

Research on the Digital Governance Mechanism of Public Welfare Forests from the Perspective of Multi-Level Governance

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Abstract

As the core resource for maintaining ecological balance and supporting the construction of ecological civilization, the governance efficiency of public welfare forests is directly related to ecological security and sustainable development. Traditional governance models for public welfare forests face issues such as fragmented systems, inefficient decision-making, and significant information barriers, making them difficult to meet the practical needs of ecological protection in the new era. This paper takes Longquan City, Zhejiang Province, as a case study. Based on multi-level governance theory and digital governance theory, it adopts a case study method and combines field research, in-depth interviews, and literature review to explore the specific path of digital technology-driven innovation in public welfare forest governance models. The study finds that digital technology breaks down information barriers by constructing a comprehensive data integration platform, optimizes management and protection processes to reduce transaction costs, and effectively enhances the cross-level collaboration efficiency among county, township, and village levels. Relying on the hierarchical responsibility system of the forest chief system, digital governance achieves precise calculation and transparent distribution of compensation funds, enhances supervision efficiency through intelligent monitoring networks, and promotes the formation of a diversified co-governance pattern through innovative public participation mechanisms, thereby facilitating the transformation of governance structure towards efficient collaboration. Based on this, suggestions are made to build a multi-level digital collaboration platform, improve information sharing mechanisms, and optimize the compensation fund supervision system, providing empirical references and practical insights for the innovation of public welfare forest governance models.

Keywords

Public welfare forest; digital governance; multi-level collaboration; forest chief system.

1. Introduction

At the National Ecological Environment Protection Conference, General Secretary Xi Jinping clearly stated that we must prioritize the construction of ecological civilization as the fundamental plan for the sustainable development of the Chinese nation, and focus on building a green, low-carbon, and circular economic system. This important directive provides a clear direction for China's ecological environment protection and governance work. As an important ecological resource for maintaining ecological balance, protecting biodiversity, conserving water sources, and purifying the air, the effective management of public welfare forests is directly related to the effectiveness of ecological civilization construction and is crucial for achieving harmonious coexistence between humans and nature.

As a crucial pillar in the construction of ecological civilization, public welfare forests not only possess ecological functions such as regulating climate, maintaining soil and water conservation, and preventing wind and stabilizing sand, but also continuously provide society with diverse ecological products and services. Currently, the ecological environment issues arising from the rapid economic and social development are becoming increasingly prominent, making the ecological value of public welfare forests even more evident. Therefore, strengthening the governance of public welfare forests and consolidating their ecological function foundation are urgent requirements and strategic tasks for addressing climate change and maintaining ecological security. Faced with the requirements of ecological civilization construction in the new era, traditional governance models for public welfare forests have become difficult to meet practical needs. There is an urgent need to innovate governance concepts and methods to effectively enhance governance efficiency.

In long-term practice, the limitations of the traditional management model for public welfare forests have become increasingly evident, making it increasingly difficult to adapt to the practical requirements of contemporary conservation and management. A prominent crux is that the governance system is overly fragmented: multiple departments such as forestry, environmental protection, and agriculture, as well as multiple levels including counties, townships, and villages, are all involved, yet there is a lack of a strong overall coordination mechanism. This leads to difficulties in forming a cohesive force in work, often resulting in overlapping management or management vacuum zones. Policy formulation between departments also often lacks effective communication, making it difficult to coordinate efforts and even offsetting each other's effects.

Low decision-making efficiency is another long-standing challenge. Due to the wide distribution and complex environment of public welfare forests, traditional methods of information collection and transmission are inefficient, and managers often fail to grasp the dynamic changes of resources in a timely and comprehensive manner. When faced with emergencies such as forest fires, outbreaks of pests and diseases, or illegal logging, the delay in information often leads to missed opportunities for optimal response, resulting in unnecessary resource losses.

