Research on Big Data Empowering Ecological Governance

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Abstract. The application of big data in the field of ecological governance has promoted the development and growth of intelligent ecological governance. Scientific discoveries enhance human ability to understand nature, and technological inventions enhance human ability to transform nature, which provide solid theoretical support for big data empowering ecological governance. In practice, big data technology can help to control existing pollution and prevent pollution from occurring. Big data also plays an important role in ecological restoration. Its prominent impact on soil restoration and biodiversity conservation fully demonstrates the enormous potential of big data in serving ecological governance. In addition, big data technology can help realize the economical use of resources and promote sustainable development. With the continuous improvement of the application of big data technology, the governance ability of ecological governance body has been greatly enhanced, which significantly improves the efficiency of ecological governance. Big data has enhanced the coordination and interaction among various bodies and improved the level of ecological governance on the whole. The integration of big data with other high and new technologies has promoted the expansion of the application scope of big data. All these demonstrate the important role of big data in promoting the modernization of ecological governance. A series of practical cases collected and listed in this paper provide strong proof for the use of big data in serving ecological governance. In conclusion, in the information age, people should vigorously promote the application of big data in the field of ecological governance, empower ecological governance with big data, and enable information technology to serve ecological civilization construction.

Keywords: big data · service · ecological governance

1 Introduction

The application of big data in the field of governance has directly promoted the emergence and development of intelligent governance. Intelligent governance refers to the continuous state and process in which intelligent technology means are relied upon and utilized, under the guidance of public authorities, and with the active participation of

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market bodies, social bodies and individuals, to jointly reduce the cost of public affairs, improve the efficiency of public affairs and optimize the experience of public affairs [1]. Intelligent governance emphasizes guiding the governance of public affairs with a digital way of thinking, and constantly improving the institutional guarantee of laws and regulations to enable the digitization of public governance through the empowerment of digital technology.

Intelligent governance in the field of ecology and environmental protection emphasizes the penetration of intelligent governance in the field of ecology and environment. It advocates the transformation of traditional governance approaches through the wide participation of multiple bodies under the government's leadership and the application of information technology in ecological governance to achieve the digitization and intelligence of ecological governance. Ecological intelligent governance highlights the potential application of big data in ecological and environmental protection, and it is a practical case of big data empowering ecological protection.

2 Theoretical Foundation

As a complex technology tool, big data has been applied to the broad field of social governance. As an emerging technology, it has been widely used in ecological governance, forming a new trend of precise positioning, scientific analysis and effective management of environmental pollution. The positive role of science and technology in ecological governance provides a solid theoretical foundation for big data to enhance ecological governance.

2.1 The Role of Scientific Discovery

'Science, in its broadest sense, refers to the theoretical knowledge that guides human interaction with external things, and usually, above all, it refers to theoretical knowledge that guides human interaction with the nature' [2]. In this paper, science is defined in a narrow sense, namely, science is the general term of human activities to consciously understand nature and explore the unknown world.

From the perspective of the development history of science, scientific discoveries have solved a series of natural mysteries, helping human beings to understand nature and understand its laws. From the perspective of the history of science, the forms of science mainly include natural history, mathematical experiment science and rational science. Natural history observes, describes and classifies plants, animals and ecosystems from a macro perspective, helping people to understand nature as a whole and to comprehend its richness and diversity. Natural history science enhances human understanding of the natural world and helps human comprehend nature. It is a bridge of communication between nature and human. It is of great significance to alleviate the tension between human and nature that has emerged since modern times.

After the 17th century, modern experimental science of mathematics began to rise and develop. This was the time when science entered the research phase and scientists began to study the causes and formation of natural things. After more than 300 years of development, modern mathematical experimental science has formed a relatively

complete subject category by the end of the 19th century, and science has been greatly improved. With the improvement of human observation, measurement and other technological tools, human beings have continuously gained batches of scientific achievements in various fields. Scientific research related to the study of nature is becoming more comprehensive and in-depth, greatly enhancing human understanding of nature.

