

Research on Integrated Management of the Yangtze River Basin Under the Background of “One Belt One Road”

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How to cite this paper: Shuifeng Zhang, Daoyou Fang, Meng Li. (2023). Research on Integrated Management of the Yangtze River Basin Under the Background of “One Belt One Road”. *OAJRC Environmental Science*, 4(2), 96-100.

DOI: 10.26855/oajrces.2023.12.006

Received: November 28, 2023

Accepted: December 25, 2023

Published: January 22, 2024

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Abstract

This paper aims to achieve the coordination between resource development and utilization and ecological environment protection in the Yangtze River Basin during its participation in the "Belt and Road" construction. It constructs a multi-objective decision support system for the comprehensive management of the Yangtze River Basin oriented towards the "Belt and Road". Firstly, the current situation of resource utilization and ecological environment protection in the Yangtze River Basin is analyzed, along with the mechanism and coordinated countermeasures for the contradiction between development and protection. Coordinated countermeasures combining regulation, compensation, and policy incentives are proposed. Secondly, a multi-objective decision model considering the objectives of different decision-making entities is constructed to balance the relationship between ecological protection and economic development. Then, data collection and intelligent analysis methods that support decision-making, as well as multi-objective optimization algorithms, are designed to enhance the scientificity of decision-making and provide technical and methodological support for the Yangtze River Basin to achieve green development.

Keywords

Yangtze River Basin, resource utilization, ecological protection, multi-objective decision-making, big data analysis

1. Introduction

With the continuous advancement of the "Belt and Road" initiative, the Yangtze River Basin is an important part of the "Belt and Road" initiative, and the contradictions between its development and utilization and ecological environmental protection are becoming more and more prominent. How to achieve ecological environmental protection while developing and utilizing is an urgent problem to be solved [1]. In response to this problem, it is necessary to establish a scientific and rational integrated management system for the Yangtze River Basin to promote sustainable development of the Yangtze River Basin [2]. This study intends to analyze the impact of the "Belt and Road" initiative on the Yangtze River Basin, analyze the contradiction mechanism between the development and utilization and ecological environmental protection of the Yangtze River Basin, propose coordinated countermeasures for development and utilization and ecological protection, and construct an integrated management system for the Yangtze River Basin oriented towards the "Belt and Road" initiative. This will have important theoretical and practical significance and provide theoretical support and technical means to coordinate the development and utilization of resources and ecological environmental protection in the Yangtze River Basin.

2. Contradictions and Coordination between the Development and Environmental Protection

2.1 Current Situation and Problems of the Development and Utilization

The Yangtze River Basin is one of the most economically active regions in China. The resources in the basin are abundant, with rich water power, mineral resources, biological resources, and huge potential for utilization. Driven by the Western Development Strategy, the development, and utilization of resources in the Yangtze River Basin have made great progress, and the regional economy has grown rapidly. However, ecological and environmental problems have emerged along with resource development [3-5]. The main issue is the over-utilization of water resources. Numerous hydropower projects have been built in the basin, changing the ecological environment of the rivers. Hydropower development has led to the degradation of fish habitats and the decline of biodiversity. In addition, the water demand for agriculture, industry, and living in the basin keeps rising, resulting in prominent contradictions between water supply and demand. Environmental pollution is caused by mineral resource development. Mining of cadmium, phosphorus, antimony, and other minerals has led to severe heavy metal pollution in soil and water, with some mining areas suffering from continuous deterioration of environmental quality. Irrational utilization of land resources is prominent. Land reclamation, urban expansion, etc. have intensified the non-agriculturalization of land, and the area of arable land has decreased rapidly. Destruction of biological resources. Reckless reclamation and over-hunting have reduced biodiversity and degraded ecosystems in the Yangtze River Basin. In summary, the Yangtze River Basin faces issues of over-development of resources and severe environmental pollution. The way resources are utilized needs to shift towards sustainable development. Going forward, pollution control and ecological restoration should be strengthened, and environmental management and monitoring mechanisms for resource development need to be established, to coordinate economic, social development and ecological environmental protection.

2.2 Current Situation and Problems of Environmental Protection

The ecological environmental protection in the Yangtze River Basin is an arduous task. The main problems include declining biodiversity, aggravated soil erosion, and ineffective pollution control. Firstly, the Yangtze River Basin is a region with rich biodiversity. However, due to over-exploitation, many species are facing extinction threats. According to statistics, 15% of nationally first-class protected animals in the Yangtze River Basin, including fish, amphibians, and reptiles, are endangered. The habitats of organisms have been changed through the construction of hydropower projects in the basin, resulting in reduced populations of fish, birds, and other species. In addition, over-fishing has led to a sharp decline in endangered species such as Chinese river dolphins and Chinese sturgeons. Secondly, soil erosion is severe in the Yangtze River Basin, with annual soil loss of about 2.2 billion tons [6, 7]. Some areas, especially upstream areas, have intense soil erosion due to their steep terrain and severe vegetation destruction. Soil erosion not only wastes soil resources but also leads to river siltation and aggravated flood disasters. Thirdly, agricultural and industrial pollution is prominent in the basin, and urban sewage treatment is ineffective, which seriously affects water quality. The basin suffers from excessive chemical oxygen demand and ammonia nitrogen pollution loads, and the overall water quality is in a slightly polluted state. In addition, there are a large number of mine tailings ponds in the upper reaches of the basin, posing daunting tailings pollution control tasks. Therefore, ecological environment investment in the Yangtze River Basin should be increased to implement the systematic management of mountains, rivers, forests, fields, lakes, grasslands, and sands, and improve ecological environment quality. Meanwhile, environmental monitoring systems should be strengthened to improve pollution control capabilities.