Furthermore, information barriers severely hinder scientific decision-making and collaborative governance. Forestry resource data, environmental monitoring information, and grassroots management records are often isolated from each other, with poor sharing channels or even complete separation, preventing effective integration and utilization of information resources.

The rapid development of digital technology is reshaping the governance model of public welfare forests, providing a key breakthrough for overcoming traditional governance dilemmas. Firstly, digital technology has broken down the barriers of time and space, opening up efficient channels for real-time collection, transmission, and sharing of information about public welfare forests. Relying on technologies such as remote sensing, GIS (Geographic Information System), and the Internet of Things, it is possible to conduct round-the-clock, high-precision monitoring of the resource dynamics and environmental changes in public welfare forests, capture high-precision data in real time, provide a solid basis for scientific decision-making, and significantly enhance the timeliness and accuracy of decision-making. Secondly, digital technology drives the reshaping of the governance process of public welfare forests, achieving a leap in management efficiency. Based on digital platforms, core business processes such as management, protection, monitoring, and law enforcement of public welfare forests have been fully online and intelligentized, significantly reducing redundant links and effectively lowering human input and management costs. For example, patrol personnel use mobile terminals to instantly enter patrol information and report data, allowing managers to grasp the management status in real time, respond quickly, and handle various issues. Thirdly, digital

technology creates conditions for the openness and transparency of public welfare forest governance and deep public participation. By establishing a public welfare forest information disclosure platform, key information such as resource status, governance measures, and fund flows are regularly disclosed to the public, smoothing the channels for public supervision. At the same time, the public can use digital platforms to easily voice their opinions, participate in the collection of governance opinions and decision-making processes, and help improve the level of democracy and fairness in governance.

The perspective of multi-level governance has injected new vitality into the research on public welfare forest governance and opened up innovative analytical paths. Traditional research on public welfare forest governance has mostly focused on the role of a single subject or level, with insufficient attention paid to the interaction mechanisms and synergistic effects among cross-level subjects. The theory of multi-level governance emphasizes the integration of the strengths of governance subjects at different levels, strengthens collaborative cooperation among subjects, and weaves a close governance collaboration network featuring top-down linkage and pluralistic co-governance through clearly defining the boundaries of rights and responsibilities. Using this perspective, it is possible to systematically analyze the functional positioning and interactive relationships of multiple subjects such as county governments, townships, village collectives, and farmers in public welfare forest governance, with a focus on exploring the construction and optimization of their collaborative mechanisms. [1] This perspective effectively overcomes the limitations of traditional research, lays a theoretical foundation for building a scientific and efficient public welfare forest governance system, promotes the deep integration and complementarity of resources and information among subjects at various levels, and ultimately achieves a systematic improvement in the collaborative efficiency of public welfare forest governance.

Europe has accumulated rich experience in the field of public welfare forest governance, especially in cross-level collaboration and digital monitoring. Liu Wei's (2020) research indicates that European countries attach great importance to cooperation and information sharing among governments at different levels when promoting the construction of ecological networks, and have established a relatively mature governance system. Taking Germany as an example, it has constructed a multi-level governance framework, clearly defined the boundaries of responsibilities and powers among the federal, state, and local governments, and formed a bidirectional supervision and support mechanism, effectively collaborating to promote the protection and management practices of public welfare forests.

In the field of digital monitoring, European countries generally apply remote sensing and GIS technologies in depth to ecological monitoring and assessment of public welfare forests. With the help of satellite and aerial remote sensing, key information such as vegetation coverage, growth trend, and occurrence of pests and diseases in public welfare forests can be obtained in real-time and accurately. Relying on GIS technology for spatial processing and in-depth analysis provides solid data support and scientific basis for governance decisions. Such digital monitoring methods significantly enhance governance efficiency and lay a shared data foundation for cross-domain and cross-level collaborative governance of public welfare forests. The domestic academic community has extensively explored the issue of multi-stakeholder collaboration in the governance of public welfare forests. Based on empirical research on the management and protection of ecological public welfare forests in M County, Li Ying (2023) found that multi-stakeholder collaboration faces significant challenges: the government's supporting measures lag behind and lacks leadership; enterprises, driven by profit-seeking tendencies, result in uneven quality of management and protection; village collective organizations rely too heavily on townships, with weak independent management and protection capabilities; and the public focuses more on self-interest, with insufficient willingness and action to participate. These issues deeply reveal the current lack of

collaboration mechanisms, leading to fragmented governance effectiveness and difficulty in uniting forces.

