

Research on Mine Ecological Restoration and Transformation from the Perspective of Chinese - Style Modernization

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Abstract: This paper focuses on the issues of mine ecological restoration and transformation from the perspective of Chinese - style modernization. Through methods such as field investigations, questionnaires, and in - depth interviews, it systematically analyzes the current situation, existing problems, and causes of mine ecological restoration, and proposes corresponding countermeasures and suggestions. The research finds that mine ecological restoration is not only related to the improvement of the ecological environment but also closely linked to people's well - being, economic development, and social stability. At present, although China's mine restoration industry has achieved certain results, it still faces challenges such as ineffective policy implementation, insufficient implementation of enterprise responsibilities, and inadequate people's livelihood protection. This paper suggests focusing on supervision to urge mining right holders to fulfill their restoration responsibilities, strengthening the coordination of social contradictions by improving the public participation mechanism, and attracting social capital to participate by constructing a market - oriented long - term mechanism, so as to achieve the sustainable development of mine ecological restoration and transformation.

Keywords: Mine Restoration; Ecological Remodeling; Beautiful China; Chinese - Style Modernization; Low - Carbon Development.

1. Introduction

1.1. Research Background

The development of mineral resources, as an important material basis for the industrialization process, has played a crucial role in supporting China's rapid economic growth. However, the environmental costs caused by extensive development are also shocking. According to data from the Ministry of Natural Resources, as of the end of 2023, there were 30,514 valid mining rights nationwide, the total output of mineral resources reached 1.73 billion tons, and the total output value of the mining industry exceeded 612.75 billion yuan, accounting for 15.36% of the total industrial output value. At the same time, the area of land damaged by mining nationwide has accumulated to more than 4 million hectares, of which the land damaged by historical legacy mines is 2.3 million hectares, and the soil erosion area is 125 million hectares, accounting for 13% of the national land area. Mining activities not only cause serious damage to the ecological environment but also trigger a series of social problems, such as geological disasters, damage to biodiversity, and a decline in the quality of life of residents.

In the context of global green and low - carbon transformation, mine ecological restoration bears multiple strategic values. The report of the 20th National Congress of the Communist Party of China listed "promoting the harmonious coexistence of man and nature" as an essential requirement of Chinese - style modernization, and mine ecological restoration has become a strategic means for ecological civilization construction. The Overall Plan for the Protection and Restoration of Major Projects in National Key Ecosystems (2021 - 2035) clearly requires that by 2025, the restoration rate of historical legacy mines must reach 60%, and new mines must achieve full coverage of "restoration

while mining". Under China's carbon peaking and carbon neutrality goals, mine ecological restoration has been given a new mission, that is, to contribute to the realization of the carbon neutrality goal by increasing carbon sinks.

1.2. Research Questions and Significance

1.2.1. Research Questions

Under the dual constraints of the "carbon peaking and carbon neutrality" goals and high - quality development, mine restoration faces the dilemma of "high investment, long cycle, and low return". According to data from the Ministry of Natural Resources in 2023, the area of land damaged by historical legacy mines nationwide is 3.62 million hectares, and the total demand for restoration funds exceeds 1.2 trillion yuan, but the coverage rate of financial funds is less than 30%. At the same time, with the improvement of the people's demand for a better life in mining areas, the traditional restoration model of "emphasizing engineering and neglecting people's livelihood" can no longer meet comprehensive demands. In addition, China's mine restoration technology still faces the bottleneck of "a large number of patents, low conversion efficiency, and weak core equipment".

In summary, mine ecological restoration, as an "ecological must - answer question" in the process of Chinese - style modernization, faces three core contradictions:

How to achieve the coordination of restoration efficiency and economic growth under the background of tightened ecological constraints?

How to balance ecological governance and people's well - being in the face of upgraded people's livelihood demands?

How to build an independent innovation restoration system in the face of the dilemma of relying on imported technology?

1.2.2. Research Significance

This research focuses on cracking the "Chinese questions" of mine ecological restoration, based on the theoretical and practical needs of Chinese - style modernization, and focusing on the coordinated governance of multi - dimensional contradictions in ecology, economy, society, and technology. It has the following systematic significance:

Theoretical Significance: Construct a new theoretical paradigm for Chinese - style ecological governance. By integrating ecological economics, social governance theory, and technological innovation theory, a coordinated path of "value transformation - interest coordination - technology adaptation" is proposed to reveal the deep - seated relationship between ecological restoration and the modernization process.