Greek rational science proposed that the nature of the world is 'logos', which has purity and rationality. It pursues science itself and forms a noble scientific spirit. Greek rational science yielded abundant achievements, advocating to use human reason to understand the universe, and paving a way for human to explore and understand the laws of nature. Although Greek rational science does not pursue the practicability of science or pay attention to the its application, it has played a significant role in human understanding of nature.

In conclusion, scientific discoveries have continuously enhanced human understanding of the laws of nature, which makes it possible for human to avoid greater environmental pollution and ecological damage.

2.2 The Role of Technological Inventions

Technology has influenced and changed human life in various ways. It has been around since the birth of humankind. In history, there were three major technological revolutions that triggered industrial revolution and then had epoch-making effects due to technological progress.

In the mid-18th century, Watt made an improved steam engine. The invention of steam engine ended the manual labor period in which human beings mainly relied on manpower for two million years, and modern machine production began to become popular. Machines replaced human labor. Human began to get rid of the limitations of natural forces, and productivity was greatly improved. At the same time, production relations were adjusted, and the field of transportation was also changed. This industrial revolution fundamentally changed the cognitive structure of human beings and the direction of social development.

In the 19th century, the capitalist economy developed rapidly and modern scientific discoveries emerged one after another. Since the mid-19th century, scientific discoveries have been closely integrated with industrial production, and the deep combination of science and technology has produced a large number of technological inventions. Electrical appliances were widely used, which promoted the improvement of productivity again, and human beings entered the 'electric age'. The power, chemical, petroleum, automobile and other industries that emerged in this industrial revolution have improved people's quality of life in terms of energy utilization, transportation and other aspects, and mankind's ability to use technology to transform nature and create a suitable living environment has been continuously enhanced.

In the 20th century, due to the development of communication, the emergence of radio, radar and signal detection technology, the speed of information generation and transmission soared, and there are more and more means of information transmission, and human beings began to enter the information age. The core technology of the third technological revolution is electronic computer technology. The generation and development of electronic computer has greatly improved the computing speed of human

beings and replaced the mental work of human beings. Nowadays, it can also partially simulate the intelligent activities of human beings, which has fundamentally changed the development process of modern society and driven the development of a large number of high-tech technologies. Automation, intelligence, information, digitization and so on have become the basic characteristics of the information age.

The three technological revolutions have had an unprecedented impact on the process of human development. And the emergence of each technological revolution has made great breakthroughs in the production capacity of human beings. Behind the technological revolution is the great progress in human understanding of nature and laws of nature. Before the British Industrial Revolution, technology mainly came from the summary of people's daily production and life experience, and the technology in this period was mainly empirical technology. After the Industrial Revolution, modern science developed rapidly, and a series of new scientific discoveries promoted the progress of technology. Technological invention was mainly the application of science. The type of technology in this period changed from empirical technology to scientific technology.

On the basis of scientific understanding, human beings' ability to utilize nature and transform nature is constantly improving. Human beings are becoming better at using technology to achieve the goal of creating a better life for human beings. Technology is playing an increasingly significant role in enhancing human beings' ability to transform nature. With the help of science and technology, human beings can realize the planned adjustment and control of human's transformation activities to nature, at the same time, they use science and technology to eliminate the harm of human activities to the ecology and environment, maintain the harmonious relationship between human and nature, so as to protect the balance of the entire ecosystem.

3 The Practice and Innovation

In the information age, the development of advanced technologies such as big data, cloud computing, the Internet of Things, artificial intelligence, 5G and other high-tech technologies has played a comprehensive role in promoting the development of human society and even the transformation of social interaction methods, and they penetrated into every corner of human life [3]. In practice, People are constantly trying to apply digital and intelligent technologies to specific pollution control, ecological restoration and environmental governance, demonstrating the bright prospect of ecological intelligent governance.