In terms of digital governance of public welfare forests, many regions in China have carried out exploratory practices. Some areas have initially established forest resource management information systems and begun to utilize digital technology to enhance governance efficiency. However, on the whole, the depth and systematicness of digital governance applications in domestic public welfare forests still need to be strengthened. This is particularly evident in key areas such as unresolved barriers to information sharing, the lack of collaborative decision-making platforms, and unsmooth channels for public participation, which urgently require systematic optimization and improvement.

2. Theoretical analysis

2.1. Core connotation of multi-level governance theory

The core of multi-level governance theory lies in emphasizing the diversification of governance entities and their cross-level collaboration. In the governance of public welfare forests, the diverse entities mainly include county governments, townships, village collectives, and farmers, each with clearly defined responsibilities and closely interacting at different levels.

The county government is at the top level of the governance system, primarily responsible for macro-level decision-making, policy formulation, and overall coordination in the management of public welfare forests. Its core responsibilities encompass formulating protection and development plans, introducing supporting regulations, allocating governance resources, and supervising the implementation by subordinates. In the interaction between the top and the bottom, the county government guides and regulates township work through policy directives, and dynamically adjusts policies and plans based on feedback from the grassroots level.

Townships occupy a pivotal position as a hub connecting the upper and lower levels. Their core task is to implement county-level policy planning, specifically organize practical work such as management, protection, monitoring, and law enforcement, coordinate inter-village interest relations, and report governance progress upwards. When communicating upwards and downwards, townships need to accurately convey the requirements of superiors and provide feedback on grassroots difficulties. When dealing with village collectives, the focus is on guiding and supervising their governance work, and providing necessary support.

The village collective serves as the grassroots stronghold for the management of public welfare forests, directly responsible for daily maintenance and the execution of specific tasks. Its primary duties include mobilizing farmers to participate in conservation efforts, implementing various management measures, and collecting and reflecting farmers' demands. In daily work, the village collective must strictly adhere to higher-level policies, actively communicate and coordinate with farmers, translate management intentions into concrete actions, and promptly convey farmers' concerns to higher authorities.

Farmers are the direct users and ultimate beneficiaries of public welfare forests, forming the terminal nodes of the governance network. Their responsibilities and rights are embodied in participating in management and protection work, complying with protection regulations, and exercising supervision rights. Farmers express their demands and participate in decision-making through the village collective platform, and effectively protect public welfare forest resources in their production and daily life.

2.2. Support from digital governance theory

The core of digital governance theory lies in enhancing public governance capabilities through information technology. The key lies in utilizing technological means to optimize governance processes and enhance effectiveness. In the field of public welfare forest governance, the

application of information technology can significantly promote information sharing and drive process optimization.

In terms of information sharing, digital technology helps bridge the information gap between different governance entities, facilitating efficient circulation and sharing of data related to public welfare forests. By constructing a unified digital information platform for public welfare forests, information scattered among county governments, townships, village collectives, farmers, and other parties can be centrally integrated, supporting real-time updating and sharing of information. Various entities can conveniently access the required information such as public welfare forest resource data, governance policies, and work progress through the platform, thereby enhancing the scientific nature of decision-making and the precision of management.

