Ready for AI: China's Eco-environmental Zoning-based Regulation System

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Introduction

China's regional resource endowments differ significantly. Eastern coastal areas have a highly developed economy as a result of their superior geographical location and policy advantages, while the western ecologically fragile areas are restricted by natural conditions and transportation factors, resulting in a much lower economic output than that of the eastern areas. Environmental management has been challenged by this imbalance. The past "one-size-fits-all" management model is difficult to adapt to the needs of different regions, and the implementation of precise management faces many challenges, such as data integration and technology implementation.

In this context, the Eco-environmental Zoning-based Regulation (EZR) System established by the Ministry of Ecology and Environment has emerged as an important institutional innovation in China's ecological environment management. It is intended to achieve refined management of the regional ecological environment by scientifically delineating the ecological protection "red line", the environmental quality "bottom line", the resource utilization "upper line", and formulating an admittance list of regulations to the ecological environment. In addition to solving problems such as large differences in regional resource endowments and uneven social and economic development, the implementation of this system will provide a scientific basis and technical support for high-quality development.

China's Ministry of Ecology and Environment launched EZR system around 2017 as an evolving environmental management system involving multiple factors, departments, and levels. According to its definition, it is a system that implements differentiated and precise controls in different regions in order to enhance ecological functions and maintain environmental quality. In the past few years, the logical relationship of "problem identification—quality target—zoning control—development control list" was developed and highlighted as part of the top-level design of the system. The general principles, contents, procedures, methods, and requirements for preparing the EZR were systematically outlined. 31 Provinces in

China have completed the EZR system results based on these technical requirements. Therefore, China's environmental governance has now entered a stage of full implementation and application of the EZR system.

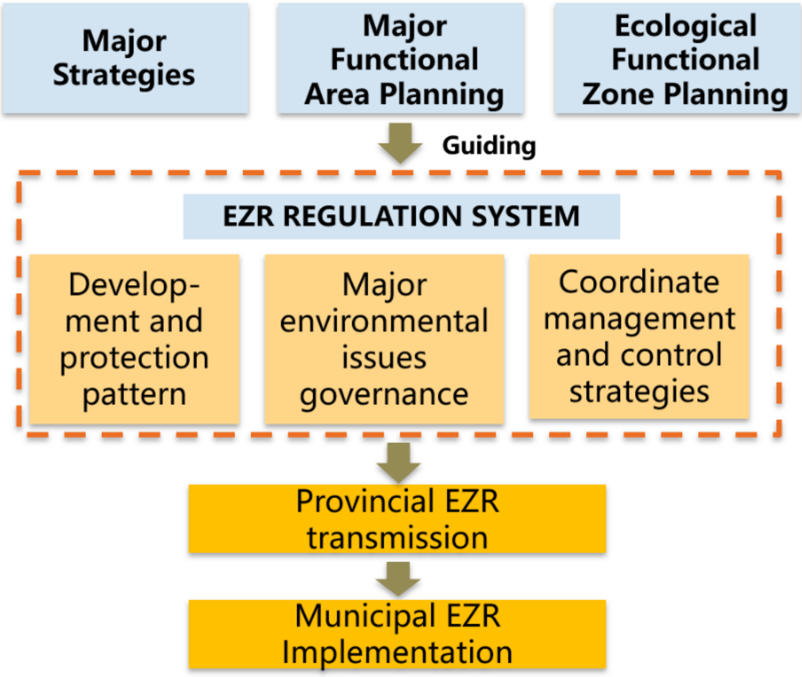

Figure 1 the logic behind EZR's technical design

Digitalization Context of China's EZR systems

(1) Data Uniformity

Data naming, vector layer encoding, text description, data exchange format, and other aspects of the EZR information platform are unified. It should be prepared for the interconnection and interoperability of EZR platforms at all levels (**Table 1**).

(2) Data Integrity

It has been stipulated that the construction of the EZR system platform should focus on building data submission, management, sharing, and application service functions, and ensure the integrity and consistency of data during the exchange process.

(3) Data Security

EZR information platform interfaces should ensure the privacy of the information of transmission objects, and conversion, encryption, or verification should be used to transmit the transmission objects. To ensure that all types of operations can be traced and monitored, the digital platform's interface should provide a log of interface calls.