3.1 Empowering Pollution Control

Environmental pollution control is an extremely important work. The quality of the environment is not only directly affecting people's lives and health, but also closely related to public well-being. Zhi Hua X. et al. [4] analyzed the impact of air pollution and water pollution on well-being by matching provincial pollution data and individual well-being data. And the study showed that the increase of nitrogen dioxide concentration and wastewater discharge would significantly reduce personal well-being. Through

model-based empirical analysis, Junjun Zheng et al. [5] concluded that with the improvement of material living conditions, people's environmental protection concept gradually strengthens, and they become more proactive in paying attention to and advocating for a green lifestyle. In the future, residents will be more sensitive to environmental pollution, and their well-being and even their quality-of-life level will be closely related to environmental quality. George MacKerron [6] conducted a survey of more than 20,000 British participants using smartphone and found that respondents were happier in all types of green environments or outdoor activities than in urban environments, indicating the positive impact of beautiful natural environments on individual well-being.

Big data is beneficial for managing existing pollution. To address the existing pollution control, first of all, it is necessary to have a clear understanding of the current situation of pollution and obtain various information about environmental pollution. Environmental monitoring technology plays an important role in understanding pollution information. It can help us timely and accurately understand changes in environmental quality and various indicators, grasp the overall state of environment, and provide scientific and effective basis for environmental management, pollution source control and environmental planning.

Big data assists in pollution prevention. The application of information technology provides data support for the delineation of pollution areas and scientifically planning of pollution prevention and control measures, making various plans for pollution prevention and control more targeted and operational. It helps to timely curbing the spread of pollution and reducing the damage to a minimum. Nowadays, environmental monitoring technology has been effectively used in various pollution control measures, demonstrating the significant effectiveness of information technology in environmental protection.

In the aspect of urban air quality monitoring, information technology can be used to make real-time disclosure of the concentrations of various pollutants in the atmosphere, so as to realize the transparency of information. Citizens can use mobile devices and other tools online to check the local air quality of the day, in case of severe air pollution, they can timely and accurately report to the relevant departments, better playing the role of public supervision. Monitoring technologies supported by big data also play a significant role in monitoring vehicle exhaust emissions and enterprise exhaust emissions. In addition, monitoring technologies are also widely used in water quality monitoring, radioactive source monitoring and many other aspects, greatly facilitating the work of wastewater treatment and the management of radioactive substances.

3.2 Empowering Ecological Restoration

As an important measure to improve ecological quality, ecological restoration is an artificial restoration activity aimed at the damage of ecosystem structure, functions and other problems. With the help of ecological restoration, partial or complete restoration of the ecosystem can be realized, so as to promote its sustainable development. The practical effectiveness of information technology in ecological restoration can be seen from the practice of ecological restoration of contaminated soil and intelligent management of biodiversity conservation.

Big data helps soil remediation. Soil pollution has hidden characteristics and is difficult to be detected, making the work of soil remediation challenging. The application of information technology greatly facilitates the monitoring of soil quality, enabling the timely identification of contaminated areas and the early implementation of pollution control, reducing the alleviation of the difficulty of cumulative pollution control. Information technology also provides convenience in understanding the current situation of polluted land, such as soil erosion, desertification, and saline-alkali land, which reduces the expenditure of manpower, resources, and finances, thereby lowering the cost of remediation. It took Da'an City of Jilin Province in China 6 years to find out the intelligent plan of saline-alkali land improvement, and successfully realized the application of information technology in saline-alkali land restoration, which demonstrates the broad prospects of big data technology [7].

