

Evaluation and Optimization Recommendations for Government Environmental Data Openness and Utilization Levels in Key National Ecological Governance Regions: An Analysis Based on Government Data Open Platforms in Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, and Fenwei Plain - Pos...

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Abstract

[Purpose/Significance] Evaluating the openness and utilization levels of government environmental data in key ecological governance areas can identify influencing factors, thereby promoting improvements in data platform openness and utilization to better serve ecological and environmental governance practices. [Method/Process] Grounded in value co-creation theory and the DPSIR model, this study constructs an evaluation index system for environmental data openness and utilization across five dimensions: driving force, pressure, state, impact, and response. Taking the Beijing-Tianjin-Hebei region, Yangtze River Delta, Pearl River Delta, and Fenwei Plain—typical cross-regional national ecological governance priority areas—as cases, we assess regional environmental data openness and utilization levels. [Results/Conclusions] Findings reveal: Significant disparities exist among the four regions, ranking from highest to lowest as Yangtze River Delta, Pearl River Delta, Beijing-Tianjin-Hebei, and Fenwei Plain; Key determinants include environmental data download volume, regional economic support capacity, number of platform functional modules, number of data security issues, and frequency of security testing and evaluation; The Yangtze River Delta's top performance stems from its superior functional module count and download volume; the Pearl River Delta's comprehensive platform layout is undermined by low download volumes; Hebei Province's inadequate platform deployment and funding constrain the Beijing-Tianjin-Hebei region's overall level; Fenwei Plain's low level results from multiple constraints

including platform construction, openness degree, and environmental data collections. To enhance government environmental data openness and utilization, governments at all levels should take measures to improve platform construction, financial investment, data openness standards, data application, and risk prevention.

Full Text

Evaluation and Optimization Suggestions on the Open and Utilization Level of Government Environmental Data in Key Areas of National Ecological Governance

—Based on an Analysis of Government Data Opening Platforms in the Beijing-Tianjin-Hebei Region, Yangtze River Delta, Pearl River Delta, and Fenwei Plain

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Abstract: [Purpose/Significance] Evaluating the level of open and utilization of government environmental data in key ecological governance areas can identify factors influencing this level, helping promote improved data platform utilization to better serve ecological and environmental governance practice. [Method/Process] Based on value co-creation theory and the DPSIR model, an evaluation index system for environmental data open and utilization level was constructed from five dimensions: driving force, pressure, state, impact, and response. Taking the Beijing-Tianjin-Hebei region, Yangtze River Delta, Pearl River Delta, and Fenwei Plain—key national ecological governance areas with typical cross-regional characteristics—as examples, the regional environmental data open and utilization level was evaluated. [Result/Conclusion] The study found: Significant gaps exist among the four regions in environmental data open and utilization level, ranking in order as Yangtze River Delta, Pearl River Delta, Beijing-Tianjin-Hebei, and Fenwei Plain; Performance on indicators such as environmental data download volume, regional economic support capacity, number of platform functional modules, data security issues, and security inspection/evaluation frequency are key determinants of regional environmental data open and utilization level; The Yangtze River Delta's highest level stems from outstanding performance on key indicators like platform functional modules and environmental data downloads; although the Pearl River Delta has comprehensive platform layout, it underperforms in downloads; insufficient platform layout and funding in Hebei Province constrain the Beijing-Tianjin-Hebei region's overall level; the Fenwei Plain's low level is constrained by multiple factors including platform construction, openness, and environmental data resource collections. To improve government environmental data open and utilization levels, governments at all levels should take improvement measures in platform construction, funding, data opening standards, data application, and risk prevention.

