Research on Evaluation Index of Mine Environment Rehabilitation

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Abstract. Mine environmental rehabilitation is an essential part of the construction of ecological civilization in the new era. Effective evaluation of the degree of regional mine environmental rehabilitation can provide decision-making reference information for the corresponding work planning. A method to calculate the index of mine environmental rehabilitation was put forward in this article. It was the value of "the area of mine environmental rehabilitation" divided " the area of mine land which should be urgent rehabilitation". The index of mine environmental rehabilitation by using the data of national remote sensing survey in 2016-2017 was calculated. The results show that the proposed evaluation method and the research results can provide a reference for mine environmental rehabilitation planning.

1. Introduction

People pay more and more attention to the ecological environment and yearn for a better living environment, while material living standard improving. The rehabilitation of mine environment is bound to become an essential part of the construction of ecological civilization in the new era. It can provide decision-making reference information for mine environmental protection and rehabilitation planning to evaluate the degree of regional mine environmental rehabilitation effectively.

The research on the evaluation index of mine environmental rehabilitation in China focuses on the effect of point rehabilitation, but less on the large area rehabilitation. The effect of mine environment rehabilitation in Xigaze area, Tibet was studied by Wang H Q and Chen L[1]. The effect of environmental rehabilitation measures in different mines in Tibet was analyzed, which used remote sensing and field investigation by Chen L[2]. The vegetation rehabilitation effects of three different control measures in the semi-arid area of Northwest China were analyzed by Wang H X et al[3]. Two indexes of mine geological environment protection and management rehabilitation were put forward by Zhang J L et al[4], according to the relevant documents, i.e. the control area of historical mine geological environment problems and the land reclamation area of abandoned mining areas. The evaluation index system of mine ecological environment protection and rehabilitation management was constructed by selecting 12 factors and 22 indexes from three aspects of ecological environment protection, ecological rehabilitation management and ecological monitoring capacity construction by Wang W and Wang H F[5], also was constructed by selecting 22 indexes from two aspects of environmental protection and rehabilitation management by Niu K K[6]. It was considered that the social benefits of environmental rehabilitation in Suichang gold mine were significant by Jin X and Cao X S[7], based on the evaluation of regional economic development, residents' life, social harmony and stability, regional image, demonstration and scientific and educational effects. It was praised the effect of the demonstration project of mine geological environment treatment in Xiangtan Manganese...
Mine Area by Wen X H and Li X D\cite{8}, from the aspects of social benefit, environmental benefit, economic benefit and demonstration driving effect. The performance evaluation method of mining ecological environment rehabilitation project was studied from three aspects of business performance, financial performance and benefit performance by Wang H L et al\cite{9}. The performance audit evaluation index system of environmental rehabilitation and governance project was constructed from four aspects: rationality, economy, efficiency and efficiency by Hou X J and Zhao Y\cite{10}. These studies involve many aspects, such as the evaluation of rehabilitation effect, performance evaluation and so on, which can solve the problem of mine environmental rehabilitation evaluation of a single mine well. However, there are few reports on the evaluation methods of regional large-area rehabilitation governance. The situation of mine environmental rehabilitation in all provinces of China were calculated use the proportion of "area of mine environment rehabilitation" in "area of all involving mine land", which called rate of mine environment rehabilitation, by Yang J Z et al\cite{11}. This method has some advantages, but it can't highlight the situation which should be urgent rehabilitation, such as the abandoned mine land or the mining subsidence land, because it calculate the area of using mining land and the area of abandoned mining land together.

The index of mine environment rehabilitation was explored in this article, for highlight the situation which should be urgent rehabilitation, and hope to be helpful for relevant research.

2. Meaning and Equation of the Index of Mine Environment Rehabilitation
In reference \cite{11}, according to the different utilization status, all involving mine land were divided into five categories: using mining land, abandoned mine land, suspended mine land, mining subsidence land and mine environment rehabilitation. The rate of mine environment rehabilitation(R) was used to calculate the situation of mine environmental rehabilitation in all provinces of China, which was the proportion of "area of mine environment rehabilitation" in "area of all involving mine land", the equation can be understood as follows:

$$R = A5 \div (A1 + A2 + A3 + A4 + A5)$$ (1)

In this equation, R represents rate of mine environment rehabilitation, A1 represents area of using mining land, A2 represents area of abandoned mine land, A3 represents area of suspended mine land, A4 represents area of mining subsidence land, A5 represents area of mine environment rehabilitation.