Practical Significance: Provide a systematic plan for the implementation of national strategies. Explore the coordinated model of ecological restoration, clean energy development, and carbon sink capacity improvement, and provide an implementation path for the carbon neutrality goal. At the same time, in response to the dilemma of "resource depletion and urban decline" in resource - based areas, a "restoration - industry - employment" chain - type development framework is constructed.

Innovation Significance: Through methodological innovation, it provides new tools for the systematic research of complex ecological problems. A comprehensive evaluation system covering ecological quality, economic transformation, social satisfaction, and technological maturity is established to achieve interdisciplinary integration.

2. Research Methods and Data

2.1. Research Methods

This research mainly uses methods such as field visits, questionnaires, in - depth interviews, structural equation modeling (SEM), and system dynamics modeling (SD) for data collection and analysis.

Field Visits: A total of 3 cities and 12 mining areas were visited to obtain first - hand information.

Questionnaires: Two questionnaires were designed, targeting residents near mine sources and employees of mining enterprises respectively. A total of 2,032 valid questionnaires were recovered.

In - depth Interviews: In - depth interviews were conducted with the principals of multiple mining enterprises and local government officials to understand policy implementation and enterprise operation situations.

Structural Equation Modeling (SEM): Based on the questionnaire data, a structural equation model was constructed to analyze the multi - dimensional impact mechanism of ecological restoration on residents' life satisfaction.

System Dynamics Modeling (SD): A system dynamics model coupling "resources - environment - economy - society" was constructed to simulate the dynamic feedback mechanism under different policy scenarios.

2.2. Data Sources

2.2.1. Existing Data Sources

The data of this paper mainly come from the statistical data released by relevant departments such as the National Bureau of Statistics, the Ministry of Natural Resources, the Ministry of Industry and Information Technology, the Ministry of

Ecology and Environment, the National Mine Safety Administration, and the National Energy Administration. In addition, some supplementary data were obtained through literature research and database queries.

2.2.2. Questionnaire Data Sources and Reliability Tests

The questionnaire data mainly come from residents near mine sources and workers in related enterprises. Questionnaires were conducted from aspects such as ecological restoration, people's compensation, people's livelihood needs, and current rules and regulations. Before analyzing the questionnaire data, reliability tests were carried out first, including reliability analysis and validity analysis. The results show that the overall Cronbach's Alpha coefficient of the questionnaire is greater than 0.8, the KMO coefficient is greater than 0.9, and the significance P - value is less than 0.05, indicating that the questionnaire data have high reliability and validity.

3. Current Situation and Challenges of the Mine Industry Development

3.1. Industry Development Status

Since the "13th Five - Year Plan", a total of 4.8 million mu of historical legacy abandoned mines have been treated nationwide. During the "14th Five - Year Plan" period, China implemented 49 ecological restoration demonstration projects for historical legacy mines, and restored and treated 30,300 hectares of historical legacy abandoned mines. However, the overall level of China's mine restoration industry still needs to be improved, and it faces multiple challenges.

3.2. Main Challenges

3.2.1. Policy Level

Vague management boundaries and inconsistent identification standards: There are ambiguous areas in the management boundaries between different government departments, resulting in situations of multi - head management or management gaps during project approval and implementation.

Unclear policies on the use of soil and stone materials and cumbersome approval processes: There is a lack of clear policy guidance for the rational use of soil and stone materials, and the approval process is complex, increasing the time cost and operation cost of enterprises.

Incomplete incentive mechanisms, insufficient capital investment, and single - channel sources: The intensity of tax preferential policies is insufficient, the standards of financial subsidies are not high, and the scope is limited, resulting in low participation of social capital.

Weak supervision power and insufficient law - enforcement efforts: The number of professional supervisors in supervision departments is insufficient, and the supervision equipment and technical means are backward.

Lack of unified planning and poor coordination among departments: Mine restoration projects in various regions lack unified planning, and the coordination and communication mechanism among departments is imperfect.

3.2.2. Enterprise Level

High financial pressure and high - difficulty technology: Mine restoration projects require high upfront investment costs and high - level technical requirements.