Keywords: government data opening platform; environmental data; open and utilization level; key areas of ecological governance

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1 Problem Statement

Government environmental data opening and utilization refers to the activity where relevant government departments release raw, unprocessed environmental data produced through government data opening platforms to the public with regular updates, allowing any organization or individual to freely access, share, and utilize this data. Essentially, it represents the process of social reprocessing and reuse of environmental data. The State Council's 2016 "Notice on Issuing the 13th Five-Year Plan for Ecological and Environmental Protection" and 2018 "Notice on Issuing the Three-Year Action Plan to Win the Blue Sky Defense Battle" designated the Beijing-Tianjin-Hebei region and surrounding areas, Yangtze River Delta, Pearl River Delta, and Fenwei Plain as key national ecological governance areas. To ensure comprehensive and typical research coverage, this study selected provincial and municipal government data opening platforms (excluding district/county-level platforms) and their environmental data from these four regions as research objects. As of July 2020, the Beijing-Tianjin-Hebei region had two provincial platforms (Beijing and Tianjin) and two municipal platforms (Chengde and Hengshui in Hebei). According to the 2019 "Outline of the Yangtze River Delta Regional Integration Development Plan," the Yangtze River Delta's planning scope was officially defined as the three provinces and one municipality of Jiangsu, Zhejiang, Anhui, and Shanghai. This region currently has three provincial platforms (Shanghai, Jiangsu, and Zhejiang), three sub-provincial platforms (Ningbo, Nanjing, and Hangzhou), and 15 prefecture-level platforms including Yangzhou, Wuxi, and Suzhou. All regional government data opening platforms in the Pearl River Delta have been established. The Fenwei Plain currently only has two provincial platforms (Shaanxi and Henan), with relevant cities in Shanxi yet to launch platforms. However, increasing platform numbers is not the government's ultimate goal; rather, the fundamental vision is that opened environmental data can be utilized by government and all social sectors to create greater social and economic value.

Environmental data opening is the prerequisite for value-added development and utilization of environmental data, and the level of environmental data open and utilization directly reflects the capacity and level of data opening platforms in serving ecological and environmental governance. Research on the level of environmental data open and utilization and its influencing factors in key ecological governance areas is crucial for improving local government data platform utilization, narrowing gaps in environmental data utilization within and between regions, achieving value co-creation and sharing between data providers and users, and enabling environmental data opening and utilization to better serve ecological and environmental governance practice.

2 Literature Review

Currently, academic literature specifically focusing on government environmental data open and utilization is relatively limited. Since environmental data open and utilization shares common characteristics with general data open and utilization, much relevant research is included within broader data open and utilization studies, concentrating primarily in four areas:

First, comparative analysis of progress in government (environmental) data open and utilization across countries to provide insights and references. M. Yi compared data quality on open government websites in the UK, US, and South Korea, proposing guidelines for standardizing data formats and integrity to improve open data quality and utilization rates. Song Qingqing et al. studied government data development and utilization in major developed countries, finding they have established systematic legislative frameworks for parallel government data opening and personal privacy protection, as well as tiered public usage fee systems. Comparing these with China's current situation, they attempted to construct a mechanism for China's government data development and utilization process, proposing policy recommendations from perspectives of policy systems, data quality, and deepened application. Zhou Wenhong et al. used case analysis to study open data application development in Canada, Australia, Mexico, New Zealand, the US, and the EU, proposing optimization strategies for China's open data utilization-oriented application development from three aspects: infrastructure, platform construction, and mechanism building.

Second, research on basic concepts, development status, problems, and countermeasures of government (environmental) data open and utilization. F. Benitez-Paez et al. first defined and explained Open Government Data (OGD), proposing a conceptual framework to help local authorities redefine current open data strategies according to user needs and improve data reuse levels. Chang Miao et al. defined the concept and characteristics of environmental data in combination with environmental sector features, elaborating on environmental data utilization in environmental quality management, environmental application management, and public participation in environmental protection. Liu Xinpeng et al. evaluated environmental data on domestic provincial and municipal government data opening platforms from data and platform layers, analyzing current status and problems of environmental data opening and utilization, and proposing corresponding countermeasures. Wen Zuqing et al. constructed a research framework for open government data utilization and output based on existing research and China's current status, studying utilization and output of open data from 82 local governments.

