Application Research of Intelligent Decision Support System in Ecological Restoration of Mining in the Anning River Basin

Jichuan Chen

215315268@qq.com

Xichang University, College of Tourism and Urban Planning, Xichang, Sichuan, China

Abstract. The Anning River Basin is located in a dry and hot valley area, and long-term mining activities have led to a large area of abandoned mining land, posing a huge challenge to the ecological environment. To achieve coordinated development between socio-economic development and ecological environment protection, effective ecological restoration measures need to be taken. This article provides a certain introduction to the ecological situation of mines in the Anning River Basin, with a focus on analyzing the current problems. Based on this, it further explores the construction of an intelligent decision support system, and combines the characteristics of mine ecological restoration to discuss the specific application of the intelligent decision support system in the ecological restoration of mines in the Anning River Basin, mainly including: optimization of ecological restoration plans Environmental monitoring and assessment, as well as risk analysis and decision support, provide reliable guarantees for the smooth implementation of ecological restoration work in mines in the Anning River Basin

Keywords. Intelligent Decision Support System; Anning River Basin; Mines; Ecological restoration

1 Introduction

With the continuous development of industrialization and urbanization, the overexploitation of natural resources and environmental pollution have become global problems, posing serious threats to ecosystems and human society. In the Anning River Valley in southwestern China, long-term mining development activities have led to a large amount of abandoned mining land, seriously damaging the local ecological environment. In order to balance the relationship between socio-economic development and ecological environment protection, it is necessary to carry out ecological restoration work on abandoned mining areas. However, this work faces complex issues, including soil quality restoration, vegetation introduction and protection, water resource management, and so on. Therefore, it is of great practical significance to conduct research on the application of intelligent decision support systems in the ecological restoration of mines in the Anning River Basin.

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2 Overview of Mining Ecology in the Anning River Basin

2.1 Current situation of abandoned mining land

The Anning River Basin, as a key dry and hot valley area in southwestern China, has abundant natural resources and strategic geographical location. However, long-term mining development activities have led to the formation of a large amount of abandoned mining land, which seriously damages the ecological environment and brings a series of problems. The current situation of abandoned mining land mainly includes:

Firstly, a large area of land is barren. Mining wasteland is usually occupied by abandoned ore, slag, and mining facilities, and the land loses production functions such as agriculture and forestry. Secondly, the decline in soil quality. Mining activities lead to soil pollution and erosion, leading to a decrease in soil fertility and affecting the sustainability of agricultural production. Once again, there is a shortage of water resources. The extensive utilization and pollution of water resources by mining activities have led to a shortage of water resources in the Anning River Basin, which poses challenges to residents' livelihoods and agricultural irrigation. Finally, biodiversity is lost. Mining activities have damaged the original ecosystem, resulting in reduced vegetation and loss of habitat for wild animals, affecting ecological diversity[1].

2.2 Basic principles and objectives of ecological restoration

The ecological restoration work of mines in the Anning River Basin needs to follow a series of basic principles and clear goals to ensure the scientific and effective nature of the restoration work.

Firstly, one of the basic principles of ecological restoration is ecosystem restoration. This means that restoration work should aim to restore the original ecosystem structure and function of abandoned mining areas. By introducing suitable vegetation types, improving soil quality, and restoring water supply, restoration work should gradually restore abandoned land to land with natural ecosystem characteristics. Secondly, the principle of sustainability is the key to ecological restoration work. This includes ensuring the long-term sustainability of restoration work to maintain the stability and health of the ecosystem. By rational planning and management of water resources, regular monitoring of soil and vegetation conditions, and regular maintenance and management, the sustainability of restoration effects can be ensured. Finally, environmental protection and rational utilization of resources are also one of the goals of ecological restoration. Remediation work should focus on reducing pollutant emissions, improving soil and water quality, and protecting the integrity of ecosystems. At the same time, it is necessary to plan and manage resources reasonably to ensure sustainable utilization of resources, meet socio-economic needs, and not harm the ecological environment[2].

3 The Construction of Intelligent Decision Support System

3.1 Data Collection and Processing

(1) Geographic Information System (GIS) data

GIS is a powerful tool for managing, analyzing, and visualizing geospatial data, providing important information about surface features, terrain, land use, climate, and water resources.

