Establishment and Research of Ecological Environment Assessment Method in Mining Area -- Taking Anshan Open-pit Mine as an Example

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Abstract. In the process of obtaining natural resources, human beings will inevitably destroy the environment and affect the ecological balance of nature. The establishment of ecological environment evaluation method for mining area and surrounding area can protect the environment of mining area and realize the construction of ecological civilization. In this paper, taking Anshan open-air iron mine as the study area, the spatial resolution image of 2m was obtained by fusion of GF-1 satellite remote sensing image data and DEM image data of the study area, and the remote sensing index information of the mining area, such as NDVI, vegetation coverage, water body information and soil index, was extracted to normalize the ecological impact index. Finally, the comprehensive index method is used to construct the mining area ecological environment comprehensive evaluation model to analyze and evaluate the mining area ecological environment.

Keywords: Anshan Open Pit Iron Mine; GF-1; Index extraction; Ecological environment assessment

1 Introduction

Mineral resources are the necessary resources for social development and also the most basic resources. In the early years of mining, environmental protection was neglected in the pursuit of quantity. The ecological environment damage in mining areas is easy to cause vegetation destruction and soil erosion, which will lead to natural disasters, harm to human life and human society and bring about property losses. The ecology of mining area is a problem that governments all over the world attach great importance to, and the research on it has been continuous.

Most of the mining area to establish an earlier time, the mining area in the process of development, has the certain scale, but in the operation of the mining area, the method is relatively single, coupled with insufficient awareness of the mining area ecological environment protection, it is easy to cause ecological damage in mining areas, and there is no a unified system of protection. As a result, the ecological environment of the mining area is still worrying [1]. With the development of science and technology, the

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number of remote sensing satellites and their functions are becoming more and more powerful. Through satellites, we can obtain image data with high time resolution and high spatial resolution. These data provide a basis for us to study the ecological environment of mining areas. Yin Jianping made use of multi-temporal Landsat images and principal component analysis to establish remote sensing ecological index model to evaluate the ecological environment of Pingshuo mining area [2]; Hu Kehong et al. made use of Landsat images and GDM to make attribution of spatial differentiation of ecological environmental quality [3]; Zhu Quan selected the samples with the separation degree over 1.8 to classify the images by the maximum likelihood method, and applied the results to the ecological assessment of land reclamation in mining areas [4]; Xiu Liancun et al. used airborne hyperspectral imager to establish a comprehensive survey technique, method and operation process, and expounded the demonstration of the application of ecological and environmental geological survey in some areas of the Yangtze River Economic Belt [5]; Song Qifan et al. extracted the mining information by using WorldView-2 image and using the method of inter-spectral relationship, normalized differential water index and supervised classification [6]; In these studies, due to the data collection accuracy, evaluation methods, funds and other reasons, the mining area environmental information can not be accurately obtained and applied to the ecological environment assessment.

GF-1 satellite data has the advantages of high spatial resolution, high temporal resolution and multi-spectrum. The GF-1 satellite contains two sensors: the PMS sensor with a spatial resolution of 2m/8m and a temporal resolution of 4Days; The WFV sensor has 16m spatial resolution and 4Days temporal resolution. In this paper, Anshan open-pit iron mine is taken as the study area. Based on GF-1 satellite data, multiple indexes are calculated to establish a comprehensive evaluation model to evaluate the ecological environment of the mining area.

2 Study area and data

2.1 Overview of the study area

Anshan Iron Mine, located in the southeast of Dagushan Town at the foot of Qianshan Mountain, Anshan City, is the earliest iron mine in Anshan. The main product is magnetite, with an annual output of 7 million tons. At present, the mine is the deepest open-pit iron mine in Asia, with a closed elevation of 78 meters. The mine is 1,620 meters long and 1,200 meters wide along the direction, covering an area of 10.6 square kilometers. The Dagushan mine has proven reserves of 340 million tons and an ore body 700 meters deep, which can only be reached to minus 450 meters by open pit mining.