In terms of process optimization, with the aid of digital technology, the workflow of public welfare forest governance has been simplified, significantly enhancing management efficiency. For instance, by utilizing digital platforms, tasks related to the management and protection of public welfare forests can be allocated, progress tracked, and assessed online, eliminating the need for traditional paper document transmission and manual statistics. Forest patrol personnel can record and report data through mobile terminals, enabling them to promptly reflect the condition of the forest area, facilitating early detection and resolution of issues, and greatly enhancing the response speed and effectiveness of management and protection work.

2.3. Hierarchical responsibility system of the forest chief system

The Forest Chief System has established a three-tiered responsibility system for forest chiefs, encompassing the county, township, and village levels. Forest chiefs at each level are responsible for the protection and development of forest resources within their respective jurisdictions, with clear responsibilities and tasks assigned to them. This responsibility system aligns closely with the theory of multi-level governance.

The multi-level governance theory emphasizes collaborative cooperation among entities at different levels, and the three-tier forest chief system is precisely designed to achieve collaborative coordination among entities at all levels in forest resource protection. The county-level forest chief oversees the protection of forest resources throughout the county, formulating overall strategies and objectives; the township-level forest chief is responsible for organizing implementation and fulfilling the deployment and requirements of the county-level forest chief; the village-level forest chief is directly responsible for the management and protection of forest resources in their respective villages, ensuring that various measures are implemented effectively. This tiered responsibility system is highly consistent with the division of levels in multi-level governance theory, including county governments, townships, and village collectives, and it facilitates top-down linkage and collaborative governance in the management of public welfare forests.

2.4. Synergy between the forest chief system and digital governance

The deep integration of the forest chief system with digital governance provides strong support for forest chiefs to efficiently and accurately fulfill their core responsibilities. Digital platforms have become key tools for forest chiefs to perform their core duties such as forest patrols, management, and protection, as well as assessments.

In the forest patrol segment, the digital platform provides forest chiefs with real-time patrol routes and information on key areas. Patrol personnel can record patrol conditions and upload on-site graphic and text data in real-time through mobile terminals. Based on this, forest chiefs can dynamically grasp the progress and problem areas of the patrol, quickly issue disposal instructions, and significantly enhance the precision and response speed of forest patrol work.

In terms of resource management and protection, the digital platform integrates information on public welfare forest resources, daily management and protection records, and pest and disease monitoring data, forming a unified view. Forest chiefs can comprehensively grasp the management and protection situation of the forest area based on the platform, formulate scientific management and protection plans accordingly, optimize resource allocation, and ensure the systematicness and standardization of management and protection work.

In the assessment and evaluation process, the digital platform automatically collects and compiles data on the work performance of forest chiefs at all levels and the effectiveness of public welfare forest protection, providing solid data support for assessment and evaluation. This not only significantly enhances the objectivity and transparency of the assessment process but also effectively strengthens the motivation and sense of responsibility of forest chiefs at all levels in performing their duties.

3. Digital Governance Enhances the Multi-Level Governance Benefits of Public Welfare Forests

3.1. Digital technology reduces transaction costs

In the field of public welfare forest governance, traditional governance models have long faced issues such as severe hierarchical segmentation, delayed information transmission, and cumbersome operational processes, leading to persistently high transaction costs. Digital governance, by reshaping information exchange and business processes, has significantly reduced coordination costs among various governance levels. The practice of digital reform in Zhejiang Province demonstrates that process reengineering can increase administrative efficiency by 30%-50%, mainly manifested in the following two aspects:

3.1.1. Break down information barriers

Holistic Data Integration Platform: A Three-Level Linkage System from County to Village. Digital governance has completely replaced the traditional paper-based reporting model, step by step, by establishing a distributed data hub that spans the county, township, and village levels. A typical case is the digital management platform for public welfare forests in Longquan City, Zhejiang Province. This platform integrates multiple datasets such as resource distribution maps, real-time management and protection records, and farmer demand databases. It also synchronously develops mobile interfaces (APP/WeChat mini-program) to enable farmers to instantly report issues through "Take a shot" and receive policy directives in seconds. Its "one platform, multiple ports" architecture compresses the information transmission time from weekly to minute-level, reducing the information error rate by over 60%.