Firstly, data collection covers multiple aspects, including geographic data, meteorological data, soil data, water resource data, etc. Geographic data is the core of GIS, which includes satellite remote sensing images, digital maps, terrain models, etc. It can be used to identify the location and scope of abandoned mining areas, as well as the characteristics of the surrounding environment. Meteorological data provides information on meteorological factors such as rainfall, temperature, and humidity, which are crucial for the impact of ecological restoration. Soil data includes information such as soil texture, nutrient content, acidity, and alkalinity, which can be used to evaluate the fertility and suitability of the land. Water resource data, including information such as river flow and water quality, is crucial for water resource management. Secondly, data processing is a key step in ensuring data quality and consistency. During the processing, operations such as data cleaning, format conversion, and spatial analysis are required to ensure the accuracy and availability of the data. In addition, it is necessary to integrate and integrate data from different sources to obtain comprehensive geographic information. Finally, the application of GIS data can not only help determine priority areas and goals for ecological restoration, but also support decision-making and resource allocation. For example, by analyzing GIS data, the location of abandoned mining areas and the potential for vegetation restoration can be determined, and corresponding restoration plans can be developed. In addition, GIS can also be used to monitor and evaluate the effectiveness of repair work, and adjust and optimize repair strategies in a timely manner.

(2) Ecological environment monitoring data

The ecological environment monitoring data includes multidimensional information about the ecological environment status, such as air quality, water quality, soil quality, biodiversity, etc., which is crucial for the development and implementation of ecological restoration strategies. The collection of ecological environment monitoring data is carried out through network remote sensing technology, on-site observation, and laboratory testing. Air quality monitoring includes measuring the concentration of various pollutants in the air, such as particulate matter, sulfur dioxide, nitrogen oxides, etc. Water quality monitoring covers water quality parameters of rivers, lakes, and groundwater bodies, such as dissolved oxygen, ammonia nitrogen, and heavy metal content. Soil quality monitoring includes the determination of indicators such as soil texture, nutrient content, acidity, and alkalinity. Biodiversity monitoring focuses on the diversity levels of various biological populations and species in ecosystems[3].

3.2 Model Development and Optimization

(1) Ecological restoration model

Ecological restoration models are usually constructed based on ecological principles and environmental science knowledge to simulate various processes and interactions in ecosystems. These models can include vegetation dynamic models, hydrological models, soil models, biodiversity models, etc. Each model is used to analyze different aspects of ecological restoration issues. For example, vegetation dynamic models can simulate the growth and competition of different vegetation species under different environmental conditions, helping to select appropriate vegetation planting strategies. Hydrological models can simulate the circulation and distribution of water resources, which helps optimize water resource management plans. Soil models can analyze changes in soil nutrients and texture, guiding soil improvement work. Biodiversity models can evaluate the distribution and stability of various species in ecosystems for the protection and enhancement of biodiversity.

The development and optimization of the model requires parameter calibration and validation based on actual data and monitoring results. This can ensure the accuracy and reliability of the model, enabling it to truly reflect the characteristics and dynamic changes of the ecosystem. At the same time, the model also needs to be continuously optimized and improved to meet the needs of different repair scenarios and strategies. This may include adjusting the model structure, updating parameters, and improving simulation algorithms.

The application of ecological restoration models can help decision-makers evaluate the potential effects of different restoration schemes and provide decision-making support. Through simulation and prediction, it can help decision-makers choose the best restoration strategy and reduce the risks and uncertainties of ecological restoration projects. In addition, the model can also be used for long-term monitoring and evaluation of the effectiveness of restoration projects, timely adjustment and improvement of restoration strategies, and ensuring the sustained recovery and healthy development of ecosystems.

(2) Water resource management model

Firstly, water resource management models can simulate the hydrological cycle processes of rivers and water bodies, including rainfall, evaporation, groundwater recharge, and runoff. By modeling and simulating hydrological processes, it is possible to predict the supply and demand of water resources in different seasons and climatic conditions. This helps to develop a reasonable water resource scheduling plan, ensure sufficient water sources in ecological restoration areas, and meet the needs of vegetation growth and soil moisture. Secondly, water resource management models can be used to optimize rainwater collection and utilization systems, achieving intelligent rainwater management. During the dry season, rainwater can serve as an important water resource supply for irrigation and vegetation maintenance. The model can predict rainfall and distribution, guide the concentration and storage of rainwater, and ensure the maximum utilization of rainwater resources. Finally, water resource management models can also be used for monitoring and managing water quality. In the process of ecological restoration in mines, issues such as wastewater discharge and water purification may be involved. The model can track changes in water quality, evaluate the concentration and diffusion of pollutants, help formulate water quality protection strategies, and reduce environmental pollution risks[4].

3.3 Integration and Development of Decision Support Systems

(1) Software Tools and Technology Selection

Choosing appropriate software tools and technologies is crucial when building intelligent decision support systems. The choice of these tools and technologies directly affects the performance, scalability, and user friendliness of the system.

