Change of Land Use in Shendong Mining Area Based on Remote Sensing

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Abstract: In order to understand the impact of mining activities on the local environment, taking Shendong mining area as the research area, the three phases of Landsat remote sensing images in 2000, 2010 and 2020 were classified and processed by using the supervised classification method, and the land use data of the three phases were obtained.Through the dynamic degree of land use and the transition matrix of land use, the changes of various land use types in Shendong mining area were studied.The results show that :grassland is the main land use type in Shendong mining area, accounting for more than 80% of the average during the study period.Construction land increased most significantly, with a growth rate of 53.37%.The grassland in the Shendong mining area is mainly transferred out, and a total of 196.74km^2 has been transferred out in the past 20 years, mainly to cultivated land and construction land.More grassland is occupied in urbanization development and mining activities.

Keywords: Mining Area; Land Use; Remote Sensing

Introduction

Coal resources are the main energy in our country, and the status of coal as the main energy will not change for a long time in the future [1].The rapid development of coal industry not only drives regional economic development, but also brings great damage to the ecological environment of mining areas [2].Coal resource mining is the primary driving force for the disturbance and change of the land in the mining area. It is manifested through changes in the surface morphology or vegetation coverage, which has a serious impact on people's production and living environment [3].Nowadays, the phenomenon of land use and landscape pattern transformation caused by production activities in mining areas has received attention, and it is more necessary to use 3S technology to monitor land use changes, grasp land evolution information in time, and make corresponding predictions, optimization, and regulation systems [4].Shendong Mining Area is the largest coal mine base in Northwest China. The mining area is rich in coal resources[5],coal mining has caused strong disturbance to its fragile ecological environment[6].Based on this, this paper takes the Shendong mining area as the research object, and selects 2000-2020 as the research period to analyze and study the law of land use change in the mining area, in order to provide a scientific basis for the optimal management of land use in the Shendong mining area and the follow-up land consolidation and reclamation work in the mining area.

1. Overview of the study area

Shendong mining area is located in the north of Yulin City, Shaanxi Province and the south of Ordos City, Inner Mongolia.Its geographic coordinates are 109°51′ ~ 110º46′ east longitude and 38°52′ ~ 39°41′ north latitude.It is one of the thirteen large-scale coal bases planned by the state, it is also the first coal production base with an annual output of 100 million tons and an important export base of high-quality thermal coal in our country.The Shendong mining area is located in the southeastern part of the Erdos Plateau and the northern edge of the northern Shaanxi Plateau,it is located in the eastern section of the transition zone between the northern edge of the Loess Plateau in northern Shaanxi and the Mu Us Sandy Land.Most of the area is typical aeolian sand dunes and sandy landforms.Mining area is mainly distributed in the middle of Ulan Mulun River and Biniu River.The mining area has a temperate semi-arid continental monsoon climate and it is located in the transition zone between steppe and forest steppe. The main vegetation types are steppe, deciduous broad-leaved shrubs and sandy vegetation.

2. Data and methods

2.1 Data and preprocessing

Theremotesensingimagesused inthis paper aredownloaded fromthegeospatialdatacloud platform(http://www.gscloud.cn/). Selecting remote sensing images with good summer vegetation coverage and less than 15% cloud cover in the study area in 2000, 2010, and 2020 as the basic data, and perform preprocessing such as radiometric calibration and atmospheric correction in ENVI5.3. A combination of supervised classification and human-computer interactive interpretation was used to classify the preprocessed remote sensing images and obtain land use maps for three periods.The classification standard of land use is divided into six categories: cultivated land, forest, grassland, water body, construction land and bare land according to the Classification of Current Situation of Land Use (GB/T21010-2017). The overall classification accuracy of land use in the three phases is higher than 80, and the Kappa coefficient is greater than 0.8, and the interpretation results meet the requirements.

2.2 Research methods

2.2.1 Dynamic degree of land use

Dynamic degree of land use is one of the commonly used models to study the temporal and spatial changes of land use [7].

Single land use dynamics: The rate of change of a certain land use type.The formula is:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\%$$

In the formula: K - the dynamic degree of a certain land use type during the study period, Ua - the area at the beginning of the study of a certain land use type, Ub - the area at the end of the study of a certain land use type, T - the length of the study period.