Big data contributes to biodiversity restoration. As the foundation of life on earth, biodiversity provides crucial ecological support for human survival and development. However, currently, 'the rate of species loss has accelerated approximately from one species per day to one species per hour'. The application of information technology in biodiversity conservation is of great practical significance and far-reaching future significance. The digitization of biodiversity conservation has evolved from basic video monitoring techniques to the comprehensive utilization of intelligent use of big data, artificial intelligence, and the Internet of Things. It Has injected powerful scientific and technological force into biodiversity conservation. With the help of the biodiversity big data platforms, interdisciplinary integration of biodiversity data such as genes, species and ecology has become possible. In-depth utilization of data can be realized on the basis of shared data, providing scientific data support for research at various levels.

In a specific case practice, Houkun Hu, the rotating chairman of Huawei in 2022, introduced a case of the application of information technology in the conservation of gibbons, an endangered animal. In the conservation work of gibbons, optical video monitoring technology used to track gibbons attracted their attention, and then gibbons would destroy the monitoring tools, rendering the monitoring ineffective. Inspired by big data, the researchers combined the characteristics that gibbons are good at singing and different kinds of calls are very different, and switched to acoustic technology. By utilizing artificial intelligence sound monitoring system, cloud recording and other methods, they created a unique acoustic identity card for each gibbon. This approach effectively improved the tracking and monitoring of gibbons and facilitated timely protection in unexpected situations.

The protection of rare species is only a small aspect of biodiversity conservation. Information technology provides a solid scientific and technological foundation for ecological restoration in various fields, such as forest and grassland ecological restoration, territorial and spatial ecological restoration, biosynthesis research and so on.

3.3 Empowering Resource Conservation and Sustainable Development

Sustainable development emphasizes that mankind should adhere to a development model that meets the needs of the present without compromising the needs of future generations to meet their own needs. Information technology is the most environmentally friendly and green technology, with virtually limitless capabilities. This is mainly due

to the low resource consumption and minimal pollution generated by the information industry, making it the industry that best conforms to and adapts to the requirements of green development. The information industry has become an important driving force for promoting green development. In addition, the integration of information technology into other industries is conducive to saving resources and improving the utilization rate of resources, which is of great significance for sustainable development. For example, numerous cases such as paperless office and intelligent garbage sorting and recycling demonstrate the positive effect of information technology on sustainable development.

4 The Modernization of Ecological Governance

Humanity is gradually entering a new era of data which not only affect people's behavior patterns but also significantly changes their thinking patterns. In the data era, people shift from making judgments based on intuition and experience to making comprehensive decisions based on data and analysis, significantly enhancing the scientific and effectiveness of decision-making. The practical effects of information technology in ecological governance at present, especially the positive effects in pollution control, ecological restoration, resource conservation, improving the ability of environmental situation prediction and comprehensive decision-making, etc., have already laid the practical foundation of ecological intelligent governance.

4.1 Enhancing the Capacity and Improving the Efficiency

Taking the pollution control of enterprises by environmental protection departments as an example, enterprises are the main body of the market, and effective pollution control is an important task for environmental protection departments. Traditional methods of relying on manual supervision to control enterprise pollution are not effective in truly pollution supervision and are not helpful in curbing unauthorized emissions or excessive emissions.

By actively adopting information technology in pollution control, real-time online monitoring of enterprise pollution can be achieved, greatly improving efficiency. Big data technology enables the automation and intelligence of enterprise pollution monitoring work. Environmental protection workers can accurately and timely understand the situation of pollution emissions without leaving their homes, master various emission information of enterprises, and give timely warnings of excessive emissions. It can effectively curb the occurrence of excessive and unauthorized emissions, and significantly improve the effectiveness and scientific nature of pollution control.

In addition, information technology has also achieved remarkable results in strengthening the environmental risk warning capabilities of management departments, emergency response capabilities for sudden environmental incidents and predictive capabilities for environmental situations. In response to sudden environmental incidents, digital video technology can be used to remotely understand the situation of the scene, timely conduct emergency command video conference, and in this way it can limit the harm caused by environmental events to the minimum range.