Firstly, in order to process a large amount of geographic information and ecological environment monitoring data, GIS (Geographic Information System) software is indispensable. GIS can be used to manage, analyze, and visualize geographic data, including terrain, land use, and water resource distribution. It can help decision support systems better understand and utilize geographic information, providing support for the formulation and optimization of ecological restoration plans. Secondly, the model development and optimization stages typically require the use of numerical simulation software. These software can be used to establish ecological restoration models and water resource management models, and simulate and optimize them. Commonly used numerical simulation software includes MATLAB, Python, etc., which have rich mathematical modeling and data processing functions and can be used to develop complex models. Thirdly, the user interface design of decision support systems also requires special attention. Choosing appropriate development tools and technologies can help create an intuitive and user-friendly user interface, making the system easier to use. Common user interface development technologies include HTML/CSS, JavaScript, React, etc., which can be used to build responsive and interactive interfaces and improve user experience. Fourthly, considering data security and system stability, database management systems are also an indispensable component. A database can be used to store and manage a large amount of geographic data, monitoring data, model input and output information. Common database management systems include MySQL, PostgreSQL, MongoDB, and others, which provide reliable data storage and retrieval capabilities. Finally, in the process of system integration and development, it is necessary to consider the issues of data transmission and communication. Choosing appropriate communication protocols and technologies can ensure data exchange and information sharing among various subsystems. Common communication technologies include RESTful APIs, WebSockets, etc., which can be used to achieve real-time data transmission and system integration.

(2) User interface design

User interface design is a crucial aspect in the integration and development of intelligent decision support systems. An intuitive and user-friendly interface can greatly improve the usability of the system, making it easier for users to understand and operate the various functions of the system.

Firstly, user interface design should consider the needs and habits of users. It is very important to understand who the end users of the system are and what their expectations are. For example, in the ecological restoration of mines in the Anning River Basin, multiple stakeholders such as government departments, environmental protection agencies, and mining companies may be involved. Each user group may have different needs and priorities, so the interface should be customized according to their needs. Secondly, the user interface should be concise and clear, avoiding too many complex charts and technical terms. In the design process, attention should be paid to the hierarchical presentation of information to ensure that users can easily obtain the required information. Graphical interface elements and visualization tools can help users better understand the output of data and models. At the same time, the interactivity of the interface is also important. Users should be able to easily interact with the system, input parameters, run models, view results, and more. The response speed should be fast to maintain user interest and enthusiasm. Appropriate feedback mechanisms and error prompts can help users better use the system. Once again, responsive design should also be taken into account to ensure that the interface can be displayed and operated normally on different devices. Users may access the system on computers, tablets, or mobile phones, so the interface should adapt to different screen sizes and resolutions. Finally, the customizability of the user interface is also a consideration. Different users may have different preferences and workflows, so the system should provide a certain degree of customization options to meet the needs of different users[5].

4 The Specific Application of 3 Intelligent Decision Support Systems in Ecological Restoration of Mines in the Anning River Basin

4.1 Introduction to Intelligent Decision Support System

Intelligent decision support system is an advanced technical tool widely used in decision-making and management of various complex problems. In the ecological restoration project of mines in the Anning River Basin, intelligent decision support systems play a key role. This system is based on advanced computer science and artificial intelligence technology, and can integrate a large amount of multi-source information such as geographic information, environmental monitoring data, land use status, and ecological parameters to support decision-makers in formulating scientific and reasonable restoration strategies.

Firstly, intelligent decision support systems have the ability to integrate and process data. It can aggregate data from different sources, including satellite remote sensing images, geographic information system (GIS) data, meteorological data, water resource data, etc., and integrate these information into an integrated platform, so that decision-makers can comprehensively consider various factors. By analyzing historical and real-time data, the system can provide detailed ecological environment conditions and changing trends, providing reliable data support for the formulation of restoration strategies. Secondly, intelligent decision support systems have the ability to establish and optimize models. The system can construct ecological restoration models, simulate the effects of different restoration strategies, and intelligently optimize based on the weights of different factors to determine the best restoration plan. This model can consider the complex interactive relationships between land, vegetation, water resources, and other aspects, helping decision-makers predict the restoration effect and providing scientific basis for decision-making. Once again, intelligent decision support systems have the function of making and implementing decisions. It can provide decision suggestions based on different scenarios, providing decision-makers with the comparison and evaluation of multiple repair plans. Decision makers can flexibly adjust repair strategies based on the information provided by the system to meet different needs and goals. The system also supports adaptive decision-making, which can adjust strategies in real-time based on environmental changes and repair progress, ensuring the flexibility and efficiency of repair work. Finally, the intelligent decision support system has the function of supervision and feedback. It can monitor and evaluate the quality and effectiveness of restoration projects in real-time, providing feedback on environmental, social, and economic benefits. This helps decision-makers adjust their strategies in a timely manner to ensure that the restoration work can achieve the expected benefits, while also helping the public and government to monitor and evaluate the sustainability and social responsibility of the restoration project[6].