2.2 Data

The data used in this study include GF-1 data, ASTGTM-DEM (30m), mining location and geographical data, etc. Since this paper is to establish a comprehensive evaluation model to evaluate the ecological environment of the mining area, there is no special requirement on the time of data shooting. The GF-1PMS data dated April 30, 2014 is selected. The GF-1 satellite was launched into orbit on April 26, 2013, and is China's first launch satellite for the National Science and Technology Major Project of the High-Resolution Earth Observation System. The data of administrative divisions are from the National Geographic Information Resource Catalogue Service System.

3 The Research methods

3.1 Ecological evaluation process of mining area

In the study of the mining area ecological environment, determine the evaluation factors of the ecological environment quality, to extract the image feature information through remote sensing and GIS, and then adopt the method of ecological factor normalization unified outline quantity of each factor by establishing a comprehensive index method to determine the weight of each influence factor index, to establish the evaluation model of ecological environment system, so as to realize the comprehensive evaluation of the ecological environment of the mining area. The technical flow chart is shown in Figure 1.

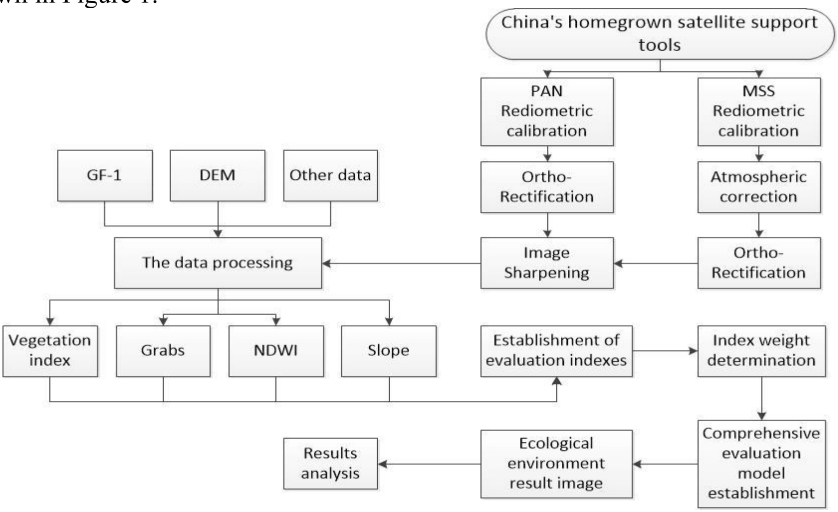


Fig. 1. Flow chart of ecological evaluation in mining area

3.2 Remote sensing data processing

Firstly, the GF-1PMS data were opened and preprocessed by the Chinese satellite support tool, and then the high-resolution image of the study area was obtained by image fusion and image cropping.

Radiometric calibration, atmospheric correction and orthographic correction were carried out for GF-1 multispectral data. Radiometric calibration and atmospheric correction were performed on GF-1 panchromatic data. Radiation calibration is to convert the recorded original DN value into radiation brightness value to eliminate the error of the sensor itself. For radiometric calibration of multispectral data, the dimension of the data should be consistent with that of the subsequent atmospheric correction processing. Atmospheric correction means that the total radiation brightness measured by the sensor is not a reflection of the real reflectivity of the surface, which includes the radiation quantity error caused by atmospheric absorption, especially the scattering effect. Atmospheric correction is the process of eliminating the radiation errors caused by atmospheric influence and inverting the real surface reflectance of ground objects. The aerosol model was selected as a city. Through the historical weather query, the weather was clear and cloudless on the day of the data shooting, so the visibility was set as 40km. Orthophonic correction is the process of using digital elevation model (DEM) data to simultaneously correct the tilt and projection error of the image, resampling the image into orthophonic image, and using the RPC orthophonic correction process tool to correct the image. Panchromatic data preprocessing is similar.