Difficult coordination of policies and regulations: The requirements of different departments for mine restoration are

inconsistent, and enterprises need to spend a lot of energy on coordination.

Unregulated market competition: The industry threshold is relatively low, market competition is fierce, and phenomena such as low - price competition, bid - rigging, and collusive bidding exist.

Complex post - monitoring and maintenance: Mine restoration involves many aspects, and the post - monitoring and maintenance work is complex and lasts for a long time.

3.2.3. People's Livelihood Level

Compensation standards do not meet psychological expectations: There is a large gap between the compensation standards for land and property losses and the psychological expectations of residents.

Insufficient flexibility in compensation methods: The existing compensation methods are mainly monetary and resettlement compensation, which are difficult to meet the long - term livelihood needs of residents.

Poor communication leading to information asymmetry: Residents have limited understanding of the formulation process and implementation details of compensation policies and lack effective participation channels.

3.2.4. Ecological Level

Serious damage to land resources: Mining has caused serious problems such as surface subsidence and land excavation.

Pollution and depletion of water resources: Wastewater generated during the mining process is directly discharged without effective treatment, causing water pollution. At the same time, dewatering operations lead to a decline in the groundwater level.

Deterioration of the atmospheric environment: A large amount of dust and waste gas are generated during the mining process, seriously affecting air quality.

Imbalance of the ecosystem: Mining activities damage vegetation and biological habitats, leading to a sharp decline in biodiversity.

4. Data Analysis and Results

4.1. Analysis of the Compensation Mechanism for Affected Residents near Mine Sources

4.1.1. Ecological Compensation Mechanism

The ecological compensation mechanism aims to promote environmental protection through economic means, ensuring that regions and individuals who contribute to environmental protection can receive reasonable economic returns. Ecological compensation costs mainly come from three levels: international, national, and enterprise. The global ecological compensation system shows various forms, including government - led, market - based mechanisms, international cooperation, and local implementation.

4.1.2. Comparison of Ecological Compensation Models

There are currently five main ecological compensation models: enterprise - funded and enterprise - compensated; enterprise - funded and local - government - organized compensation; joint compensation by enterprises and local governments; state - funded and government - organized compensation; and compensation through investment promotion. Each model has its own advantages and disadvantages, and an appropriate model needs to be selected according to the actual situation.

4.1.3. Calculation Method of Ecological Compensation Fees

The calculation of ecological compensation fees is based on the value of ecological damage caused by mineral resource development. Considering the time value of money, a discount rate is introduced for calculation. Taking a mining area in Hainan Province as an example, the total compensation cost for the loss of ecosystem service value in this mining area is calculated to be approximately 229.5956 million yuan, and the annual compensation cost is approximately 8.8306 million yuan.

4.2. Analysis of the Mechanism of the Impact of Mine Ecological Restoration on Residents' Life Satisfaction

4.2.1. Model Fit Test

The structural equation model constructed in this study passed the model fit test, and all indicators met statistical standards, indicating a good fit between the model and the data.

4.2.2. Measurement Model Analysis

The factor loadings of the observed variables of each variable and the reliability and validity indicators reached a good level, indicating that the measurement model has good internal consistency and convergent validity. Among them, air quality and water quality are the core indicators for residents to evaluate the mining area environment.

4.2.3. Structural Model Analysis

Through path coefficient analysis, the progressive mechanism of "economic environment perception → ecological perception → compensation response → restoration participation → life satisfaction" was verified. The perception of mining area development has a negative impact on the perception of the ecological living environment, the ecological perception has a positive impact on compensation and employment satisfaction, and compensation and employment satisfaction have a positive impact on both restoration expectations and life satisfaction.

4.2.4. Mediation Effect Test

The significance of the mediation effect was tested by the Bootstrap method, and it was found that the path by which ecological perception indirectly affects life satisfaction through compensation and employment satisfaction was significant.

4.3. System Dynamics Model Analysis

4.3.1. System Structure

This study divides the system into four parts: the mine subsystem, the environment subsystem, the economy subsystem, and the society subsystem, and constructs a structural diagram of the coordinated system for mine ecological restoration and economic development.

4.3.2. Hypothesis Conditions

To ensure that the model can effectively reflect the dynamic coordination mechanism between mine ecological restoration and economic development, multiple hypothesis conditions were proposed in combination with the background of Chinese - style modernization, including policy continuity, complete supervision, and certainty of carbon sink measurement.

