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Research on rural ecological protection based on digital technology

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Abstract
The advancement of digital technologies−particularly the Internet of Things (IoT), big data, remote sensing, and artificial intelligence (AI)−has opened new avenues for rural ecological conservation. However, challenges persist, including technological limitations, inadequate infrastructure, talent shortages, insufficient policy support, and villagers' limited ecological awareness. This paper systematically examines the challenges and issues in applying digital technologies to rural ecological protection, proposes corresponding solutions, and aims to provide intellectual support for empowering sustainable rural ecological development.

Keywords: Rural ecological protection, digital technology, rural revitalization strategy

Introduction

In the face of escalating global ecological crises, environmental protection has become a fundamental consideration for sustainable development. Rural ecological conservation, as a crucial component of the rural revitalization strategy, directly impacts the sustainable use of natural resources including farmland, forests, grasslands, rivers, lakes, and wetlands. It also affects rural residents' livelihoods, development levels, and national ecological security. For decades, rural areas have suffered from widespread ecological degradation and overexploitation of resources. In some regions, the deterioration of fragile ecosystems has outpaced the recovery of rural resources. As the rural revitalization strategy advances, the demand for ecological protection has intensified, becoming more urgent than ever. Recent years have seen digital information technologies−particularly internet, big data, IoT, remote sensing, and AI−emerge as new research hotspots in agriculture, environmental protection, and rural development. Their integration with ecological conservation offers viable solutions for future rural ecological construction. Therefore, how to effectively apply digital technologies to advance rural ecological protection has become an urgent challenge requiring immediate attention.

Literature Review and Problem Setting

The Rural Revitalization Strategy positions rural ecological conservation as a cornerstone of its implementation (Liu Haifeng, 2024) [1]. This conservation effort plays a vital role in boosting agricultural productivity, maintaining ecological balance, and advancing sustainable development. While rural ecological protection has gained increasing attention alongside the strategy's execution, it still faces multiple challenges. First, irrational exploitation of traditional farming methods has led to land degradation and water pollution. Second, inadequate infrastructure, limited governance capacity, and insufficient funding and talent remain critical bottlenecks. Third, ecological conservation and rural revitalization often conflict, with conservation efforts frequently treated as secondary tasks lacking long-term investment and institutional mechanisms. Theoretical foundations for rural ecological protection include ecosystem theory, sustainable development theory, and socio-ecosystem (SES) theory. Ecosystem theory emphasizes the interconnectedness between ecological balance and internal system components (Zhang Peng, 2025) [2, 8], while sustainable development theory advocates meeting current needs without compromising future generations' interests. SES theory highlights the dynamic interactions between social systems and ecosystems. China's rural conservation efforts have evolved from localized protection to systematic integration into master plans, with recent years witnessing the gradual implementation of green development and prioritized environmental protection concepts (Suo Xiangdong, 2022) [3]. However, persistent challenges remain, including overexploitation of resources, environmental pollution, weak ecological restoration capacity, and underdeveloped governance structures. Rural areas are grappling with escalating ecological degradation from overexploitation of land and forest resources, coupled with excessive use of chemical fertilizers and pesticides in farming. Some villages face particularly challenging ecological restoration, with issues like soil erosion and land abandonment proving difficult to resolve, often requiring prolonged efforts with limited success. The fragmented grassroots governance and lack of coordinated measures have resulted in a lack of systematic and sustained ecological protection efforts. In the process of rural revitalization, striking a balance between ecological conservation and rural industrial development remains a pressing challenge that demands urgent solutions.

The advancement of digital technologies, particularly the Internet of Things (IoT), big data, remote sensing, and artificial intelligence (AI) (Fuloyi, 2024), has opened new avenues for rural ecological conservation. These technologies are primarily applied in data monitoring, analysis, predictive modeling, and decision support. IoT systems deploy sensors across rural areas to track real-time soil, water, and air quality, enabling continuous monitoring of ecological changes. Big data analytics process massive environmental datasets to inform conservation strategies. Remote sensing tracks land use patterns and vegetation shifts, while AI employs machine learning and deep learning algorithms to forecast ecological trends and optimize resource allocation.

Both domestic and international efforts in applying digital technologies to ecological conservation have seen significant progress. Countries like the United States, European nations, and Australia have achieved notable results in agricultural monitoring, forest conservation, and wildlife protection through the use of remote sensing, IoT, and other digital technologies. For instance, forest fire prevention and agricultural disaster monitoring systems utilize remote sensing drones. Internationally, IoT is employed to monitor water resources and soil quality, while remote sensing and drone technologies assess forest ecosystems. Domestically, digital ecological technologies have also advanced, with applications like digital agriculture, smart forestry, and intelligent water governance emerging in certain regions (Cheng Lei, 2024). Examples include IoT-based monitoring of rural non-point source pollution, remote sensing applications for forest ecological monitoring in Sichuan, and Shandong Province's big data-driven rural water resource management platform. While digital technologies show promising potential in ecological conservation, challenges remain−particularly in rural areas where comprehensive infrastructure and skilled personnel (such as technical staff and equipment) are often lacking.