Cross-domain Synergy Effect: Innovation in Multi-sector Governance Paradigm. More importantly, it has facilitated the transformation of collaborative mechanisms among governance entities. Taking the "Zhejiang Government Ding" system in Zhejiang Province as an example, it integrates databases from departments such as forestry, environmental protection, and land, reducing the boundary identification period for public welfare forests from 45 days to 7 days, effectively avoiding the cost of repeated surveying and mapping caused by data conflicts. Similar collaborative models have been further deepened in Jiangxi Province's "One Leader, Two Members" (forest leader + supervisor + ranger) system: grid members synchronize data in real-time through a unified platform, and the forestry department dynamically allocates law enforcement resources accordingly, significantly improving cross-sector collaboration efficiency.

3.1.2. Optimize the management and maintenance process

Paperless closed-loop management: The traditional process involving 12 types of paper forms, signatures and seals from 5 departments, task dispatching → on-site execution → material

acceptance → fund application, is reconstructed into an online closed-loop of "platform dispatching - mobile receipt - intelligent verification - online payment". The case of Chongqing Forest Fire Prevention Digitalization Center shows that after forest rangers receive fire hazard warnings through the terminal, they upload videos of on-site disposal, and the system intelligently identifies the effectiveness of the disposal. The entire process is completed within 2 hours, which is 85% faster than the original process.

Intelligent Assisted Decision-making: At a deeper level, data-driven approaches have driven the transformation of governance decision-making. The intelligent analysis module of the Longquan City platform integrates historical data on meteorology, soil, and pests and diseases, automatically generating a priority list for management and protection. For example, when the system identifies a red alert for the spread risk of pine wilt disease in a certain area, it will automatically push a treatment plan to the responsible forest rangers and allocate drone operation resources. Such predictive management has reduced disaster losses by 35% and emergency fund usage by 20%.

3.1.3. Case evidence

The practice in Longquan City has achieved positive results. After the platform was launched, 200,000 paper reports were saved annually (equivalent to a printing and labor cost of 1.2 million yuan); the turnover efficiency of management and maintenance tasks increased by 30%, which means that the management and maintenance area can be expanded by 150,000 mu with the same resources; the decision-making response time was shortened by 50%, resulting in an increase in the initial disaster control rate to 98%. What is more convincing is the innovation in Ninghai County, Ningbo City, Zhejiang Province - the county achieved a "100% consistency rate of people, land, map, and money" in compensation fund distribution through digital management of public welfare forests, historically resolving the cost of disputes caused by ambiguous ownership and reducing administrative litigation expenses by 800,000 yuan annually.

3.2. Optimize compensation management

The management of compensation funds for public welfare forests has long suffered from pain points such as inaccurate measurement, delayed distribution, and ineffective supervision, which have seriously dampened the enthusiasm of farmers for management and protection. Digital governance, through the innovative management model of "data verification - intelligent distribution - penetrating supervision", has effectively improved the accuracy and efficiency of compensation fund management in pilot areas such as Ninghai County

3.2.1. Accurate accounting

The compensation mechanism for public welfare forests is transitioning from static area accounting to multi-dimensional dynamic measurement. The digital system integrates multiple sources of data, including stand quality (such as canopy density and tree species value), management and protection effectiveness (such as pest and disease control rate and fire occurrence rate), and ecological service functions (such as water conservation capacity and carbon sequestration capacity), to establish a dynamic compensation algorithm. The practice in Ninghai County demonstrates that public welfare forests with key ecological locations and optimal management and protection ratings can receive compensation per acre up to 1.8 times that of ordinary forest land, truly implementing the principle of "high quality, high compensation". What deserves more attention is the dynamic adjustment mechanism: the system updates forest growth indicators quarterly, and when the annual increase rate of stock volume in a certain area is detected to exceed 5%, it automatically triggers an increase in compensation. In 2023 alone, 47 villages in Ninghai County benefited from this, with the highest increase rate reaching 25%, directly driving a 40% year-on-year increase in the number of farmers actively participating in tending operations.