Third, research on government (environmental) data open and utilization behaviors and paths from different perspectives and theories. M. S. Talukder et al. built an integrated model based on the Unified Theory of Acceptance and Use of Technology (UTAUT) and IS Success Model, using Bangladesh as a

case study to empirically research determinants of open government data acquisition and utilization. Duan Yaoqing et al. analyzed current utilization of open data in Harbin, Jinan, Shanghai, Wuhan, Guangzhou, and Guiyang from thematic and regional perspectives using multiple indicators including browsing rates and download rates. Liu Yiling studied environmental data and its open utilization status on Beijing, Shanghai, and Guangzhou government data opening platforms from three dimensions: data, platform, and management, using citizen participation in environmental governance as an opportunity. Ma Renjie et al. defined the internal relationship between government data value realization and its utilization from a value realization perspective, constructing a government data utilization state model, identifying value conflicts under different states, and thereby discovering effective states and possible paths for government data utilization development.

Fourth, using “utilization” as a measurement indicator to evaluate government data opening platform construction. S. Saxena evaluated Saudi Arabia’s open government data website using a usability framework proposed by R. Machova, M. Hub, and M. Lnenicka, aiming to emphasize greater participation and dataset usage by government agencies and the public. Lin Mingyan et al. used Delphi method and analytic hierarchy process to screen indicators and assign weights, constructing a government data opening platform performance evaluation index system including foundation, data, platform, and application layers to evaluate and analyze eight provincial-level government data opening platforms in China. Zhou Wenhong et al. built a local government open data platform evaluation framework from data sharing and utilization perspectives, assessing achievements and shortcomings of launched platforms and proposing optimization strategies from a stakeholder perspective.

In summary, existing research has studied government data opening platforms and data open and utilization from different perspectives, providing important intellectual sources for this study. Overall, research content specifically focusing on environmental data open and utilization levels on government data opening platforms is scarce, particularly lacking cross-regional comparative studies on environmental data open and utilization levels and their internal and external influencing factors. Methodologically, scholars mostly adopt qualitative research methods, with evaluation indicators primarily being qualitative, which has promoted in-depth research on domestic government data opening platforms and data open and utilization to a certain extent. However, few studies construct indicator systems from holistic and systematic analysis perspectives considering causal relationships among various environmental indicators. Based on this, this study further focuses research questions, using value co-creation theory and the DPSIR model as theoretical foundations to provide a holistic analytical framework for constructing an evaluation index system for environmental data open and utilization levels, thereby offering new ideas and directions for research in this field. By comparing and analyzing environmental data open and utilization levels on government data opening platforms in the Beijing-Tianjin-Hebei region, Yangtze River Delta, Pearl River Delta, and Fenwei Plain, this study

explores important factors causing regional differences in environmental data open and utilization levels, providing policy recommendations for narrowing gaps between and within regions in government environmental data open and utilization levels, maximizing the social and economic value of environmental data open and utilization, and thereby achieving efficient ecological and environmental governance.

3 Theoretical Foundation and Analytical Framework

3.1 Value Co-Creation Theory

Value co-creation first emerged in the service economy field as a new value creation approach proposed by management guru C. K. Prahalad et al. They argued that product or service value is co-created by producers and consumers, not solely determined by producers. Value co-creation theory has no clear definition to date, with varying connotations and forms across different theoretical perspectives and contexts. The theory primarily emphasizes interaction between both parties during service processes to create use value, with interaction being the core and key to value creation. Consumers (users) actively participate in enterprises' (providers') production and R&D activities, helping improve product quality and address shortcomings while contributing knowledge and sharing user experiences to create better use value, demonstrating that value creation is built upon consumer (user) participation and co-creation with enterprises (providers).