NNDiffuse Pan Sharpening method is used to fuse data in image fusion. This method can preserve the color, texture and spectral information of the image well. A 2M spatial resolution multispectral remote sensing image was obtained by processing. Through visual judgment, the image is cut manually to get the appropriate image of the study area. After the GF-1 data is processed by the above method, the high-resolution multispectral image of the study area is obtained (Figure 2).

Fig. 2. Data preprocessing result map

3.3 Mining environmental information extraction

3.3.1 Vegetation coverage.

Firstly, the difference between the reflection value of the near infrared band and the reflection value of the red band is used to obtain the normalized vegetation index (NDVI), and then the vegetation coverage is calculated. The calculation formula is as follows:

$$FC = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}} \tag{1}$$

FC is the vegetation coverage, NDVI is the normalized vegetation index， $NDVI_{max}$ and $NDVI_{min}$ is the maximum and minimum of NDVI.The NDVI value of the image was calculated by NDVI tool, and the NDVI range was calculated by using computational statistics. According to the statistical results, the cumulative percentage was selected as the standard and the corresponding pixel values at 5% and 95% were read respectively to determine the maximum and minimum values of effective NDVI, and finally the vegetation coverage map of the study area was obtained (Fig. 3a).

3.3.2 Grabs.

The soil brightness index and greenness index can be used to judge bare soil and vegetation. Therefore, the bare soil vegetation index is formed through the linear combination of the greenness index and soil brightness index. Its calculation formula is as follows:

$$GRABS = VI - 0.9178BI + 5.58959 \tag{2}$$

GRABS is bare soil vegetation index，VI is the greenness index of ear cap transformation, and BI is the soil brightness index of ear cap transformation. Calculated soil index diagram (Fig. 3b).

3.3.3 NDWI.

Normalized water index is the difference between the green band and the near-infrared band of remote sensing image. Its calculation formula is as follows:

$$NDWI = \frac{G-NIR}{G+NIR} \tag{3}$$

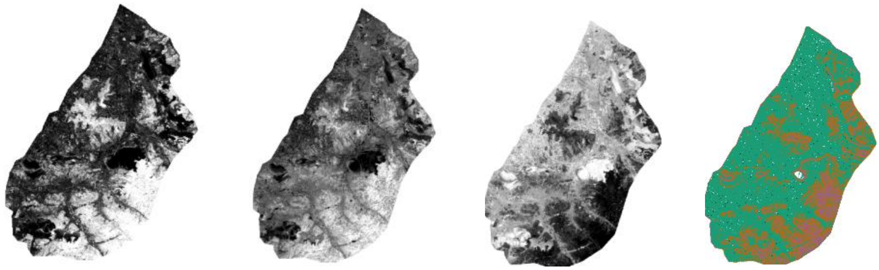
NDWI is the normalized water body index, G is the green light band and Nir is the near-infrared band. Figure 3c of water index in the research area was obtained by calculation.

3.3.4 Slpoe.

Slope is the degree of steepness of surface units. The ratio of vertical height and horizontal distance of slope surface is usually called slope. Its calculation formula is:

$$\text{Slope} = \text{Elevation difference}/\text{horizontal distance} \tag{4}$$

Calculated Slope Map of the Research Area (Figure 3d)



(a) (b) (c) (d)

Fig. 3. Image classification results

3.4 Ecological environment assessment

3.4.1 Ecological factor normalization.

Vegetation coverage and soil index can be used as ecological factors for research, but each factor has a corresponding dimension. Therefore, data need to be normalized for comprehensive evaluation. Density segmentation method is used to divide it into ten levels (1-10). The coding value is proportional to the pixel value. The larger the coding value is, the larger the pixel value is. Using the above methods, vegetation coverage, slope and soil index were divided into 10 grades. After the grading is completed, the data pixel value is normalized to 1-10.