Although digital technology has shown great potential in ecological protection, it is necessary to systematically discuss the challenges and problems faced by digital technology in rural ecology, so as to enable the sustainable development of rural ecology.

Challenges and Problems of Digital Technology in Rural Ecological Protection

While digital technologies have significantly enhanced efficiency in ecological conservation, optimized resource management, and accelerated restoration efforts for digital rural ecosystems, multiple constraints persist. These include technological limitations, inadequate infrastructure, talent shortages, insufficient policy support, and villagers' limited ecological awareness. To achieve sustainable implementation of digital rural ecological protection, it is essential to analyze these root causes and develop targeted solutions.

1. Limitations of the technology application

While digital technologies hold great promise for rural conservation, their practical implementation faces significant technical challenges. Firstly, these technologies are still in their infancy when applied to rural areas. Core innovations like remote sensing, IoT, and AI models have yet to be fully integrated into specific applications. The lack of standardized technical protocols and data formats has resulted in fragmented implementations, undermining their overall effectiveness. Secondly, the complex ecological demands of rural environments pose unique challenges. Current solutions often fall short in addressing the specific needs of these regions. For instance, conducting high-precision, continuous ecological data collection in ecologically fragile and remote areas remains difficult. In disaster-prone regions, insufficient data availability hampers early warning systems and emergency response capabilities. Therefore, further refinement and improvement of digital technologies are crucial to enhance their effectiveness in rural ecological conservation.

2. The restriction of infrastructure lag on technology application

The lack of infrastructure in rural areas remains a major bottleneck for digital technology adoption. Firstly, low internet penetration rates−particularly in remote mountainous regions and rural areas−result in frequent network instability, rendering digital technologies like IoT, remote monitoring, and cloud computing ineffective. Secondly, inadequate power grids, communication networks, and transportation systems in some rural areas fail to meet technical standards, hindering stable infrastructure development. Thirdly, limited government investment in rural digital infrastructure leaves rural communities without adequate technological support. For instance, advanced technologies such as ecological monitoring devices and smart irrigation systems require substantial funding and technical expertise, which many rural communities cannot afford. This infrastructure gap significantly hampers the application of digital technologies in rural ecological conservation.

3. High costs and technical adaptation issues

The high cost of technology remains a key barrier to digital solutions 'adoption in rural ecological conservation. Rural areas, with their fragile economic foundations and limited financial resources−particularly in impoverished regions−frequently lack government support and local funding, resulting in low household affordability. While digital technologies offer significant ecological benefits, their high costs for equipment, software development, and technical services have limited widespread implementation to economically stable villages. This leaves many underdeveloped communities without access, hindering technological expansion. Moreover, adapting digital solutions to local conditions poses a major challenge. Most rural ecosystems face geographical, climatic, and environmental constraints that restrict applicability, as existing technologies rarely work across all rural areas. The critical issue lies in how to develop localized and customized solutions tailored to each region's specific needs, ensuring these technologies truly serve their intended purpose.

4. Data privacy and security issues

Data privacy security remains a critical risk in digital technology applications. Rural ecological data contains sensitive information such as land use management records, farmland management details, and water environment data, which involve ecological information and residents' privacy and interests. Any data breach or misuse could severely compromise both the safety of rural communities and ecological environments. Balancing data openness with security in digital applications presents a major challenge. During the processes of data collection, storage, transmission, and analysis, ensuring privacy protection and preventing unauthorized tampering or leaks has become a technical imperative for both developers and governments. Equally crucial is facilitating cross-regional information flow and technical collaboration among departments to promote digital technology sharing−key to advancing ecological conservation through technology.

5. Shortage of talent and the problem of technology popularization

Rural ecological regions face a critical shortage of digital literacy among residents. The lack of technical professionals in these areas−particularly those specializing in ecological monitoring, data analysis, and system maintenance−has directly hindered the full utilization of digital technologies. Moreover, most villagers demonstrate limited understanding and practical application of digital tools, often showing both operational unfamiliarity and low acceptance of technology adoption. This digital divide significantly impedes the effective implementation of eco-technological solutions in rural conservation. To address this, rural communities should establish robust digital training programs and talent recruitment mechanisms, with a focus on enhancing the digital capabilities of agricultural technicians and grassroots ecological conservation personnel. Through digital literacy education, hands-on skill development, and targeted talent cultivation initiatives, rural residents can develop the necessary awareness and proficiency to effectively leverage digital technologies in ecological protection efforts.