(4) Data Scalability

An expansion of the interface of the EZR digital platform is possible according to economic and technical development needs. A seamless interface expansion should maintain the compatibility and consistency between interfaces.

Table 1 Common Norms for National EZR System Results

GB/T 17278-2009 Basic requirements for digital topographic map products
GB/T 19710.1-2023 Geographic information metadata Part 1: Basics
GB/T 22239-2019 Basic requirements for network security level protection of information security technology
GB/T 33453-2016 Specification for the construction of basic geographic information databases
GB/T 38674-2020 Information security technology application software security programming guide
GB/T 7408.1-2023 Date and time information exchange representation Part 1: Basic principles
HJ/T 416-2007 Environmental information terminology
HJ/T 419-2007 Environmental database design and operation management specification
HJ 729-2014 Technical specification for environmental information system security
Technical Guidelines for the Preparation of Eco-environmental Zoning-based Regulation System (Trial) (No. 99, 2017)
Technical Requirements for the Preparation of Eco-environmental Zoning-based Regulation System (Trial) (No. 14, 2018)
Data Specifications for Eco-environmental Zoning-based Regulation System Results (Trial) (No. 18, 2018)
Mapping Specifications for Eco-environmental Zoning-based Regulation System (Trial) (No. 4, 2019)
Interim Measures for the Management of Sharing of Government Information Resources (No. 51, 2016)

The effective implementation of EZR control relies on systematic data integration and integration, which was also the intention of its comprehensive coordination of multi-layer and multi-source data. In the compilation process, the data integration dimensions cover natural environment data (topography, water system, and others), socioeconomic data (population distribution, industrial structure, GDP, and others), environmental quality data (air, surface water, soil), and resource utilization data (intensity of land development, water resource carrying capacity, and energy consumption). Through the use of unified data formats, coding rules, and classification standards, data standardization allows for efficient circulation and in-depth application of data. By utilizing spatial topology and attribute association technology, we are able to establish cross-data set associations and integrate data to the greatest extent possible. Data will also be updated dynamically to ensure accuracy and timeliness. On this basis, the EZR data platform, as the core carrier, integrates data storage and management modules, and turns complex data into intuitive information through visualization methods such as ArcGIS map overlay, thereby generating a scientific basis for the formulation of environmental control strategies. When a properly designed data foundation is in place, more advanced data analysis tools (such as artificial intelligence and deep learning) can be used to maximize the value of the data.

Multi-layer Data Platform We Have Built

EZR is characterized by spatialization, integration, and refinement, that is, integrating the ecological environment control requirements of single element zones and implementing them in integrated control units. In addition, a differentiated local instruction access list is determined based on the characteristics of the environment and economic development, such as atmosphere, water, ecology, and the type of industry in the basic data of the unit. To achieve the refinement of ecological environment control measures, multi-factor management and comprehensive integration of functional zoning space are integrated in this manner. In the actual application of environmental management, the following core results are used:

(1) Integrated eco-environmental regulation units

Spatial analysis technology is used to generate a control zone map by integrating and matching ecological, environmental, resource, and other features. **Priority protection units** include ecological protection red lines, nature reserve areas, other ecologically protected areas, surface water priority protection zones, and atmospheric priority protection zones. **Key control units** include major towns, residential areas, industrial parks, and areas with a poor meteorological and hydrological condition, concentrated pollution emissions, poor environmental quality, or high environmental risks. A city's other areas will be mapped as **general units**. Several rounds of verification and local feedback are required before the final release of the results is made.