3.4.2 Establishment of index system.

Ecological environment evaluation is to quantitatively determine the ecological environment of the study area. In this paper, the comprehensive index method is adopted. Under an evaluation index system, the weighted average of all kinds of indexes is carried out, and the comprehensive value is calculated to evaluate the ecology of mining area. The evaluation model is:

$$E = W_1 * S_{v1} + W_2 * S_{v2} \tag{5}$$

E is the comprehensive index value, W is the weight value, and S_v is the number of various indicators. According to Meng Xiangliang et al. 'Technical Specification for Assessment of Ecological Environmental Condition', the weight ratio of vegetation coverage, soil index and slope is 8:2[7]. The result graph is divided into four categories to construct the environmental evaluation table.

Table 1. Grading table of ecological environment evaluation

Rating	Comprehensive evaluation index	instructions
Excellent	9~10	The environment is not damaged and the structure is reasonable.
Good	6~9	The environment is not damaged and the structure is reasonable.
Medium	3~6	Environmental damage, unreasonable structure.
Poor	1~3	Serious environmental damage, unreasonable structure.

4 Evaluation results and analysis

The vegetation coverage and soil index extracted from GF-1PMS image were used as the ecological image index, which was normalized, and the comprehensive index method was used to calculate in ENVI to obtain the ecological environment index results of the study area. Finally, the percentage of each gray value was calculated by

Compute Statistics. Finally, the ecological environment evaluation results of Anshan open-pit mining area are obtained. The ecological environment of Anshan open-pit mining area can be divided into four levels: excellent, good, medium and poor (Figure 4).

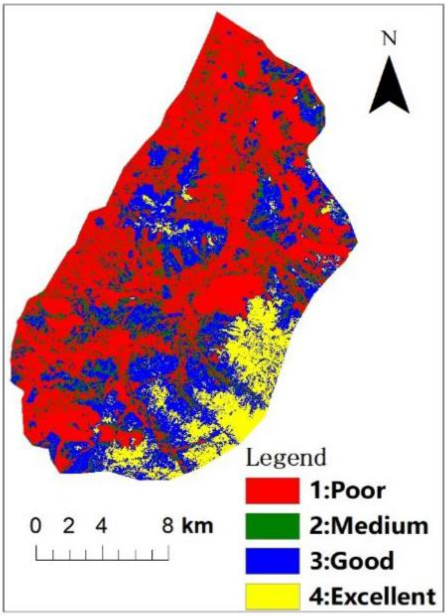


Fig. 4. Results of ecological environment evaluation

Table 2. Statistical results

DN	1	2	3	4
Percentage (%)	41.83	19.25	18.51	20.41

According to the area statistics of the four ecological environment zones in the mining area, the proportion of each zone in the total area of the mining area is obtained (Table 2).The evaluation results show that the percentage of the evaluation index within the range of 1-3 is 41.83%, which is the highest value, indicating that most of the natural ecology in this region is in a poor state, The main area is the mining area and the surrounding areas of the mining area, and the rest is concentrated in the urban construction land. The evaluation index of 9-10 is 20.41%, which indicates that the natural ecology of this region is in an excellent state. Most of these regions are concentrated in mountainous areas with good vegetation growth. The area with the evaluation index from 3 to 9 accounted for 37.76%.

5 Conclusion

This study takes Anshan open-pit iron mine as the research area, and uses GF-1 (PMS) satellite data, DEM data and other data to process and analyze to get the ecological environment information of the mining area, such as vegetation coverage, water body information, soil index. On this basis, the ecological factors were normalized, and the comprehensive index method was used to analyze and evaluate the ecological environment of the mining area. The research results show that about 60% of the ecological environment in Anshan open-pit iron mining area is in good condition, and about 40% of the regional comprehensive index is in poor condition. The Gaofen-1 satellite data used in this study has the advantages of high resolution and multi-spectrum compared with other remote sensing data, and the evaluation method is simpler and easier to implement than the traditional method. For the next step, it is necessary to increase the extraction of the index information of the mining area, so as to make a more comprehensive evaluation of the mining environment. The most important thing is to establish a general evaluation system for the mining areas with different landforms and landforms, which is helpful to the environmental monitoring of mining areas and the prevention of disasters in advance.

Acknowledgments

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