With increasing national attention to ecological and environmental protection and increasingly severe environmental pollution, sustainable environmental development has become a highly concerned issue. Government data opening platform construction and environmental data open and utilization enable all social sectors to participate in environmental protection and governance, creating conditions for further realizing environmental data sharing and co-creation of utilization value. Environmental data providers on government data opening platforms are primarily governments, while data users include the public, enterprises, and research institutions. The level of government data open and utilization results from joint efforts by both parties. Government data opening platforms provide necessary resources for users to create environmental value. For environmental data providers, sustainable environmental development and enhanced utilization value of environmental data are also formed during users' value creation processes. The two are not isolated but interconnected and mutually influential. Through government data opening platforms, governments can guide and promote data users to actively participate in environmental data utilization processes, expressing their opinions and suggestions to achieve value-added environmental data utilization.

3.2 DPSIR Model

The DPSIR model, or Driving Force-Pressure-State-Impact-Response model, was developed based on the PSR and DSR models. Originating in sociology, it has become an effective analytical tool. This indicator selection framework, based on causal relationships among indicators, traces causes and explores improvement methods by analyzing changes in environmental data and its utilization level, comprehensively grasping the occurrence and development process of environmental data. It provides a basic framework for decomposing and simplifying complex and abstract problems before effective synthesis, making indicator systems clearer and simpler while facilitating explanation of complex logical relationships among multiple indicators. By revealing connections among internal elements and development processes, forming causal chains, and exploring environmental data open and utilization levels, it not only offers a new quantitative path for research but also provides relatively clear ideas, frameworks, and methods for problem-solving. Therefore, constructing indicators based on the five dimensions of the DPSIR model can make evaluation clearer and more objectively reflect regional environmental data open and utilization levels, ensuring scientific and rational evaluation.

To better explain and analyze environmental data open and utilization levels on government data opening platforms, this study constructs an analytical framework for the environmental data open and utilization level evaluation index system based on value co-creation theory and the DPSIR model, as shown in Figure 1 [Figure 1: see original paper]. In this framework, the value goal jointly achieved by environmental data providers and users is improving environmental data open and utilization levels. Environmental data providers create government data opening platforms and jointly participate with environmental data users in creating utilization value, enhancing environmental data utilization value through interaction to achieve efficient ecological and environmental governance. Interactions between data providers and users have direct and indirect causal relationships. For environmental data open and utilization on government data opening platforms, the DPSIR model effectively explains this logical causal relationship. Driving force refers to the original driving power promoting government data opening platform construction and environmental data open and utilization, such as policies issued by data providers represented by governments and user demands. Pressure refers to pressure factors formed on environmental data providers after driving forces, promoting platform construction and data open and utilization as effects of driving forces. State refers to the open state of environmental data under pressure, also representing the utilization state formed during interaction between providers and users participating in environmental data utilization. Impact refers to current impacts of environmental data opening and utilization on ecological environment and data security. Response refers to measures jointly taken by providers and users to continuously optimize environmental data open and utilization status. Since response measures are qualitative concepts, they are quantified mainly from

perspectives of financial investment and evaluation.

4 Construction of Environmental Data Open and Utilization Level Evaluation Index System Based on DPSIR Model

4.1 Evaluation Samples and Indicator Selection

To ensure sample typicality and representativeness, this study comprehensively considered geographical distribution and economic development levels, selecting government data opening platforms launched by key national ecological governance areas (Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, and Fenwei Plain) as of the first half of 2020 (see Table 1). The study evaluates each region's government data opening platform's environmental data open and utilization level and value since launch, identifies existing problems, and proposes corresponding countermeasures and suggestions for future platform optimization and environmental data open and utilization.

Indicator construction and screening follow this logic: “driving force (D)” formed by political, economic, ecological, and user demand factors represented by environmental data providers and users creates certain “pressure (P)” on government work (environmental data opening, platform construction, and services), placing various aspects in certain “states (S)” that generate certain “impacts (I)” on environmental quality and data security. To remedy impacts and optimize utilization status, data providers and users adopt certain “responses (R)” – countermeasures—to continuously optimize environmental data utilization status and improve government environmental data open and utilization levels. Following this analytical logic, this study constructs a comprehensive evaluation index system for government environmental data open and utilization level consisting of three levels (target, factor, and indicator layers), five factors, and 24 indicators, as detailed in Table 2.