4.3.3. Simulation Results

Dynamic feedback model of mine resource mining and

ecological restoration: There is a positive synergy between ecological restoration capital investment and resource mining efficiency, and the increase in carbon sinks has a significant offset effect on mining costs.

Synergistic growth model of mine restoration ecological benefits and economic benefits: There is a positive correlation between the ecological restoration rate and the number of green industry employees. Carbon sink trading has a catalytic effect on green technology innovation, and investment in environmental governance PPP projects has a leverage effect on increasing income.

Dynamic growth model between social satisfaction and low - carbon economic development: Environmental governance has a driving effect on residents' satisfaction, green consumption has a pulling effect on low - carbon industries, green employment has an optimizing effect on the income structure, and public service investment has a supporting effect on sustainable development.

5. Countermeasures and Suggestions

5.1. Focus on Supervision to Promote Mining Right Holders to Fulfill Restoration Responsibilities

It is recommended to integrate the supervision functions of departments such as natural resources, ecological environment, and forestry, and establish a joint supervision center for mine ecological restoration. Implement full - life - cycle supervision and establish a digital supervision platform for the entire process of "exploration - mining - restoration - monitoring". Link the restoration compliance rate with the enterprise credit rating, and innovate the use mode of funds, allowing enterprises to use part of the governance funds for profitable restoration projects.

5.2. Strengthen the Social Contradiction Coordination Mechanism by Improving the Public Participation Mechanism

It is recommended to establish a coupling mechanism between compensation willingness and restoration benefits, and divide compensation costs into basic compensation and development right compensation. Construct a negotiation index that includes economic compensation satisfaction, employment support, and the frequency of participation in decision - making as the basis for policy adjustment.

5.3. Guide the Construction of a Market - Oriented Long - Term Mechanism to Fully Attract Social Capital Participation

It is recommended to expand the path of carbon sink assetization and include eligible restoration projects in the national carbon market. Develop derivative financial instruments for restoration, such as issuing "mine restoration income bonds". Innovate the value realization mechanism of ecological products to attract social capital participation.

5.4. Strengthen the Analysis of Special Environments, and Adapt to Local Conditions to Learn from Domestic and International Technologies

It is recommended to compile a technology adaptability map to clarify the optimal technology combination for

different regions. Improve the technology trading market and promote in - depth integration of industry, academia, and research. Strengthen international cooperation and exchanges, and learn from foreign advanced technologies and experiences.

6. Reflections and Inspirations

6.1. Innovate Mining Restoration to Promote the Transformation of Resource - Based Cities

Mine ecological restoration is not only an inevitable requirement for environmental governance but also a strategic fulcrum for resource - based cities to achieve sustainable development. By restoring abandoned mines and developing emerging industries such as ecological agriculture, eco - tourism, and new energy, the industrial structure can be optimized, and the transformation and development of resource - based cities can be realized.

6.2. Improve the Environment through Mining Restoration and Realize the Transformation of Lucid Waters and Lush Mountains into Gold and Silver Mountains

Mine ecological restoration can quantify ecological values and promote a systematic transformation from "lucid waters and lush mountains" to "gold and silver mountains". Restored mines can develop ecological industries to achieve an organic combination of ecological and economic benefits.

6.3. Promote Technology through Mining Restoration to Contribute to Carbon Neutrality at Home and Abroad

In the context of global efforts to address climate change and China's promotion of the carbon peaking and carbon neutrality goals, mine ecological restoration has been given a new mission. Through technological innovation and international cooperation, the efficiency and quality of restoration can be improved to contribute to the realization of the carbon neutrality goal.

6.4. Boost Enterprises through Mining Restoration and Win the People's Hearts through Utilization and Protection

Mine ecological restoration brings new development opportunities for enterprises. By fulfilling social responsibilities, adopting green mining technologies and environmental protection equipment, and strengthening communication and cooperation with local residents, enterprises can improve their social image, create new economic growth points, and win the hearts of the people.

7. Conclusion

Mine ecological restoration is an important task in the process of Chinese - style modernization, which is not only related to the improvement of the ecological environment but also closely linked to people's well - being, economic development, and social stability. Through systematic analysis of the ecological value transformation path of restoration projects, the transformation mechanism of resource - based cities, and the technology - coordinated innovation model.

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