6. Inadequate policies and institutions

While national and local governments have implemented policies to support rural revitalization and ecological conservation, no corresponding measures have been introduced to leverage digital technologies in rural environmental protection. Firstly, existing policies and regulations lack specificity and detail, with no clear guidelines or practical approaches for applying digital technologies in rural ecological preservation. Secondly, no dedicated regulatory bodies exist to coordinate the deployment and integration of digital technologies in rural ecological protection. Meanwhile, limited funding, inconsistent policy promotion, and inconsistent support from local governments further hinder implementation. Thirdly, there is a critical gap in legal frameworks and management protocols. As digital technology advances faster than legislative updates, coordinating data security, technological compliance, and ecological safeguards through legal means remains a persistent challenge. The absence of standardized legal frameworks and technical specifications makes it difficult to establish orderly, sustainable digital applications that protect rural ecosystems.

7. The Problems of Cognition and Acceptance of Rural Residents

The varying levels of digital literacy among rural residents significantly influence the adoption and effectiveness of digital technologies. While digital tools hold substantial potential for rural ecological development, many villagers still lack basic understanding of these technologies, with some even showing resistance. This stems from two key factors: First, limited education prevents rural residents from grasping the fundamental principles and practical applications of digital technologies. Second, traditional farming practices have fostered skepticism among certain communities, who perceive digital solutions as impractical and disconnected from real-world needs. To bridge this gap, three strategic approaches are essential: 1) Enhance public awareness through targeted campaigns and training programs, helping residents overcome initial apprehension and misconceptions; 2) Demonstrate tangible environmental benefits through concrete case studies to build confidence and engagement; 3) Establish grassroots support networks through rural technology service centers and local experts, providing accessible technical assistance to boost community participation.

Implementation Strategy of Digital Technology in Rural Ecology

The core mission for the future lies in implementing and promoting the effective application of digital technologies in rural ecological conservation practices. To achieve this, we must establish a robust technical ecosystem that facilitates the adoption of digital solutions for rural ecological protection. This requires comprehensive measures including: securing foundational resources, creating policy frameworks, fostering institutional support, developing technical expertise and training programs, promoting industrial collaboration, and mobilizing public participation.

1. Strengthening infrastructure development

Digital infrastructure serves as the cornerstone for implementing technological solutions. For remote rural communities, robust digital infrastructure development ensures reliable access to modern technologies. First, expanding network coverage in rural areas remains critical. Currently, inadequate internet infrastructure in these regions−characterized by low coverage rates and unstable signals−significantly hinders the adoption of IoT and sensor monitoring systems. Governments should prioritize infrastructure investments, particularly in rural broadband development, 5G network deployment, and data transmission speed improvements. These upgrades will enable effective ecological monitoring, resource management, and data transmission operations. Second, enhancing hardware infrastructure like sensors and monitoring devices is essential. Ecological monitoring requires extensive sensor networks to collect environmental data on soil, water quality, and air conditions, forming the foundation for digital technology applications. However, insufficient hardware availability and high maintenance costs in rural areas limit the practical effectiveness of digital solutions. Both public and private sectors must collaborate to upgrade rural infrastructure, ensuring the proper installation and sustained operation of ecological monitoring equipment across these regions.

2. Policy Support and Institutional Innovation

Policy guidance and institutional innovation are prerequisites for the successful implementation of digital technologies. First, it is essential to refine policy frameworks for digital technologies in rural ecological protection, establishing a comprehensive policy system to provide institutional safeguards. Governments should introduce relevant policies to guide the application scenarios, operational guidelines, and procedures for digital technologies in rural ecological conservation, thereby ensuring the effective implementation of work strategies. Simultaneously, public-private partnerships should be encouraged by involving social entities such as tech companies and research institutions in rural ecological protection projects. Second, efforts must be made to formulate and revise ecological protection laws and regulations to effectively regulate the application of digital technologies in this field. Rural ecological protection involves multiple domains including land conservation,

water resource management, and air quality improvement. The effectiveness of digital technology applications in ecological protection directly depends on how legal measures govern their use in these areas. It is crucial to strengthen the development and refinement of relevant laws and regulations, establishing clear norms and restrictions on specific aspects such as data collection, ecological restoration, and technology utilization. This ensures that ecological protection technologies do not become mere formalities that deplete resources and damage ecosystems. Additionally, enhanced enforcement of legal frameworks is necessary to prevent governments, enterprises, and rural communities from arbitrarily adopting environmentally harmful technological measures.