Comprehensive land use dynamics:The regional comprehensive change degree of land use type can be expressed by comprehensive land use dynamic degree.The higher the comprehensive land use dynamic index, the more intense the land use change in the study area during this period, and vice versa.The lower the comprehensive land use dynamic index, the more stable the land use in the study area during this period.The formula is:

$$LC = \left[\frac{\sum_{i=1}^{n} \Delta LU_{i-j}}{2\sum_{i=1}^{n} LU_i}\right] \times \frac{1}{T} \times 100\%$$

In the formula: LC- comprehensive land use dynamic degree, ΔLUi-j-i The area of class i land use type converted to area of non-i land use type during the study period ,T - study period, when T is the year, LC is expressed as the annual change rate.

2.2.2 Land use transition matrix

The transition matrix of land use change can comprehensively and concretely show the direction of change of each land use type and the characteristics of land use structure in a specific time period within the research scope.The land use transfer matrix reflects the type of land use change and the transformed area in the form of a matrix or table, which can be used as a basis to analyze the land use structure and direction of change.The formula is:

$$S_{ij}\begin{vmatrix} S_{11} & S_{12} & S_{13} & \cdots & S_{1n} \\ S_{21} & S_{22} & S_{23} & \cdots & S_{2n} \\ S_{31} & S_{32} & S_{33} & \cdots & S_{3n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ S_{n1} & S_{n2} & S_{n3} & \cdots & S_{nn} \end{vmatrix}$$

In the formula: Sij-the area of land of type i converted to land of type j ,S - the area of the study area, n - the number of land use types, i - the land use types at the beginning of the study, j - the land use types at the end of the study.

3. Results and Analysis

3.1 Changes in the quantity of land use

3.1.1 Status quo of land use in Shendong mining area

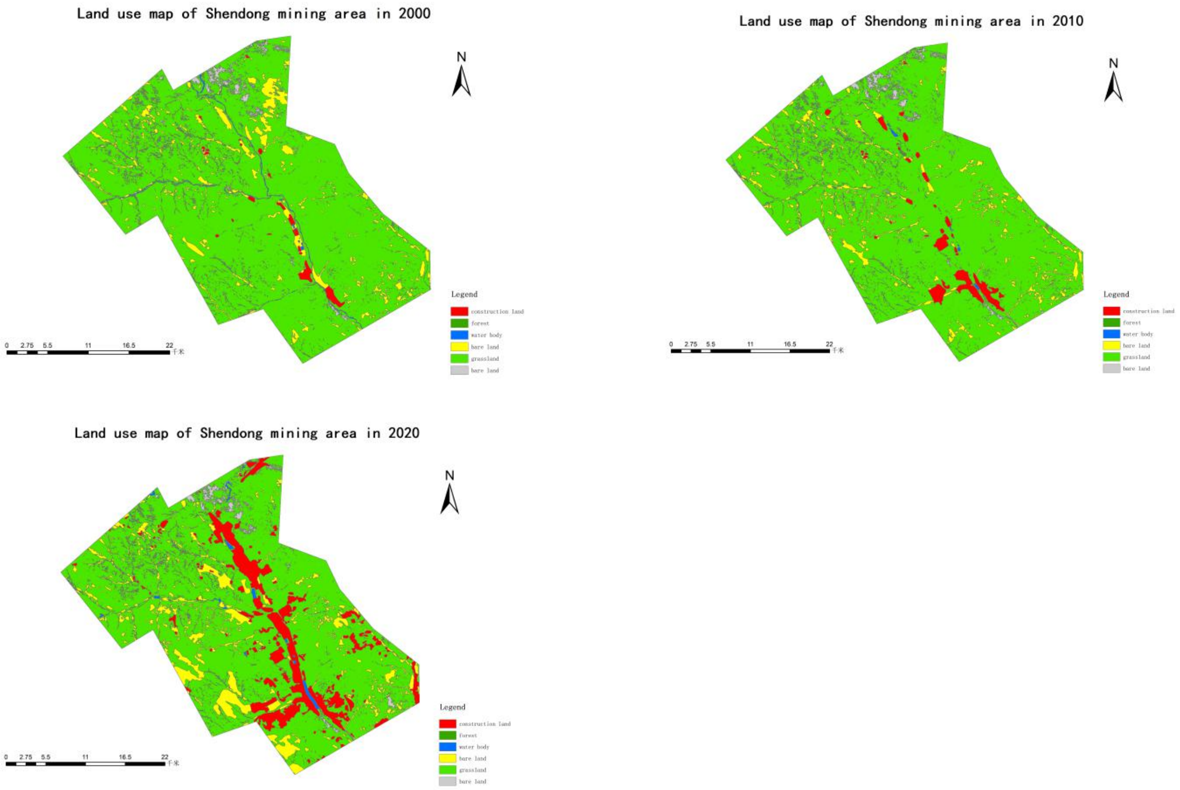
From the perspective of land use structure(Table1), the grassland area in the study area is the largest, accounting for 76.83%.Construction land accounted for 10.34%.Cultivated land accounted for 9.36%,The water body has the smallest area, accounting for only 0.52%.