The index of mine environment rehabilitation(I), which was discussed in this article, was the value of "the area of mine environmental rehabilitation" divided "the area of mine land which should be urgent rehabilitation", the equation can be understood as follows:

$$I = A5 \div (A2 + A4)$$ (2)

Compared with the rate of mine environment rehabilitation in reference \cite{11}, the index of mine environment rehabilitation reflects the relationship between the area of mine environment rehabilitation and the area of mine land which should be urgent rehabilitation. It can be seen directly whether the area of mine environment rehabilitation exceeds the area of mine land which should be urgent rehabilitation. It can highlight the situation which should be urgent rehabilitation, and effectively evaluate the degree of regional mine environmental rehabilitation.

3. Calculation Results about Index and Rate of Mine Environment Rehabilitation
The index and rate of mine environmental rehabilitation about each province in 2016-2017 was calculated, based on the area of abandoned mine land, the area of mining subsidence land and the area of mine environment rehabilitation in reference \cite{11}, which was shown in Table 1.
| Region/Province | Index of mine environment rehabilitation(I) | Rate of mine environment rehabilitation(R) | 2017 | 2016 | Change value | 2017 | 2016 | Change value |
|-----------------|-------------------------------------------|-------------------------------------------|------|------|--------------|------|------|--------------|
| Huabei Region   | 0.1215                                    | 0.0982                                    | 0.0233 | 0.0831 | 0.0669       | 0.0162 |
| Beijing         | 0.1009                                    | 0.0770                                    | 0.0239 | 0.0890 | 0.0674       | 0.0216 |
| Tianjing        | 0.6662                                    | 0.7527                                    | -0.0865 | 0.3850 | 0.3096       | 0.0753 |
| Hebei           | 0.1406                                    | 0.1024                                    | 0.0381 | 0.1064 | 0.0792       | 0.0272 |
| Shanxi          | 0.0597                                    | 0.0467                                    | 0.0130 | 0.0467 | 0.0356       | 0.0111 |
| Inner Mongolia  | 0.2087                                    | 0.1817                                    | 0.0269 | 0.1068 | 0.0933       | 0.0135 |
| Dongbei Region  | 0.2407                                    | 0.2120                                    | 0.0287 | 0.1445 | 0.1191       | 0.0254 |
| Liaoning        | 0.1397                                    | 0.1439                                    | -0.0042 | 0.0953 | 0.0772       | 0.0181 |
| Heilongjiang    | 0.3766                                    | 0.2950                                    | 0.0815 | 0.2062 | 0.1759       | 0.0303 |
| Jilin           | 0.2250                                    | 0.1264                                    | 0.0985 | 0.1071 | 0.0668       | 0.0402 |
| Huadong Region  | 0.3797                                    | 0.3167                                    | 0.0630 | 0.1869 | 0.1497       | 0.0372 |
| Shanghai        | 2.7031                                    | 1.4796                                    | 1.2235 | 0.4363 | 0.3436       | 0.0927 |
| Jiangsu         | 0.5986                                    | 0.4565                                    | 0.1421 | 0.3007 | 0.2193       | 0.0815 |
| Zhejiang        | 0.6313                                    | 0.5038                                    | 0.1275 | 0.2651 | 0.2269       | 0.0382 |
| Anhui           | 0.3183                                    | 0.2200                                    | 0.0984 | 0.1834 | 0.1318       | 0.0517 |
| Fujian          | 0.1396                                    | 0.0925                                    | 0.0471 | 0.0978 | 0.0713       | 0.0265 |
| Jiangxi         | 0.2217                                    | 0.1706                                    | 0.0511 | 0.0965 | 0.0783       | 0.0182 |
| Shandong        | 0.4426                                    | 0.4224                                    | 0.0202 | 0.1990 | 0.1657       | 0.0334 |
| Huazhong Region | 0.2009                                    | 0.1367                                    | 0.0643 | 0.1053 | 0.0743       | 0.0310 |
| Henan           | 0.1226                                    | 0.0773                                    | 0.0453 | 0.0750 | 0.0450       | 0.0299 |
| Hubei           | 0.1753                                    | 0.0799                                    | 0.0954 | 0.0637 | 0.0296       | 0.0341 |
| Hunan           | 0.3476                                    | 0.2345                                    | 0.1132 | 0.1689 | 0.1355       | 0.0335 |
| Huanan Region   | 0.8466                                    | 0.5398                                    | 0.3067 | 0.2373 | 0.1798       | 0.0575 |
| Guangdong       | 0.5582                                    | 0.3277                                    | 0.2305 | 0.1897 | 0.1212       | 0.0685 |
| Guangxi         | 0.7309                                    | 0.3943                                    | 0.3365 | 0.2059 | 0.1461       | 0.0598 |
| Hainan          | 4.1305                                    | 3.4648                                    | 0.6657 | 0.4594 | 0.4369       | 0.0225 |
| Xinan Region    | 0.3417                                    | 0.2528                                    | 0.0889 | 0.1465 | 0.1098       | 0.0367 |
| Chongqing       | 0.2119                                    | 0.1883                                    | 0.0236 | 0.1415 | 0.1226       | 0.0189 |
| Sichuan         | 0.2416                                    | 0.1252                                    | 0.1164 | 0.0944 | 0.0583       | 0.0361 |
| Guizhou         | 0.1422                                    | 0.0927                                    | 0.0496 | 0.0652 | 0.0401       | 0.0252 |
| Yunnan          | 0.3823                                    | 0.2700                                    | 0.1123 | 0.1596 | 0.1064       | 0.0531 |
| Tibet           | 1.9584                                    | 1.2544                                    | 0.7039 | 0.3777 | 0.3518       | 0.0259 |
| Xibei Region    | 0.1866                                    | 0.1121                                    | 0.0745 | 0.0485 | 0.0294       | 0.0190 |
| Shaanxi         | 0.1701                                    | 0.0938                                    | 0.0763 | 0.0958 | 0.0595       | 0.0363 |
| Gansu           | 0.1409                                    | 0.0787                                    | 0.0622 | 0.0702 | 0.0429       | 0.0274 |
| Qinghai         | 0.3229                                    | 0.2927                                    | 0.0303 | 0.0349 | 0.0256       | 0.0093 |
| Ningxia         | 0.5442                                    | 0.1699                                    | 0.3743 | 0.1955 | 0.0832       | 0.1122 |
| Xinjiang        | 0.1104                                    | 0.0724                                    | 0.0380 | 0.0269 | 0.0168       | 0.0101 |
| All China       | 0.2122                                    | 0.1646                                    | 0.0476 | 0.1074 | 0.0827       | 0.0247 |