3.2.2. Transparent distribution

The application of blockchain technology ensures full transparency in the circulation of compensation funds: key data such as farmer identity, forest right information, calculation formula, and payment amount are all recorded on the blockchain, allowing farmers to track the movement of funds in real time through their mobile phones. The practice in Sichuan has verified this effect - by entering their ID number on the "Tianfu Forest" APP, farmers can clearly view the detailed calculation of funds and the countdown of bank disbursement, resulting in a significant decrease of 76% in related complaints. More importantly, an efficient online dispute resolution mechanism has been established. Drawing on the experience of the bidding objection platform in Lanzhou, when farmers have doubts about the compensation amount, they can submit a review application online; the system automatically links electronic evidence such as remote sensing images and management and protection acceptance records, and completes online hearings and result feedback within 15 days, with processing efficiency increased by four times compared to the past.

3.2.3. Strengthening supervision

Intelligent risk control and visual audit constitute the dual safeguards for compensation security. During the distribution process, the system's built-in early warning rule engine can intercept abnormal operations in real time - for example, when the total amount of a certain batch of payments suddenly exceeds 15%, or when the amount received by a single household deviates abnormally from the average, the transaction will be automatically frozen and transferred to the audit department for verification. The practice in Chongqing shows that such rules have increased the efficiency of detecting illegal withholding behavior by over 90%. At the same time, regulatory authorities can track the entire chain path of each fund from the fiscal account to the farmer's bank card through the "fund flow heat map". After Ninghai County applied this function, the number of cases of compensation withholding and embezzlement decreased sharply from an average of 12 cases per year to 2 cases, a decrease of up to 83%. Villagers' trust in compensation distribution has significantly increased.

3.3. Enhance regulatory efficiency

Traditional public welfare forest supervision often faces challenges such as manpower shortage, limited coverage, and slow response speed. In contrast, digital governance, relying on the collaborative construction of the "air-ground-space integrated monitoring network" and "intelligent analysis hub", significantly enhances the breadth, accuracy, and response efficiency of supervision.

3.3.1. Constructing an intelligent monitoring network

In key ecological locations, IoT devices such as visible light/infrared cameras, soil sensors, and acoustic monitors are deployed to construct a three-dimensional monitoring network covering the air, land, and underground. Taking Liandu District in Lishui City, Zhejiang Province as an example, 28 forest fire monitoring points have been established in combination with drone patrols, achieving real-time monitoring coverage of 86% of the public welfare forest area in the district. The accuracy rate of fire detection is 95%, and the initial fire suppression rate is close to 100%. At the same time, by applying acoustic recognition and AI image analysis technology, the monitoring system can intelligently track the activity trajectories of key species such as the white-necked long-tailed pheasant. In 2023, the system successfully warned of three habitat destruction incidents in Liandu District, reducing the risk of habitat destruction in relevant areas by about 40%. In addition, based on the accumulated data analysis of wildlife migration patterns, the system also provides a basis for scientifically optimizing the boundaries of protected areas, effectively alleviating potential conflicts between ecological protection and community development.