From the perspective of land use distribution(Fig.1), construction land is distributed on both sides of the Ulan Mulun River, and other construction land is scattered around towns.ultivated land is mainly distributed near towns,grasslands are distributed throughout the study area.

Table.1 Land use structure in 2020

2020	area（km^2）	percentage(%)
grassland	844.03	76.83%
cultivated land	102.79	9.36%
construction land	113.58	10.34%
forest	18.27	1.66%
bare land	14.12	1.29%
water body	5.73	0.52%
total	1098.52	100.00%

Fig.1 Land use map of Shendong mining area



3.1.2 Analysis of land use quantity changes

According to the interpretation results, the land use information of Shendong mining area in three years is counted, as shown in Table 2.

Table.2 Land use structure of Shendong mining area from 2000 to 2020

	2000		2010		2020	
grassland	976.12	88.86%	972.5	88.53%	844.03	76.83%
cultivated land	70.1	6.38%	60.9	5.54%	102.79	9.36%
construction land	9.73	0.89%	27.19	2.47%	113.58	10.34%
forest	20.21	1.84%	20.63	1.88%	18.27	1.66%
bare land	15.01	1.37%	15.15	1.38%	14.12	1.29%
water body	7.33	0.67%	2.13	0.19%	5.73	0.52%

It can be seen from the above table that the land use type in the study area from 2000 to 2020 is dominated by grassland, accounting for about 80% of the total area of the mining area, followed by cultivated land and construction land, and the proportion of water body is the smallest.From the perspective of land structure changes, due to the disturbance effect of coal mining, the land use structure in the study area has undergone significant changes, and the concentrated expression is a significant increase in construction land.

The types of land use that increased from 2000 to 2010 were construction land, forest and bare land. Among them, the construction land increased the most, with an increase of 17.63km^2. Forest and bare land increased by 0.42km^2 and 0.14km^2, respectively.The reduced land types are grassland, cultivated land, and water bodies, respectively.The cultivated land decreased the most, by 9.2km^2. Grassland and water bodies decreased by 3.62km^2 and 5.2km^2, respectively.

The types of land use that were increased from 2010 to 2020 were cultivated land, construction land, and water bodies. Among them, the construction land increased the most, with an increase of 86.39km^2. Cultivated land and water bodies increased by 41.89km^2 and 3.6km^2, respectively. The reduced land types were grassland, forest and bare land, respectively. Among them, the grassland decreased the most, with a decrease of 128.47km^2. Forest and bare land decreased by 2.36km^2 and 1.03km^2 respectively.

The change trend of land use in the study area during the 20 years from 2000 to 2020 was relatively strong. Cultivated land and construction land have the most significant changes, and water bodies have also changed significantly. On the whole, construction land has been growing and has grown substantially, which is most obvious in the 2010-2020. Cultivated land and water bodies first increased and then decreased. Grassland showed a decreasing trend, and forest and bare land changed little.

3.2 Changes in the speed of land use

3.2.1 Single dynamic degree of land use

According to the formula, the single dynamic degree of land use in Shendong mining area for 20 years from 2000to 2020 is calculated，as shown in Table 3.

Table.3 Single dynamic degree of land use in Shendong mining area from 2000 to 2020

land use type	2000-2010	2010-2020	2000-2020
grassland	-0.04	-1.32	-0.68
cultivated land	-1.31	6.88	2.33
construction land	17.94	31.77	53.37
forest	0.21	-1.14	-0.48
bare land	0.09	-0.68	-0.30
water body	-7.09	16.9	-1.09

From 2000 to 2010, the growth rate of construction land was the fastest, with a change rate of 17.94%. The growth rate of bare land was the slowest, with a change rate of 0.09%. The water body decreased the fastest with a change rate of -7.09%. The grassland decreased the slowest with a change rate of -0.04%. Forest and bare land have a slight growth trend and a slower growth rate. The cultivated land showed a decreasing trend with a change rate of -1.31%.