2.3 Contradiction Mechanism between Development and Protection

There are obvious contradictions between the development and utilization and ecological environmental protection in the Yangtze River Basin, which are mainly manifested in the conflicts and contradictions in the ways resources are utilized. Driven by economic interests, humans develop and utilize the resources in the Yangtze River Basin through constructing water conservancy hubs, mining mineral resources, etc. This changes the ecological processes of the rivers and the structure of terrestrial ecosystems, destroys biodiversity, and goes against the need for ecological environmental protection. For example, the constructed hydroelectric power stations block fish migration channels and lead to reduced fish populations; mining operations damage vegetation and cause soil erosion; urban expansion occupies farmland, etc. These contradict the need for ecological protection in the Yangtze River Basin. In addition, due to insufficient funding, lack of technical means, and ineffective supervision for ecological environmental protection, pollution control is ineffective, and ecological restoration progresses slowly, which also contradicts the need for rational development and utilization of resources [8]. Overall, the Yangtze River Basin faces issues of over-development and utilization of resources while neglecting ecological protection [9]; there are also issues of ineffective ecological protection which affects the rational utilization of resources. Coordination is needed at the mechanism level between the intensity of resource development and ecological protection, to achieve a balance among resource development, ecological

protection, and economic and social development.

2.4 Coordination Strategies between Development and Protection

To coordinate resource development & utilization and ecological environmental protection in the Yangtze River Basin, full-process control and monitoring mechanisms should be established for resource development, ecological compensation should be implemented, and economic and policy means should be adopted to form restraining incentive mechanisms. Firstly, establish full-process monitoring mechanisms for resource development and utilization. Carrying capacity assessment of resources and environment should be conducted before development to propose reasonable scales and approaches for development. Dynamic monitoring should be implemented during development, and models established regarding outputs of resources and environmental impacts, to realize refined regulation and control. Ecological restoration after development also requires monitoring and management. This calls for unified monitoring networks and databases to realize data collection, transmission, and analysis throughout the whole process of resource development. Secondly, establish a system where developers compensate for ecological environment protection. Compensation should be used for constructing ecological protection zones and biodiversity conservation. Compensation costs of developers should be linked to development scales and ecological environmental impacts. Supervision mechanisms for compensation fund usage should also be established. Thirdly, establish restraining and incentive policy mechanisms. Punishments should be given to behaviors that damage the ecology, so as to restrain over-development; rewards should be provided to entities that take ecological protection measures during development and utilization. Meanwhile, environmental tax systems should be established to internalize ecological costs. Through the above mechanisms of monitoring, compensation, and policies, the resource development behaviors and ecological protection needs in the Yangtze River Basin can be coordinated, to achieve an optimal balance between resource utilization and ecological protection.

3. Construction of a Multi-Objective Decision Support System for the Integrated Management in the Context of the "Belt and Road Initiative"

3.1 Multi-faceted Assessment of the Impacts of the "Belt and Road Initiative"

The "Belt and Road Initiative" has brought multifaceted impacts on the Yangtze River Basin, requiring comprehensive assessments from economic, social, and ecological environmental perspectives. Economically, the Initiative will promote infrastructure construction, industrial development, foreign trade levels, and regional economic growth in the Basin. However, excessive resource exploitation will lead to the overloading of resources and environmental carrying capacities. Therefore, assessments of environmental impacts from infrastructure planning are needed to avoid ecological damage. Socially, the Initiative will facilitate population flow, change population structures and employment patterns, and influence community cultures in the Basin. Attention should be paid to the shocks of population flow on traditional communities and cultures to prevent social problems. Ecologically, infrastructure construction may occupy land and damage vegetation, while industrial development can also lead to pollution, both exerting adverse impacts on ecosystems. Environmental impact assessments are required to protect biodiversity. Moreover, increased regional openness can also increase the risks of alien invasive species propagation. Thus, monitoring and early warning systems for invasive species should be established. In summary, the "Belt and Road Initiative" adds complexity and uncertainty to the economic development and ecological environment protection in the Yangtze River Basin. Scientific and rational assessment methods must be adopted to coordinate development and protection.