4.2 Data Sources and Processing

Primary data sources are regional government data opening platforms. To ensure comprehensive indicators and credible evaluation results, some data also come from policy documents released on official local government websites, 2019 and first-half 2020 China Local Government Data Opening Platform Reports, 2019 China Environmental Status Bulletin, 2019 National Economic and Social Development Statistical Bulletins, and 2020 provincial/municipal statistical yearbooks. Since Shanxi Province currently has no platform, and Hengshui, Nanjing, Nantong, Jinhua, Shaoxing, and Tongling platforms have no environmental data resources, they are excluded from subsequent environmental data evaluation. Data collection was updated to December 17, 2020, during paper revision. Raw data are shown in Table 3.

To ensure objectivity and reduce subjective errors, this study adopts objective

weighting—entropy method—to assign weights and ultimately obtain comprehensive scores for each sample's environmental data open and utilization level for comparative analysis. When an indicator's entropy value is smaller, uncertainty is lower, more useful information is provided, the indicator is more important, and thus weight is higher, and vice versa. Since entropy method can reflect internal relationships among indicators to a certain degree, has higher credibility than subjective weighting methods, and offers transparent and reproducible evaluation processes, this study uses entropy method to weight 24 indicators.

Detailed entropy method calculation steps are as follows:

- (1) Data standardization processing. To ensure comparability of raw indicator data, according to entropy method calculation steps, original data for each indicator in the ecological governance key areas' environmental data utilization level evaluation index must first be standardized.

For positive indicators where larger is better:

$$x_{ij} - \min\{x_i\} / \max\{x_i\} - \min\{x_i\}$$

For negative indicators where smaller is better:

$$\max\{x_i\} - x_{ij} / \max\{x_i\} - \min\{x_i\}$$

- (2) Calculate characteristic proportion of sample i under indicator j: Assuming n samples and m indicators, X_{ij} represents the value of sample i for indicator j ($i = 1, 2, \dots, n$; $j = 1, 2, \dots, m$).

$$p_{ij} = X_{ij} / \sum_{i=1}^n X_{ij}$$

- (3) Calculate entropy value e_j for indicator j:

$$e_j = -k \sum_{i=1}^n p_{ij} \ln(p_{ij}), \text{ where } k = 1/\ln(n) > 0, \text{ satisfying } e_j > 0$$

- (4) Calculate information entropy redundancy: $d_j = 1 - e_j$. For indicator j, greater differences in indicator values y_{ij} mean greater role in sample evaluation, smaller entropy values, and thus larger d_j indicates more important indicators.
- (5) Calculate weight values for each indicator:

$$w_j = d_j / \sum_{j=1}^m d_j$$

Following calculation steps from formulas 1-5, standardized values and weights for the evaluation index system can be determined, as shown in Table 4. Based

on indicator weights and data, linear weighting method is used to calculate comprehensive evaluation indices for each region's factor layer and target layer. The comprehensive evaluation index for factor layer i is calculated as:

$$S_i = \sum_{j=1}^m w_j \cdot r_j$$

where w_j is indicator weight, r is standardized value, and m is the number of indicators in a certain layer.

4.3 Comprehensive Evaluation

Based on the above data processing steps, comprehensive evaluation indices for environmental data open and utilization levels of government data opening platforms in Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, and Fenwei Plain can be obtained, as detailed in Table 5 .

5 Evaluation Results and Analysis

5.1 Analysis of Important Environmental Data Indicators by Region

Comparing weights of each layer in the environmental data open and utilization level evaluation index system (Table 4) reveals that “state” has the highest weight in the factor layer, followed by pressure and driving force. This reflects that current environmental data open and utilization levels in each region are primarily manifested through state indicators. Among indicator layer weights, the most important indicators are environmental data download volume, regional economic support capacity, number of platform functional modules, number of data security issues, security inspection/evaluation frequency, and number of data open and utilization policy documents. These indicators significantly influence environmental data open and utilization levels in the four regions and should be prioritized in future platform construction and improvement, with deficiencies addressed.