3.3.2. Innovative closed-loop control mechanism

In terms of control mechanisms, intelligent technology has established an efficient closed loop of "early warning-scheduling-handling". Taking the "forest fire cockpit" system in Chongqing as an example: it integrates multiple sources of data such as meteorological early warnings and infrared fire detection, automatically generating heat maps for forest fire danger warnings. Once the risk value of a certain area exceeds the threshold, the system immediately pushes handling tasks to forest rangers within a 5-kilometer radius. Forest rangers can transmit real-time on-site conditions through handheld terminals, while the command center dynamically deploys firefighting forces based on a three-dimensional electronic map. This closed-loop process significantly reduces the response time from risk detection to resource scheduling, effectively containing the spread of fire. Similarly, Liandu District has applied an intelligent solution in the prevention and control of pine wilt disease: through satellite remote sensing, it identifies abnormal discoloration areas in pine forests, dispatches drones to precisely locate (with centimeter-level accuracy) diseased trees (infected wood), and the system automatically plans the optimal removal path, then issues instructions to professional teams through a mobile application. This model not only significantly improves efficiency but also reduces the cost per tree removal from about 120 yuan to around 65 yuan.

3.4. Promote diversified co-governance

Digital governance is profoundly reshaping the management model of public welfare forests, gradually breaking the traditional pattern of "government unilateral management" and promoting the establishment of a governance system featuring multi-party participation, clear rights and responsibilities, and incentive compatibility, moving towards the direction of joint construction, joint governance, and shared benefits.

3.4.1. Innovation in public participation mechanism

Through mobile mini-programs such as "Public Welfare Forest Steward", farmers are able to deeply participate in the management of public welfare forests: they can not only scan and view the real-time ecological data of their responsible forest sections, but also take photos and upload any abnormal situations such as illegal logging and fires at any time, and provide satisfaction evaluations on the management and protection effects. This convenient participation method has significantly enhanced the enthusiasm of farmers. Practice data from Sichuan shows that the proportion of farmers participating in management and protection has jumped from 28% to 67%. At the same time, digital platforms utilize visualization technology to transform the originally abstract ecological value into concrete benefits that farmers can perceive - after logging into the system, farmers can clearly see key indicators such as the annual carbon sequestration and oxygen release of their own forests, and can intuitively convert them into corresponding ecological benefit amounts. This method of "clearly marking" ecological contributions allows farmers to truly appreciate the value of protecting mountain forests (research shows that their recognition of public welfare forests has increased by 40%), thus more actively extending their management and protection contracts, and the renewal rate has significantly increased.

3.4.2. Multi-departmental collaborative governance upgrade

In Ninghai County, a digital collaboration platform centered around the county-level forest chief has broken down business barriers among 28 departments, including natural resources (forest land data), finance (compensation funds), and public security, procuratorial, and judicial departments (law enforcement information). When the system automatically identifies incidents such as illegal logging, it will immediately push disposal instructions to the forestry law enforcement team and simultaneously send a notification to the procuratorial organs for supervision. As a result, the average case handling time has been significantly reduced from 45

days to 12 days. On the other hand, Guangdong's "Guangdong Digital" platform has explored a new path to attract social capital: enterprises can use its public welfare forest adoption module to select target forest areas online, view ecological indicators, sign electronic management and protection agreements, and ultimately obtain carbon sequestration certificates for ESG disclosure. In 2024 alone, this innovative model successfully leveraged 370 million yuan of corporate investment, opening up a sustainable market-oriented channel for the management and protection of public welfare forests.

3.5. Deep-level transformation of governance structure

Digital governance drives the transformation of the public welfare forest management system towards efficient collaboration: village-level organizations report information directly through the platform, significantly reducing township-level intermediary links; third-party agencies can access the system to conduct independent performance evaluations; and university research teams are authorized to obtain desensitized data to support ecological research. This platform-based governance model effectively enhances the adaptability and resilience of the governance system through multi-stakeholder participation (village-level organizations/third parties/research institutions) and cross-domain knowledge integration.

4. Policy Suggestions

Currently, the governance of public welfare forests faces challenges such as fragmented management, inefficient operations, and insufficient transparency, urgently requiring the application of digital technology to drive innovation in governance models. Drawing on practical explorations in places like Longquan, Zhejiang, and in response to the national digitalization strategy for forestry, the following specific policy recommendations are proposed.