From 2010 to 2020, the fastest growing land is still construction land, with a change rate of 31.77%, which is even faster than the previous stage, indicating that large-scale urbanization and coal mining activities are being carried out in this stage. The slowest growth rate is cultivated land, with a change rate of 6.88%. Grassland decreased the fastest, with a change rate of -1.32%. Bare land has the slowest reduction, with a change rate of -0.68%. The water boody increased rapidly, with a change rate of 16.90%. The forest decreased slightly, but the decrease rate was slow, and the change rate was -1.14%.

Overall, construction land grew rapidly in the 20 years from 2000 to 2020, with a rate of change of 53.37%. It shows that the construction of urbanization and the mining of coal resources, the construction of workshops and the construction of dumping and dumping grounds have led to the continuous increase of construction land in the past 20 years. Except for arable land, other land types also decreased slightly.

3.2.2 Comprehensive dynamic degree of land use

According to the formula, the comprehensive dynamic degree of land use in Shendong mining area for 20 years from 2000 to 2020 is calculated, as shown in Table 4.

Table.4 Comprehensive dynamic degree of land use in Shendong mining area from 2000 to 2020

period	2000-2010	2010-2020	2000-2020
comprehensive dynamic degree of land use	0.16	1.2	0.62

From 2000 to 2010, the comprehensive dynamic degree of land use was 0.16%, and the degree of change was relatively low.It indicates that during this period, 0.16 square kilometers per 100 square kilometers per year will be converted to other land types.The comprehensive land use dynamic index in this period from 2010 to 2020 is relatively high, reaching 1.2%.It shows that the conversion between different land use types is frequent, and every 100 square kilometers of land has a change of 1.2 square kilometers, which is a significant increase compared with the previous stage.On the whole, from 2010 to 2020, the degree of human-induced land use disturbance was greater than that in the previous stage.The overall stability of comprehensive land use in this period from 2000 to 2010 indicates that the land system was relatively stable at that time, which reflects that human activities had less interference with the land.

3.3 Land use transition matrix

According to the reclassification, overlay analysis and other functions of ArcGIS as the analysis methods, the land use transition matrix of each stage from 2000 to 2020 was obtained ,as shown in Table 5 and Table6.

Table.5 Land use transition matrix of Shendong mining areafrom 2000 to 2010

	land use type	2010						
		grassland	cultivated land	Construc-tion land	forest	bare land	water body	transfer out
	grassland	935.10	24.32	15.47	0.00		1.23	41.02
	cultivated land	29.40	35.98	3.39	0.89	0.26	0.16	34.1
2000	construction land	1.85	0.02	7.73	0.07	0.00	0.05	1.99
	forest		0.47	0.22	19.53		0.00	
	bare land		0.00	0.14		14.87		0.14
	water body	6.15	0.11	0.23	0.13	0.02	0.69	6.64
	Transfer in	37.4	24.92	19.45	1.09	0.28	1.44	84.58

During 2000-2010, a total of 84.58km^2 of land was transferred.Grassland has the largest transfer area, with 41.02km^2 transferred out, mainly to cultivated land and construction land, with 24.32km^2 and 15.47km^2 transferred out respectively.This is because coal mine infrastructure and road construction occupy a large area of land resources, and coal mining subsidence also accelerates the transformation of cultivated land into grassland in the region.Bare land has the least transfer area, and is mainly converted into construction land.Cultivated land and water bodies also converted 20.40km^2 and 6.15km^2 to grassland, respectively.The transferred area of grassland is also the largest, 37.40km^2, mainly from cultivated land.Cultivated land is not only the land use type that accounts for the largest proportion of the grassland transferred out, but also the main source of grassland transfer in.The transfer of bare land is the smallest, mainly from cultivated land. Because coal mining subsidence affects soil quality, making cultivated land deserted and turned into bare land.