3.2 Construction of a Multi-Objective Decision-Making Framework for Integrated Management

To construct a multi-objective decision-making framework for the integrated management of the Yangtze River Basin, the goals of different decision-making entities should be clarified, coordination mechanisms designed to resolve goal conflicts, and big data technologies integrated to support decision-making. The integrated management of the Yangtze River Basin involves multiple entities like government, enterprises, and the public. Their demands differ regarding resource utilization means and environmental protection levels. For example, the government focuses on overall protection from its perspective while enterprises favor resource exploitation based on economic interests. Public demands are also diverse. Therefore, decision-making goals that reflect the demands of different entities should be set, and multi-objective planning models established under constraint conditions. Priorities or weights of different goals should also be reasonably set. During multi-objective decision-making, coordination mechanisms should be created to balance goal conflicts among entities and reach consensus on governance strategies. Consultation platforms can be set up for different entities to negotiate commonly acceptable decisions. Compensation systems can also help coordinate goal conflicts. Decision support systems need big data technologies to acquire various data like environmental monitoring and socioeconomic data, conduct analysis, and provide the basis for multi-objective decisions. Intelligent optimization algorithms can also be utilized to solve multi-objective planning problems and generate optimized solutions under constraints.

3.3 Methods for Big Data Acquisition and Processing

To construct a multi-source heterogeneous big data acquisition, processing, and analysis system to support integrated management decisions in the Yangtze River Basin, first, environmental monitoring networks should be established to collect real-time data on water quality, meteorology, etc. Second, satellite remote sensing should be utilized to obtain spatial-temporal information on land use, vegetation coverage, etc. Third, data resources like economic statistics from government departments should be integrated. Fourth, internet data on social sentiments should be collected. Fifth, public participation platforms should be built to obtain public opinion. For massive multi-source heterogeneous data, cleaning, integration, and storage are needed. Cloud computing can be used to build distributed storage platforms and deep learning is employed to establish knowledge graphs for integrated analysis of multidimensional data. Analysis can be conducted from time and space dimensions - time series analysis to detect ecological and socioeconomic trends, and spatial analysis to identify environmentally sensitive areas, ecological red-lines, etc. System dynamics models can also be applied to simulate integrated impacts under different decisions. Scientific data acquisition and intelligent analysis can support the scientific formulation and coordinated optimization of multi-objective decisions.

3.4 Application of Intelligent Optimization Models in Multi-Objective Decision Making

Multi-objective decision-making requires solving target optimization problems, where intelligent optimization algorithms can be utilized to find optimal solutions. Typical multi-objective optimization problems have tradeoff relationships between objectives, i.e. improvement in one objective leads to deterioration of others. Usually, there is no single optimal solution, but a set of relatively Pareto-optimal solutions. The main goal of solving multi-objective optimization is to quickly locate this solution set. Considering the characteristics of multi-objective optimization problems, some heuristic intelligent algorithms like genetic algorithms, particle swarm optimization, simulated annealing, etc., can be adopted. These algorithms introduce random search mechanisms to quickly traverse the solution space and use metrics to narrow down the search scope. Biological evolution mechanisms can also be borrowed to iteratively generate better solutions. Intelligent algorithms need to combine constraint conditions of problems so that solutions satisfy realistic restrictions. Meanwhile, interactive visualization systems can assist decision-makers in evaluating and selecting solutions. In summary, intelligent optimization models can effectively solve complex multi-objective planning problems and provide scientific support for integrated management decisions in the Yangtze River Basin.

4. Conclusions and Prospects

This study constructed a multi-objective decision support system for the integrated management of the Yangtze River Basin oriented towards the "Belt and Road Initiative", to achieve regional sustainable development through coordinating resource exploitation and ecological protection. Firstly, the current situation of resource utilization and ecological protection in the Yangtze River Basin was analyzed, and a coordination strategy framework centered on regulation, compensation, and policy was proposed, providing a theoretical basis for coordinated regional development. Secondly, a multi-objective decision model considering the demands of different stakeholders was built, which can scientifically balance ecological, social, and economic goals and generate coordinated governance strategies. Finally, methods for big data collection, analysis, and multi-objective optimization algorithms were designed to support decision-making and enhance the scientificity of the system. In the future, constraints and objective formulations in the decision support system should be further enhanced to improve the interpretability and operability of solutions. In methodology, technologies like machine learning can be introduced to enable autonomous learning and adaptation to complex problems, so the system can make better decisions under new circumstances. Virtual simulation techniques can also be utilized to build digital twin systems and support the simulation and evaluation of various management plans. In addition, exploring new technologies like blockchain is beneficial for improving the efficient operation of collaborative decision-making. In terms of application, the system can expand service areas and sectors to support broader integrated regional management decisions. It can also open services to the public and establish new models of social collaborative decision-making. In summary, under the background of the Belt and Road Initiative, the construction of intelligent decision support systems for integrated management of the Yangtze River Basin needs continuous innovation and development, in order to effectively serve the high-quality and sustainable development of China's economy and society.

Funding

This research was funded by the 2022 General Project of Philosophy and Social Sciences of Colleges and Universities "Research on Multi-objective Collaborative Development Decision-making Model for Integrated Management of the Yangtze River Basin Driven by Artificial Intelligence" (2022SJYB0091); the 2022 Jiangsu Provincial Social Science Fund Project "Research on Multi-objective Collaborative Optimization Decision-making Model for Agricultural Watershed Integrated Management Driven by Artificial Intelligence" (22GLD011); and Jiangsu Higher Education Institutions' "Qinglan Project" in 2022.

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