5.2 Factor Layer Evaluation Results Analysis

Table 5 shows evaluation index differences among the five factor layers across the four regions. Driving force evaluation indices rank as: Yangtze River Delta, Pearl River Delta, Beijing-Tianjin-Hebei, Fenwei Plain. The driving factor weight index shows that high-quality regional economic development, strong government support and promotion, and policy guidance play important roles in platform construction, service function development, and environmental data open and utilization. Pressure evaluation indices show the same ranking pattern as driving force indices. The Pearl River Delta ranks higher than Beijing-Tianjin-Hebei in pressure factors due to more diverse platform functions, such as user evaluation and data error correction functions being richer than in Beijing-Tianjin-Hebei.

State evaluation indices overall rank consistently with the first two factors, indicating the Yangtze River Delta outperforms other regions in indicators like environmental data resource collection quantity, environmental data download volume, and public interaction methods. This advantage stems not only from numerous provinces and cities but also from most having established government data opening platforms with well-developed service functions and environmental data utilization. As economic development models shift toward sustainable development, green GDP drives higher requirements for environmental data open and utilization. Existing research also shows that government data platform construction and environmental data open and utilization are constrained by regional economic development levels, which positively promote government environmental data open and utilization. Thus, regional economic support capacity significantly influences environmental data open and utilization level improvement. Additionally, when governments prioritize ecological environment, formulate comprehensive policies, and actively implement them, environmental data open and utilization levels are relatively higher, demonstrating driving force impacts. In future environmental data open and utilization processes, factors with larger weights should be prioritized.

Meanwhile, impact and response weight indices are relatively low, indicating that environmental data open and utilization currently has limited impact on ecological environment and society, with corresponding response measures needing urgent strengthening.

5.3 Target Layer Comprehensive Evaluation Results Analysis

The comprehensive evaluation index from the target layer shows significant gaps in overall environmental data open and utilization levels among the four key national ecological governance areas. The highest level is in the Yangtze River Delta, with a comprehensive evaluation index of 0.7918. The Yangtze River Delta includes Shanghai, Jiangsu, Zhejiang, and Anhui, with most provinces and municipalities having government data opening platforms. Against the backdrop of high economic development and openness, environmental data utilization is relatively high, but non-negligible problems remain, such as incomplete comprehensive platform construction, non-standard environmental data resource collections that overlap with urban-rural construction and resource energy data, inaccessible data download links, absence of open authorization agreements on some platforms, and vague content in existing agreements that fails to protect user rights. Moreover, despite numerous provinces and cities, overall platform construction funding in the Yangtze River Delta falls far short of needs.

The Pearl River Delta ranks second in overall environmental data utilization level, with a comprehensive evaluation index of 0.4024. All Pearl River Delta government data opening platforms have been established, with the Guangdong provincial website allowing direct switching to municipal platforms, effectively enhancing environmental data open and utilization value. Although the Pearl

River Delta has comprehensive platform layout with higher platform interaction activity and environmental data coverage than the Yangtze River Delta, environmental data download volume is far lower than access volume, representing an important reason for its lower ranking. This not only indicates room for improvement but also suggests data providers should offer more effective environmental data.

The Beijing-Tianjin-Hebei region and Fenwei Plain rank third and fourth, with comprehensive evaluation indices of 0.2105 and 0.1050, respectively. Beijing and Tianjin in the Beijing-Tianjin-Hebei region established platforms earlier, but slow platform construction in Hebei Province and low overall environmental data open and utilization levels hinder smooth implementation of environmental data opening and sharing. This not only results in lower overall environmental data sharing and utilization levels than the Pearl River Delta but also impacts efficient collaborative ecological governance. The Fenwei Plain's low level is constrained by multiple factors including limited data open policy documents, small environmental data resource collection quantity, low environmental data download volume, and missing data opening platform construction in Shanxi Province.