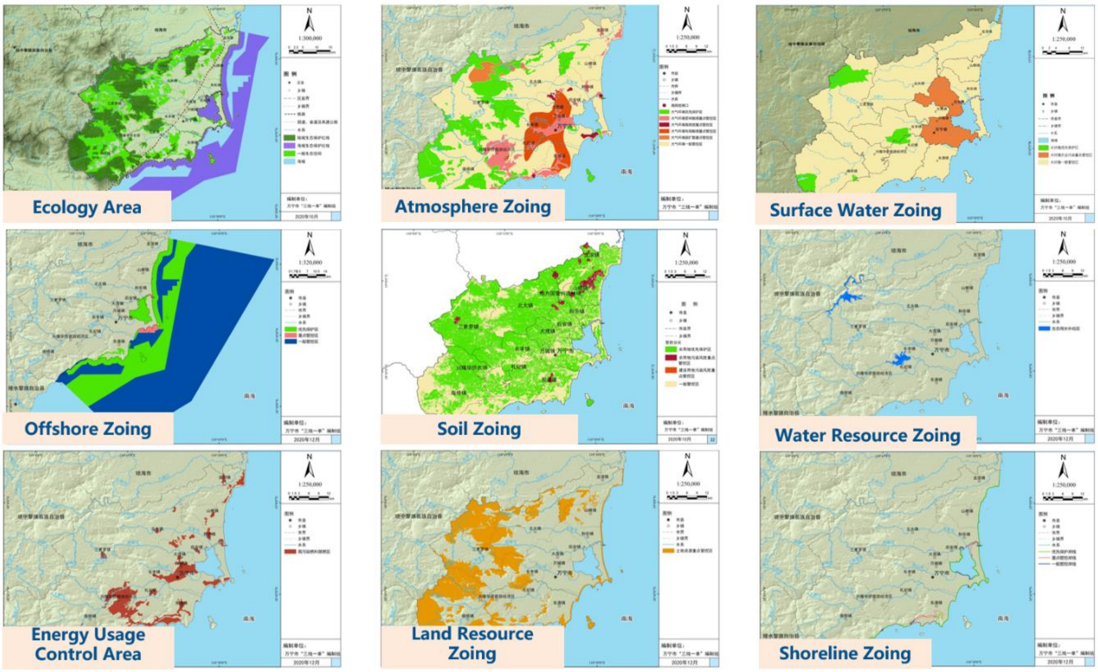

Figure 2 Highly standardized, scientific and systematic results

(2) Detailed compilation of the admittance list

During multiple rounds of discussion, each unit follows the general guidelines based on environmental input and response relationships, as well as resource and environmental carrying capacities. In addition to considering fairness, efficiency, and economy, each team selects and proposes control measures for each ecological environment control unit that takes into consideration these factors. With this as a carrier, the multi-element control measures are connected and integrated to establish an ecological environment control data set with coordinated "environmental target—local space—county—street/township. The admittance list provides measures and environmental suggestions from the four dimensions of spatial layout constraints, pollution emission control, resource using efficiency development and environmental risk prevention.

By the end of 2024, China has outlined more than 40,000 integrated eco-environmental regulation units at the national level, and their spatial scale has been reached to the level of townships and parks, enhancing the accuracy of spatial control of source prevention to an unprecedented level. With this number of units exceeding 40,000, all 31 Chinese provinces (autonomous regions and municipalities), 143 districts, and 382 prefecture-level administrative regions have their own distinct eco-environmental admittance lists. It has been possible to gradually refine, implement, and differentiate the national development strategic goals and the eco-environmental governance requirements through the use of this system.

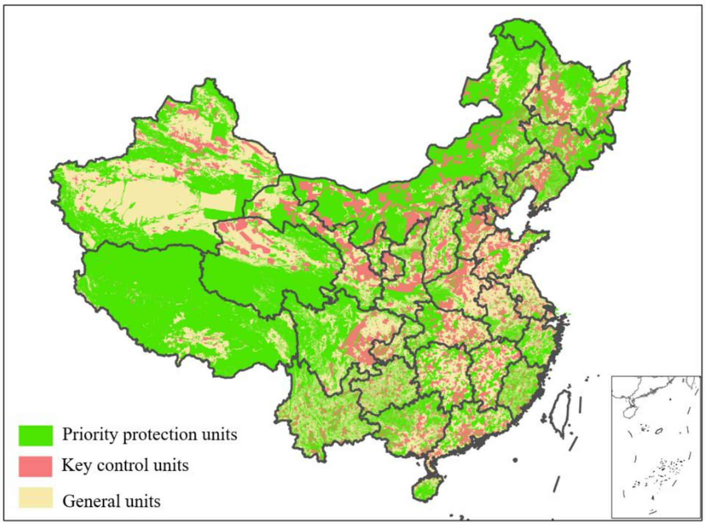

Figure 3 40,000+ Integrated eco-environmental regulation units in China

Implication Challenges of the EZR System for AI

The EZR digital platform has been built, but as the EZR control system enters the AI era, it is foreseeable that there will still be some challenges.