3. Improving the Training and Education of Technical Talents

The cultivation of technical professionals is the primary prerequisite for the successful implementation of digital technologies. To enhance technology adoption in rural areas, it is essential to prioritize the development of digital literacy training systems. Key measures include: 1) Upgrading local talent capabilities and standardizing educational resources, particularly through specialized training in information security and ecological conservation. Establishing digital technology courses in rural communities will equip local administrators, villagers, and stakeholders with modern technical skills, ensuring effective utilization of digital tools for ecological monitoring and resource management. 2) Emphasizing training programs for farmers and village officials to master digital technologies and tools. Farmers should understand core concepts and operational processes of digital agriculture, smart irrigation systems, and precision fertilization techniques to improve their digital literacy. 3) Government and social organizations should systematically organize rural workshops, demonstration projects, and online training initiatives to help farmers acquire these technologies and accelerate their adoption.

4. Strengthening government-enterprise cooperation

First, the government should collaborate with tech companies to promote the widespread application of digital technologies in rural ecological conservation. Governments need to strengthen partnerships with tech firms, encouraging increased investment in digital ecological protection—particularly in IoT, big data, and remote sensing monitoring. Through this collaboration, governments can not only obtain technical support but also leverage social capital and technological expertise to drive comprehensive digital adoption. Second, tech companies should develop tailored solutions based on rural communities' specific needs, providing targeted technical services. By partnering with local governments, businesses can introduce cutting-edge, practical technologies to address rural challenges. Governments may support corporate innovation and technology implementation through policy incentives and funding. Additionally, companies should offer long-term maintenance and upgrade services for rural ecological projects, ensuring sustainable technological development.

5. Enhancing public participation and community collaboration

First, public participation and community collaboration are key factors in the successful application of digital technologies in rural ecological governance. Enhancing public awareness and engagement with digital ecological protection technologies not only boosts social acceptance of these technologies but also improves their accessibility and effectiveness. Second, governments can promote digital technology adoption through multi-channel campaigns. By organizing ecological awareness programs, science outreach events, and technology demonstrations, they can foster public interest and trust in digital solutions, helping villagers recognize their practical value in environmental protection. Third, fostering community collaboration is essential for effective technology implementation. As the fundamental unit of rural governance, community involvement ensures the success of technological applications and ecological management. Governments should establish participatory mechanisms that engage villagers in technology adoption, data collection, and ecological restoration efforts. This approach transforms villagers from passive beneficiaries into active practitioners of environmental protection, leveraging community synergy to enhance environmental consciousness and achieve sustainable development in rural ecological conservation.

References

1. Liu Haifeng. Rural Revitalization and Sustainable Agricultural Development: Ecological Protection Strategies and Practices [J]. Hebei Agricultural Machinery,2024:19:154-156
2. Zhang Peng, Li Xiaohong. Research on the Driving Mechanism and Promotion Path of the First Issue Economy under the Perspective of Innovation Ecosystem Theory [J]. China Soft Science,2025:06:88-98.
3. Suo Xiangdong. New Development Philosophy: Prioritizing Ecology and Promoting Green Development [J]. Weishi,2022:06:62-64.
4. Freud. From the Internet of Things to the Digital Network: How Big Data Can Turn Waste into Treasure [J]. World Science,2024:11:31-34.
5. Cheng Lei. The Impact of Digital Agriculture on the Economy in the Context of Rural Revitalization [J]. Shanxi Agricultural Economics,2025:22:57-59
6. Yang Zhenning, An Wenjie. "Digital-Physical Integration" in Technology Trading: Digital Technology Trading Network and Total Factor Productivity in Manufacturing [J]. Foreign Economics and Management,2025:47(11):99-116. DOI:10.16538/j.cnki.fem.20250723.401.
7. Wang Bingbing, Song Jian. Study on the governance effect of enterprise digital technology application under the background of digital economy [J]. Economic Cross,2025:11:118-128. DOI:10.16528/j.cnki.22-1054/f.202511118.
8. Zhang Xinwen, Sang Yuan. Operational Mechanisms and Implementation Paths of Digital Technology Empowering Rural Public Services [J]. Learning Forum, 2025, 06.
9. Song Jie. The Impact of Digital Technology Development on Regional Economic Resilience from the Perspective of Industrial Structure Upgrading. Journal of Business Economics,2025:21:175-178.
10. Chen Jun, Chen Ziyi. Empowering the Realization of Ecological Product Value through Digital Technology: Intrinsic Logic, Mechanism of Action, and Optimization Pathways [J]. Ecological Economics,2025:41(11):208-216.