It is not difficult to see from Table 1, both index and rate of mine environment rehabilitation in Huanan Region were highest in the 7 regions, indicated that the degree of Huanan Region mine environmental rehabilitation was highest. Both index and rate of mine environment rehabilitation in Hainan and Shanghai were highest in the 31 provinces, indicated that the degree of Hainan and Shanghai mine environmental rehabilitation were highest.
4. Compared the Calculation Results between Index and Rate of Mine Environment Rehabilitation

There are two understandings, which were gotten through compared the calculation results between index and rate of mine environment rehabilitation:

1. Restricted by the equation, the rate of mine environment rehabilitation value can't larger than 1, actually less than 0.5. The index of mine environment rehabilitation value may larger than 1, and actually there were 3 indexes in Hainan, Shanghai and Tibet, all larger than 1, Indicated that the area of mine environment rehabilitation were larger than the area of mine land which should be urgent rehabilitation in these 3 provinces. That was to say, the difference of the degree among different regional mine environmental rehabilitation was more obvious in index than rate of mine environment rehabilitation.

2. All the change value of rate of mine environment rehabilitation from 2016 to 2017 were positive, indicated that the rate of mine environment rehabilitation in all provinces and regions were increased. But the change value of index of mine environment rehabilitation in Tianjin and Liaoning from 2016 to 2017 were negative, indicated that the value of "the area of mine environmental rehabilitation" divided "the area of mine land which should be urgent rehabilitation" values in these two provinces had decreased. That was to say, the mine environmental rehabilitation weakened region can be more obvious reflected through index than rate of mine environment rehabilitation.

5. Summary

The index of mine environmental rehabilitation, which was discussed in this article, for highlight the situation which should be urgent rehabilitation, was the value of "the area of mine environmental rehabilitation" divided "the area of mine land which should be urgent rehabilitation". Compared with the rate of mine environmental rehabilitation, the difference of the degree among different regional mine environmental rehabilitation was more obvious, the mine environmental rehabilitation weakened region can be more obvious reflected.

It is a complex process to evaluate regional mine environmental rehabilitation, needs the long-term exploration and practice of scholars. The method discussed in this paper is simple and easy to operate, but there are some shortcomings, such as not considering the difference of mine environmental rehabilitation effect, and so on. Scholars with aspirations can further study and explore were hoped.

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