Firstly, the current data island dilemma is more prominent. Generally, most of the data collected by the MEE is not shared with other ministries. A lack of sharing mechanisms and a difference in format standards result in insufficient AI model training samples to support decision-making across departments.

Second, there is a significant bottleneck in terms of computing power. The government must also consider how to allocate the large amount of computing resources it uses in order to fully utilize the EZR system. For each 30-meter resolution remote sensing image across the country, it generally takes more than 1,000 CPU core hours. Due to the conflict between the large amount of environmental data across all domains and the limited computing resources, technological advances have been resisted.

The third requirement is to strengthen data quality and security, and to develop a full-process quality control system as well as encryption protection mechanisms. In China, it is difficult to bypass this problem when connecting management data between different departments, as well as when integrating ecological and environmental data between international platforms in the future.

Moreover, government departments are hindered from carrying out AI technology applications for management data due to a lack of funding support mechanisms and the supporting laws, regulations and policy frameworks, some of which are not yet in place. As a result, existing data platforms may not be able to keep up with the new era's innovation rhythm.

Obviously, if breakthroughs occur in the above aspects in the future, the opportunities for AI technology empowerment will also be significant.

1) With real-time monitoring and intelligent analysis, artificial intelligence can significantly improve the efficiency of collecting environmental data.

2) With the aid of deep learning algorithms, it is possible to provide more accurate decision-making support in the areas of pollution source tracing and ecological restoration.

3) Through the use of natural language processing and visualization technology, the development of a public participation platform will be able to significantly increase the response time to complaints related to environmental protection.

4) By integrating AI tools, the EZR platform would be able to offer recommendations and countermeasures for the coordinated development of economy and environment, in a timely manner, and become a "high-quality development tracker" for management and decision-making departments.

5) Instead of manually combing through environmental management rules, autonomous discovery of environmental problems, and then provides corresponding measures. For example, identifying inconsistent air quality targets in the same region, or unreasonable water quality targets upstream and downstream of the same river, or protection areas adjacent to development areas (especially heavily polluted areas) at the interface between provinces.

To address the above challenges, it requires the collaboration of multiple ministries, as well as building a full-chain solution that combines data governance, computing power infrastructure, talent cultivation, and institutional innovation in order to unlock the core effectiveness of AI in eco-environmental governance.