4.2 Optimization of ecological restoration plans

(1) Vegetation planting and soil improvement strategies

Firstly, in terms of vegetation planting, intelligent systems can use big data and machine learning algorithms to analyze multidimensional information such as local meteorological data, soil quality, and vegetation growth status to determine the most suitable vegetation type and density for restoring abandoned land. The system can consider factors such as climate conditions, soil types, and vegetation characteristics to develop planting plans to maximize the survival rate and growth rate of vegetation. In addition, the system can also monitor the growth status of vegetation and make adjustments based on real-time data to ensure the smooth progress of restoration work.

Secondly, in terms of soil improvement strategies, intelligent systems can analyze the chemical and physical characteristics of soil, identify existing problems, and propose corresponding improvement measures. The system can develop soil improvement plans based on parameters such as soil quality, nutrient content, and pH value, such as adding organic matter, minerals, and microorganisms to improve soil structure and fertility. The system can also monitor soil changes and make adjustments based on actual conditions to ensure soil restoration and ecosystem health.

Through the application of intelligent decision support systems, ecological restoration plans can be optimized more scientifically and efficiently. The system can quickly analyze complex data and ever-changing environmental factors, providing strong support for decision-makers to develop reasonable vegetation planting and soil improvement strategies, thereby accelerating the ecological restoration process of mining waste land, improving the success rate of restoration work, and achieving sustainable resource utilization and ecological environment improvement. This application field will play an important role in the ecological restoration of mines in the Anning River Basin, helping to achieve high-quality ecological restoration and sustainable socio-economic development.

(2) Water resource management and scheduling plan

Firstly, water resource management plays a crucial role in ecological restoration plans, especially in dry and hot valley areas such as the Anning River Valley. Intelligent systems can establish water resource management models by analyzing multi-source data such as rainfall, groundwater level, and river water volume to ensure water balance and sustainable utilization in the restoration area. The system can develop an intelligent rainwater centralized utilization plan, store and allocate rainwater reasonably to the restoration area to meet the needs of vegetation growth and soil conservation. In addition, the system can also conduct seasonal water resource scheduling plans, adaptively adjusting water resource allocation based on meteorological conditions and ecological restoration progress, ensuring that the soil moisture and vegetation growth needs of the restoration area are met.

Secondly, the optimization of water resource management and scheduling plans is crucial for the ecological restoration of mines in the Anning River Valley region. In this region with special climate conditions, reasonable management of rainwater and water resources can minimize soil erosion, water resource loss, and other issues, help maintain soil moisture, improve vegetation growth speed, and reduce water resource waste. With the support of intelligent systems, water resource management plans can be formulated and executed more scientifically and accurately to ensure the success of ecological restoration work[7].

4.3 Environmental Monitoring and Assessment

(1) Pollutant discharge and water quality monitoring

Pollutant discharge and water quality monitoring are essential links in the ecological restoration process, aimed at protecting and improving the ecological environment, and ensuring that the restoration work achieves the expected environmental benefits. The intelligent decision support system can integrate various sensors and monitoring equipment to monitor the environmental parameters of air, water quality, and soil in the remediation area of mining waste in real time, including particulate matter emissions, heavy metal content in water, soil quality, etc. The system can also utilize big data analysis technology to conduct real-time analysis and evaluation of monitoring data, identify pollution sources and potential environmental risks, and take timely measures to adjust and respond. Through the application of intelligent decision support systems, high-precision monitoring and evaluation of environmental conditions can be achieved, helping decision-makers better understand the actual progress of ecological restoration work and environmental conditions. Once pollution issues or environmental risks are identified, the system can promptly issue alerts and provide corresponding suggestions to take necessary measures to reduce environmental damage.

(2) The evaluation of the effectiveness of restoration projects mainly focuses on quantitative and qualitative analysis of the restoration of ecosystems and the increase in biodiversity. The intelligent decision support system can integrate ecological models and remote sensing technology to monitor and evaluate the vegetation coverage of the restoration area, as shown in Fig 1. It can be seen that over time, the vegetation coverage has increased year by year, indicating that ecological restoration work is achieving positive results; The soil quality, as shown in Fig 2, has steadily improved with the progress of remediation work, indicating that the health and fertility of the soil are constantly improving[8].