Table.6 Land use transition matrix of Shendong mining areafrom 2010 to 2020

land use type		2020						
		grassland	cultivated land	Construction land	forest	bare land	water body	transfer out
2010	grassland	816.03	50.52	84.37	12.37	4.52	3.94	155.72
	cultivated land	8.61	48.9	2.71	0.5	0	0.1	11.92
	construction land	2.09	1.73	23.25	0.02	0	0.1	3.94
	forest	12.61	1.31	1.14	5.36	0.02	0.17	15.25
	bare land	3.75	0.21	1.59	0	9.56	0.01	5.56
	water body	0.27	0	0.45	0		1.41	0.72
	transfer in	27.33	53.77	90.26	12.89	4.54	4.32	193.11

From 2010 to 2020, a total of 193.11km^2 of land has been transferred. The area of grassland transferred out is still the largest, with 155.72km^2 transferred out, and the largest transfer out area is still to cultivated land and construction land, with 50.52km^2 and 84.37km^2 transferred out respectively. Urban expansion, the increase of land for industrial and mining enterprises, and the relocation of villages in mining areas are the main reasons for the conversion of grassland to construction land. On the other hand, mining activities inevitably lead to surface subsidence, and the formation of a certain area of subsidence and water accumulation is also a key factor in reducing grassland.The area of water transfer out is the least, and it is mainly converted into construction land.Cultivated land and forest also converted 8.61km^2 and 12.61km^2 to grassland, respectively. The largest transfer area of construction land is 90.26km^2, of which 90% comes from grassland.The transferred areas of cultivated land and grassland are 53.77km^2 and 27.33km^2 respectively, which are derived from grassland and forest.The transfer area of water boody is the smallest, mainly from grassland.

4. Conclusion

The mining of coal resources will inevitably have a serious impact on the surface ecological environment. In this study, multi-source remote sensing images were used to obtain land use information in the Shendong mining area (2000, 2010 and 2020) through human-machine visual interpretation. On this basis, its spatiotemporal evolution characteristics are analyzed.

(1) Grassland is the main land use type in Shendong mining area, accounting for more than 80% on average during the study period.The growth of construction land is the most obvious.Forest and bare land did not change much, while cultivated land and water body showed a trend of first decreasing and then increasing.

(2) From the perspective of land use change rate, construction land has grown rapidly, with a growth rate of 53.37%.From 2010 to 2020, the regional comprehensive change degree of land use types was relatively high. During this time , the land use changes in the study area were intense, and coal mining had a greater disturbance to land use.

(3) During the study period, the grassland in Shendong mining area was mainly transferred out, and a total of 196.74km^2

was transferred out in the past 20 years, mainly to cultivated land and construction land.It can be seen that more grassland is occupied in urbanization development and mining activities.The most transferred land is construction land, mainly from grassland.

Coal mining activities are the main driving force for changes in land use structure in Shendong mining area. With the continuous advancement of mining activities, it is necessary to strengthen the routine monitoring of the ecological environment, implement effective land reclamation and ecological improvement measures in a timely manner, and maximize the sustainable development of the production and living environment in the mining area.

References

[1] Yang, GH, Hu, ZQ, Yang, YQ. Information extraction of coal mining subsidence farmland submerged in water taking Jining city of Shandong province as a case [J]. Metal Mines, 2013(09):152-157.

[2] Chang, XY, Li, XJ, Diao, HT. Analysis on the spatial-emportal changes of land use and the gravity center shift in mining area[J]. Journal of Inner Mongolia Agricultural University (Natural Science Edition), 2021, 42(02): 41-48. DOI:10.16853/j.cnki. 1009-3575.2021.02.008.

[3] Huang, YN, Huo, ZW, Xia, XB, Liu, JM, Yu, L. Analysis of land use change characteristics in Zhaolou mining area based on RS [J]. China Mining Industry, 2020, 29(S2): 102-106.

[4] Han, WB, Jia, W, Sun, TS. Change of land use and landscape pattern in Pingshuo open coal mines based on the 3S technology [J]. China Land Science, 2012, 26(04): 60-65.

[5] Wu, LX, Ma, BD, Liu, SJ. Analysis to vegetation coverage change Shendong mining area with SPOT NDVI data[J]. Journal of Coal, 2009, 34 (09):1217-1222.

[6] Liu, Y, Wei, JL, Bi, YL, Yue, H, He, X. Evaluation of ecosystem service function in Shendong mining area[J]. Journal of Coal, 2021, 46(05):1599-1613.

[7] Xiao, HT, Yao, YH, Zhang, Y, Li, M. Analysis of land use change and driving force in the Greater Xing, an Mountains based on GIS and RS[J]. Science and Technology Innovation and Application, 2022, 12(12): 63-69+75. DOI:10.19981/ j.CN23-1581/G3.2022.12.015.

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