5.4 Influencing Factor Analysis

Comparative analysis of key indicators causing significant differences in environmental data open and utilization levels across the four regions reveals important influencing factors. Among driving factors, sound data open policies, strong regional economic support, developed information technology services, strong user demand, and frequent environmental emergencies help promote environmental data open and utilization level improvement. Comparatively, regional economic support capacity and data open policy document quantity have the largest weights with significant positive effects, representing primary driving forces. Among pressure factors, from environmental data open authorization agreements to platform access restrictions and functional module quantity all influence utilization levels. Open authorization agreements legally guarantee users' basic rights to free access and non-discriminatory utilization, representing an important prerequisite affecting environmental data open and utilization. Platform functional module quantity directly affects users' ability to efficiently locate and utilize environmental data, serving as the functional carrier and important guarantee for government environmental data open and utilization.

Among state factors, greater environmental data download volume indicates higher attention to ecological environment and utilization degree, representing an important sign of whether environmental data is being utilized and a key indicator affecting utilization levels. Among impact factors, environmental data open and utilization affects ecological governance and data security, with data security being a crucial issue in the information age. Finding balance between open sharing and secure utilization is an important factor affecting environmental data open and utilization level improvement. Among

response factors, user feedback, platform construction funding, and security inspection/evaluation measures represent positive responses to improving environmental data open and utilization levels. The endogenous driving force for environmental data open and utilization lies in data security inspection and evaluation, making security inspection/evaluation indicators significantly promotive for environmental data open and utilization.

6 Conclusions and Recommendations

6.1 Conclusions

Based on value co-creation theory and the DPSIR model, this study constructed a comprehensive evaluation index system for regional environmental data open and utilization levels from five aspects: driving force, pressure, state, impact, and response. Taking the four key ecological governance areas—Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, and Fenwei Plain—as research objects, the study thoroughly analyzed important factors causing regional differences in environmental data open and utilization levels. Through empirical testing, the following conclusions are drawn:

- (1) Significant regional differences exist in environmental data open and utilization levels. Affected by geographical location, economic development status, and openness, environmental data utilization on government data opening platforms varies across Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, and Fenwei Plain. The Yangtze River Delta includes 27 cities across three provinces and one municipality, with 17 of 22 cities having platforms offering environmental datasets, confirming its highest overall utilization level. The Pearl River Delta has comprehensive platform layout but lags in environmental data download volume compared to the Yangtze River Delta. Slow platform construction and insufficient funding in Hebei Province constrain the Beijing-Tianjin-Hebei region's overall level. The Fenwei Plain's low level stems from incomplete platform construction, low openness, and low environmental data utilization rates, showing obvious gaps and substantial room for improvement.
- (2) Important factors influencing environmental data open and utilization levels were identified. Evaluating overall environmental data open and utilization levels across the four regions revealed that regional economic support capacity (economic driving force) and data open policy document quantity (political driving force) are primary driving factors. Platform functional modules help users better locate environmental data and promote integrated utilization, forming the foundation and prerequisite. Open authorization agreements legally protect users' basic rights to free access and utilization, representing important prerequisites affecting pressure factors. Environmental data resource collection quantity reflects government openness, while environmental data download volume reflects effective utiliza-

tion. Data security issues and security inspection/evaluation are crucial factors for improving utilization levels and value. Therefore, regional economic support capacity and data open policy document quantity in driving factors, platform functional module quantity and open authorization agreement quantity in pressure factors, environmental data download volume and resource quantity in state factors, data security issue quantity in impact factors, and security inspection/evaluation frequency in response factors significantly influence regional differences in environmental data open and utilization levels.

6.2 Recommendations

To further promote environmental data open and utilization levels and value on government data opening platforms, and achieve collaborative sharing and value co-creation of environmental data within and between regions, the following optimization suggestions are proposed:

- (1) Improve laws and regulations regarding platform construction and data utilization to strengthen policy guarantees. Efficient collaborative utilization of environmental data on regional government data opening platforms requires proper legal norms and guidance. Since environmental data on government platforms is collected and produced by specialized environmental management departments, environmental datasets differ across regions in content, format, and sources. Some local environmental datasets integrated with urban-rural construction and resource data may confuse users in collection and utilization. Additionally, slow platform construction in individual local governments in Beijing-Tianjin-Hebei, Yangtze River Delta, and Fenwei Plain requires the central government to strengthen legislation, improve legal systems, and legally require all provinces and municipalities to gradually establish unified government data opening platforms to accelerate platform construction. Local governments should respond to central calls, gradually refine specific policy norms and measures, standardize environmental dataset names and classifications, and guide rational utilization to provide effective policy guidance for environmental data open and utilization. In summary, from central to local governments, a complete set of policy guarantees should be established.
- (2) Appropriately increase government funding to optimize platform construction and services. Government data opening platforms are important carriers for effective environmental data utilization. Their establishment, improvement, and perfection require government financial support. Currently, most regional platforms are imperfectly constructed, with some local data platforms sharing government websites, experiencing link failures and incomplete functions, and funding falling far short of platform construction and user utilization needs. Beijing-Tianjin-Hebei, Fenwei Plain, and Yangtze River Delta should accelerate supplementary construction

of government data opening platforms. For provinces and municipalities with existing platforms, government platform construction expenditures should be appropriately increased to provide technical and financial support, ensuring persistent effective links, convenient data access, and quality application development. By real-time capture and measurement of public browsing data, predicting and deeply analyzing user interests, characteristics, and needs, intelligent push and guidance can be proactively performed to enhance efficient utilization of government data opening platforms and environmental data. Additionally, leading provinces and municipalities should play exemplary roles, learning from each other, and continuously optimizing platform services by improving interactive communication, feedback, and data error correction functions.

- (3) Improve environmental data opening standards to enhance utilization quality. Effective environmental data utilization presupposes openness, convenience, and feasibility of accessing environmental data on government data opening platforms. Currently, some provinces and municipalities in Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, and Fenwei Plain lack data open authorization agreements. Existing authorization agreements suffer from brief, incomplete content with vague wording, and environmental datasets have varied forms and non-uniform standards. Dataset content, openness, and standards significantly affect utilization quality and synergy among data users. Therefore, achieving environmental data open and utilization value requires ensuring quality in open formats and licensing agreements to enhance utilization feasibility. Currently, promoting establishment of government data open and utilization authorization mechanisms can provide corresponding open government licensing agreements for environmental and other datasets, standardizing environmental data opening standards and improving utilization levels.
- (4) Encourage diversified data applications to improve environmental data application result conversion rates. Accelerating conversion of environmental application results is crucial for ecological governance in the process of government data open and utilization. Currently, environmental data development and utilization is insufficient on regional government data opening platforms, with gaps between data provision and utilization, few environmental application results, and monotonous forms. Application diversification includes not only diversified data user types but also diversified and innovative application results and forms. Currently, the scope of data users should be expanded to guide participation by various types of users including enterprises, citizens, universities, and research institutions, especially strengthening public innovation and environmental awareness to enable diversified environmental data utilization and accelerate conversion of environmental data application results based on existing open and utilization. Regional governments including Beijing-Tianjin-Hebei can also maximize user enthusiasm and initiative through publicity and guidance, diversified incentive measures, and government-enterprise

cooperation demonstration effects, achieving diversified application results and practical implementation.

- (5) Prevent environmental data security risks and emphasize feedback and evaluation of open and utilization results. Environmental data security is an important prerequisite for achieving environmental data sharing, utilization, and sustainable development. Currently, most governments have not released annual website work reports summarizing and evaluating data security issues. Particularly in the Fenwei Plain region, evaluation systems have not been established, and platform construction effects and data security issues have not been emphasized. Therefore, relevant provincial and municipal governments with established platforms should supplement and improve annual website work reports, strengthen data security evaluation and inspection, and prevent environmental data security risks. For general environmental data, governments can impose fewer platform restrictions, while for important environmental data, governments can require users to provide more information, achieving dynamic balance between data security and data utilization. User feedback on data utilization should also be emphasized to further prevent data security risks and improve environmental data utilization.

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Note: Figure translations are in progress. See original paper for figures.

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