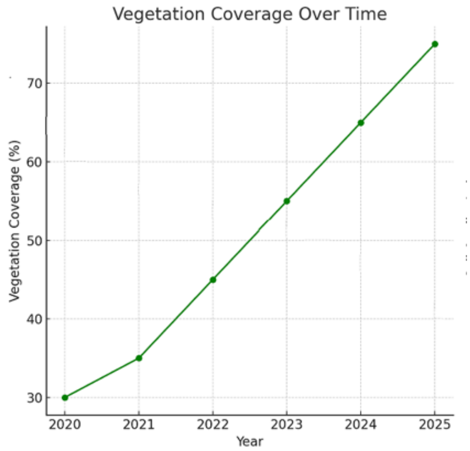

Fig.1 Vegetation Coverage Trend Chart

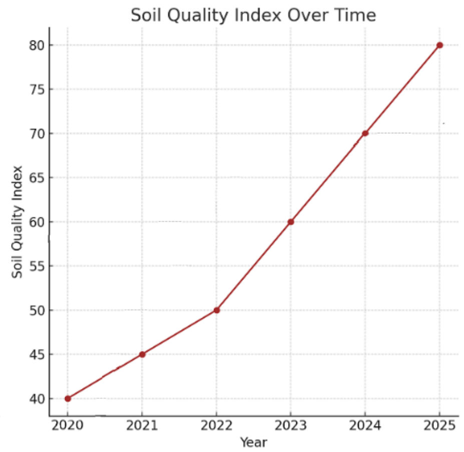

Fig.2 Soil Quality Index Trend Chart

4.4 Risk Analysis and Decision Support

(1) Disaster warning and emergency response

Risk analysis and decision support are essential components in the ecological restoration of mines in the Anning River Basin, especially in the face of natural disasters and emergencies. Intelligent decision support systems play an important role in this regard to ensure the smooth progress of restoration work and the safety of the ecological environment.

Firstly, the system can integrate meteorological monitoring data and meteorological prediction models, monitor meteorological conditions in real-time, and conduct risk assessment and warning for potential natural disasters such as floods, droughts, storms, etc. By analyzing meteorological parameters such as atmospheric pressure, precipitation, and wind speed, the system can detect potential natural disaster risks in advance and issue warning information to relevant departments and decision-makers, in order to take emergency response measures in a timely manner and protect the safety of restoration projects and ecosystems. Secondly, the system can also integrate geological monitoring data and geological disaster prediction models to analyze and evaluate geological disaster risks. By monitoring geological parameters such as groundwater level, geological structure, and seismic activity, the system can identify potential geological disaster risks and provide corresponding suggestions and decision-making support. When a geological disaster occurs, the system can track the disaster situation in real-time, assist in emergency response work, and reduce disaster losses. Finally, intelligent decision support systems can also provide data support for emergency response, including disaster images, monitoring data, resource allocation, and other information to assist decision-makers in making quick decisions and guiding emergency rescue work. The system can also provide data support for post disaster assessment, helping to assess the impact of disasters on restoration projects and ecosystems, and providing scientific basis for subsequent restoration work[9].

(2) Policy and investment decision support

In the ecological restoration project of mines in the Anning River Basin, policy and investment decision support are crucial factors, which directly affect the implementation of the restoration project and the investment of funds. Intelligent decision support systems play a crucial role in this regard by integrating policy information and investment data, providing decision-makers with scientific policy recommendations and fund allocation plans.

Firstly, the system can analyze relevant government policies and regulations, including land use policies, environmental protection policies, resource management policies, etc., to ensure the legality and compliance with regulatory requirements of the restoration project. The system can monitor policy changes in a timely manner, provide policy interpretation and policy adjustment suggestions, to ensure that the repair project is steadily advancing within the policy framework. Secondly, the system can analyze investment needs and resource allocation, helping decision-makers formulate reasonable investment plans. By comprehensively considering the scale, time, manpower, and material requirements of the repair project, the system can optimize resource allocation, reduce investment risks, and ensure the economic benefits of the repair project. Finally, the system can also provide decision support tools to assist decision-makers in risk assessment and decision analysis. By simulating the effects of different policies and investment plans, the system can provide decision-makers with multiple options to make wise decisions in different scenarios[10].

5 Conclusions

In summary, the application of intelligent decision support systems in the ecological restoration of mines in the Anning River Basin provides effective tools and methods for achieving coordinated development of socio-economic development and ecological environment protection. Through scientific decision-making and precise management, it is expected to achieve high-quality ecological restoration work, promote ecosystem restoration and increase biodiversity, and lay a solid foundation for future sustainable development.

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