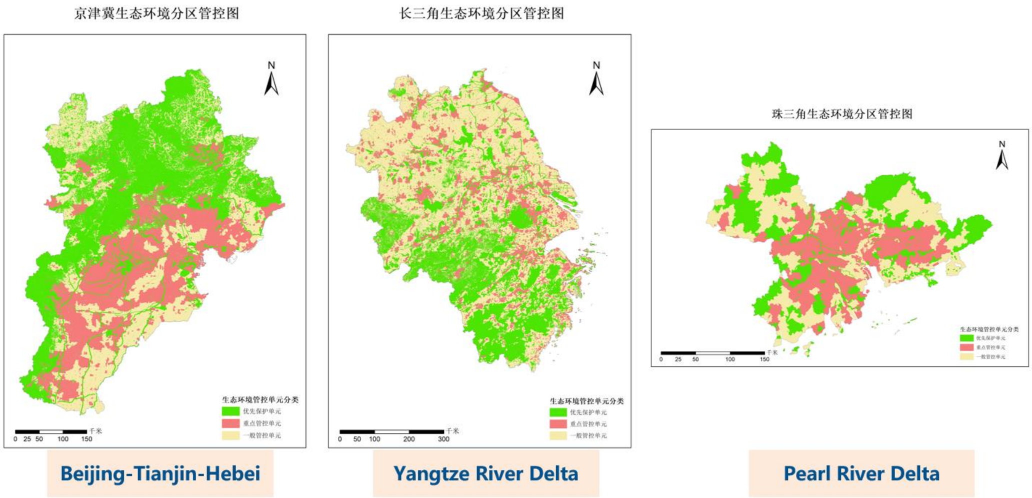

Figure 4 Extraction and further analysis of key regional EZR data

Interpretation of the EZR system's core and essence

EZR is an institutional manner of governance that divides national space into multiple control units and implements differentiated environmental management strategies based on regional ecological and environmental characteristics, environmental carrying capacity and development positioning. Its basic logic is that the interaction between human activities and ecological and environmental systems is spatially heterogeneous. Through precise zoning and policy implementation, the interference of human development activities with the structure and function of the ecosystem can be systematically reduced, and coordination of development and protection can be achieved.

Complex social and environmental systems refer to a complex system in which the natural environment and human society are intertwined (especially in the mega and large cities we live today). The interference of human activities is mainly reflected in three aspects: ecological space encroachment and functional degradation, environmental pollution loads exceeding ecological carrying capacity, and excessive resource development causing systemic risks. As a result, the EZR system measures incorporate control requirements for these aspects.

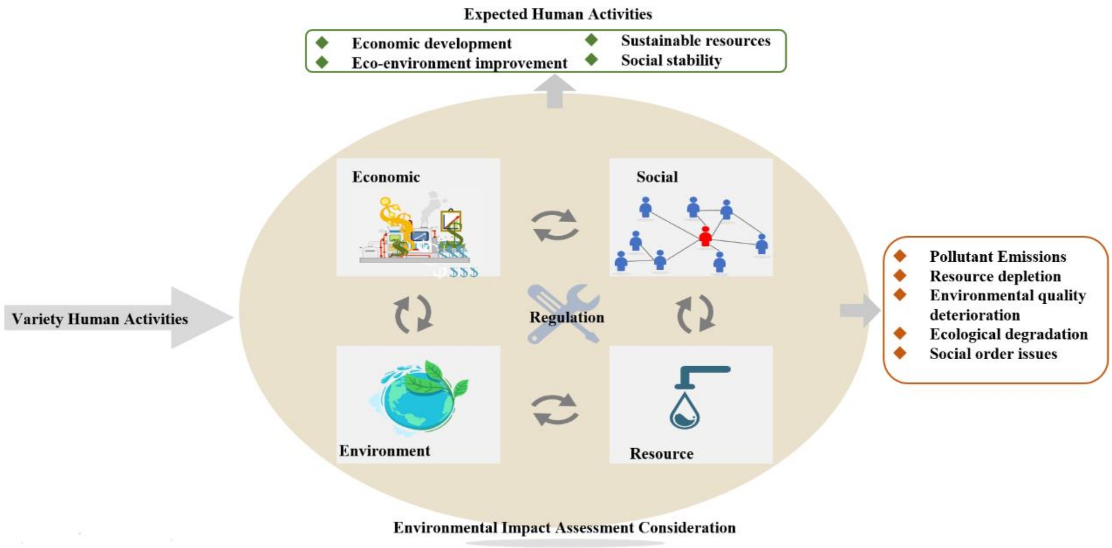

Figure 5 Complexity Theory Behind the EZR System

EZR system directly supports multiple dimensions of the United Nations Sustainable Development Goals (SDGs) by reducing interference: SDG13 (climate action), SDG14 (life below water) and SDG15 (life on land), SDG6 (clean water and sanitation), SDG8 (decent work and economic growth).

One of the important essences of ecological and environmental zoning control is to control the interference of human activities in the social environment system within the ecological threshold. This is done through the reconstruction of spatial governance rules. Its core lies not only in "passively reducing" development damage, but also in "actively guiding" the transformation of development modes - based on scientific zoning, embedding ecological protection needs into the spatial development decision-making chain, and ultimately achieving a paradigm shift from "environmental overdraft development" to "sustainable development". This mechanism not only responds to the interdependence between human activities and the ecological environment in complex systems, but also provides a practical spatial governance solution for the global sustainable development goals.

Figure 6 A pattern of how environmental governance such as EZR contributes to sustainable development