade.

From the spatial dynamic analysis chart, it can be concluded that two factors in environmental factors show fluctuation characteristics; three factors in vegetation factors show rising characteristics; three factors in soil erosion factors show decline characteristics. Comparing the change trend of vegetation factors and soil erosion factors every year, soil erosion decreased in the year when vegetation coverage was high.

Combined with remote sensing image maps, it can be concluded that the main factor affecting the ecological suitability of Shendong mining area is vegetation coverage. The Shendong mining area has an arid and semi-arid climate, with large temperature differences, dryness with little rain, wind and heavy sand, and difficult vegetation growth. Due to sparse vegetation, concentrated precipitation, mostly heavy rain, and other harsh weather conditions, coupled with man-made destruction, the ecological environment in the region is fragile, the land is desertified, and soil erosion is serious. It further confirms the importance of vegetation coverage in the mining area, and this result is basically consistent with previous studies. Relevant studies have shown that one of the main factors of ecological restoration in mining areas is vegetation restoration [10-13]. Wang Li et al. [14] constructed a conceptual model for quantitatively measuring the resilience of vegetation ecosystems in mining areas based on different spatial scales and ecological organization dimensions. The evaluation result is It can provide a scientific basis for ecosystem service management decision-making at the macro level, and it can also provide a reference for species selection and cultivation management at the micro level. In the mining process, in almost all cases, mining activities exceed the restoration capacity of the ecosystem. Relying on self-recovery is a slow process, and it will take at least 50-100 years to restore vegetation in the abandoned mines [15]. Therefore, appropriate man-made measures can be taken, such as substrate improvement technology [12]. The Shendong mining area belongs to the saline-alkali area. Desulfurized gypsum can be used to improve the saline-alkali land to balance the acid-base ions of the soil and make the vegetation grow better.

There are still shortcomings in the research, which need further research and improvement. Although the selection of impact factors and the weights of evaluation indicators are rigorous, there are still some subjective assumptions. How to reduce the influence of human factors to a greater extent is worthy of further research. At the same time, the selection of evaluation indicators is not perfect. The selection of evaluation indicators is based on the availability of indicators, and other impact factors can be analyzed in a targeted manner.

Taking ecological priority as the premise, consider the suitability of the mining area from the perspective of ecological priority. In terms of governance, vegetation factors and soil erosion factors have a greater impact, and vegetation restoration should be emphasized, so that the ecological suitability influencing factor analysis of the Shendong mining area is more environmentally friendly and provides a basis for the ecological suitability analysis of the mining area.

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