4.2 Improving the Level of Ecological Governance

The generation and resolution of ecological and environmental problems are extremely complex. 'The public nature of environmental problems is crucial to environmental problems. Their causes are decentralized and interconnected, and the harm and impact they produce are extensive, cumulative, and persistent.' [9]. It is no longer possible to rely solely on any one party to deal with the increasingly complex ecological issues. It is necessary to continuously strengthen the comprehensive cooperation among various stakeholders, achieve the cooperative governance of ecological and environmental issues, and finally enhance the level of governance and its effectiveness.

The development of information technology greatly facilitates the cooperation among various governance entities. In terms of the cooperation between ecological and environmental protection departments, information technology can not only standardize the basic data and basic business of environmental protection business, but also enhance the effective decomposition and integration of the departmental business, enabling the comprehensive cooperation between departments.

In addition, the establishment of the big data service platform for ecological and environmental protection gathers the business data from of environmental protection systems in various regions. With the support of the Internet and the Internet of Things, the intelligent analysis of data is carried out to continuously build and improve the information system for environmental monitoring, management and public services. On the platform, all bodies can obtain real-time information on various aspects of environmental quality, such as air, water and other aspects, and the public can report and complain about pollution incidents to effectively protect their ecological rights and interests. The environmental protection department can grasp the environmental situations at any time, promptly detect anomalies, and facilitate dynamic management.

4.3 The Integration with Other High-Tech Technologies

The application of information technology itself in ecological governance has greatly improved the current ecological governance ability and ecological governance level, and provided a realistic possibility for ecological intelligent governance. In addition, the integrated development of information technology and other high and new technologies has also injected powerful scientific and technological forces into ecological governance, playing an important role together in ecological governance.

Significantly, the fusion of information technology and biotechnology stands out. Biotechnology is characterized by low cost, simple operation and sustainability, so it occupies an important position in ecology and environmental protection. The integrated development of information technology and biotechnology has provided new impetus for ecological governance. The integration and development of biotechnology and information technology will promote the research and development of advanced biological manufacturing. Relying on biological manufacturing technology, we can try to replace chemical raw materials and processes with biotechnology, develop high-performance biological environmental protection materials and biological agents, promote the deep integration of chemical, material and other industrial product manufacturing with biotechnology. To achieve green, low-carbon, non-toxic, low-toxicity and sustainable development. At the same time, biological technologies such as microorganisms

and enzyme preparations will be used to solve environmental pollution problems such as phosphorus removal in water bodies, heavy metal soil remediation, and waste plastic utilization and disposal, so as to facilitate the smooth progress of pollution prevention and control.

5 Conclusion

The development of science and technology is of great assistance to human understanding and transformation of nature, especially with the promotion and application of green technology in recent years. Green technology is developed to solve ecological and environmental problems, which mainly includes two types of technology: protection of green technology and promotion of green development. For example, sand control technology and sewage treatment technology belong to protection of green technology, while efficient utilization of solar energy technology and development of new energy technology arise for promotion of green development. The direct effect of green science and technology is reflected in the effectiveness of current pollution control. In the long run, green science and technology will bring about fundamental changes in human production and life style, and fundamentally realize sustainable development and ecological protection.

It is worth noting that the realization, application and promotion of green technology involve not only the feasibility of science and technology, but also the support of economic, social and policies. In reality, there are many scientifically correct and technically feasible pollution control technologies and ecological agriculture technologies, fail to achieve sustainable application due to the lack of necessary economic policy support or low profitability and public participation. Therefore, in order to play the positive supporting role of science and technology in ecological governance, it is necessary to take into account various factors and overcome many obstacles. In particular, the government should actively promote various scientific research and technological inventions related to ecological governance, provide policy support for ecological intelligent governance, and become a proactive promoter and strong supporter of ecological intelligent governance, allowing green science and technology to inject powerful scientific and technological force into ecological governance, and play a supportive role in ecological intelligent governance.

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