4.1. Build a multi-level digital collaboration platform

The governance of public welfare forests involves four levels of entities: county, township, village, and farmer households. There is an urgent need to achieve "vertical integration and horizontal collaboration" through platform integration.

4.1.1. Build a four-level integrated collaborative platform

Digital management of public welfare forests enhances governance efficiency through multi-level collaboration: At the provincial level, the "Public Welfare Forest Data Sharing Directory" and interface standards are formulated to break down data barriers between water conservancy, environmental protection, and other departments; county-level decision-making is aligned with the "one map" of natural resources, integrating data from the third national land survey to support dynamic adjustments to public welfare forests (such as the Fujian Provincial Smart Forestry Platform, which realizes the linkage of policy and resource analysis); township implementation relies on the forest chief system platform to strengthen supervision, with real-time linkage between inspection and law enforcement systems (data from Jiangxi Province in 2023 shows that mobile task push has reduced the response time for illegal logging by 64.3% and accelerated fire hazard handling by 64.5%); village-level channels provide farmers with a simple operation interface for direct event reporting, combining ownership data to integrate sources and resolve disputes (620,000 mu of public welfare forests in Anji County, Zhejiang Province have achieved consistency in "land, map, and money" information) [3].

4.1.2. Visual supervision system for forest chief's performance of duties

The digital supervision system for public welfare forests enhances constraint effectiveness through quantitative assessment and intelligent supervision: it automatically generates performance scores for forest chiefs based on core indicators such as forest coverage, incidence of illegal logging, and fire suppression timeliness, and publicly ranks them (for example, Yiliang

County in Yunnan Province has achieved a 40% improvement in patrol efficiency by relying on "sky-ground" supervision data). It automatically triggers alerts for abnormal data such as missing management and protection records, directly pushing them to the superior forest chiefs' mobile devices to form a closed loop of "monitoring-supervision-rectification". It also integrates compliance review results from departments such as land and environmental protection, increasing assessment weights to curb illegal occupation of forest land in projects.

4.2. Improve the digital information sharing and communication mechanism

4.2.1. Establishment of public welfare forest monitoring database

The digital management of public welfare forests constructs a dynamic monitoring system through multi-source data aggregation: integrating satellite remote sensing (vegetation dynamics), drone inspections (dead tree location), IoT terminals (soil/fire risk), and farmer-reported information, while implementing hierarchical permission management (county-level full data/township jurisdiction reports/farmer individual warnings). As demonstrated in Yunnan's practice, it effectively balances data security and application needs; establishes an automatic docking mechanism for land change survey data to trigger adjustments to the boundaries of public welfare forests, supporting precise compensation allocation (Guangdong accurately allocated 2.8 billion yuan of ecological funds based on this in 2023).

4.2.2. Developing a mobile terminal for farmer-benefiting services

Digital governance of public welfare forests optimizes public services through five-dimensional functions: farmers can take photos of pests and diseases and upload them in real-time, and GIS automatically locates and connects with rangers for rapid response (Zhejiang Anji model); relying on spatial coordinates, differentiated compensation policies are targetedly pushed out [4] (such as the independent accounting mechanism for mangrove forests in Guangdong in 2024); electronic signature applications support online agreement signing, combined with digital authentication to ensure legal validity (refer to the practice in Zhejiang Jingning) [5]; the fund supervision module generates an embedded verifiable distribution table to ensure consistency of information between "people-land-map-money" (Zhejiang Ninghai case); online dispute mediation establishes a four-level joint mediation mechanism, integrating parcel annotation and video mediation functions (learning from Jiangxi's experience in graded early warning).

4.3. Optimize the compensation supervision system

The payment of compensation is the core of the credibility of public welfare forest governance, and it is necessary to reconstruct the trust mechanism through technology.

4.3.1. Innovation in accounting standards

Provincial standard framework + local parameter calibration: Longyan, Fujian Province, has introduced carbon sink monitoring data, using the increment of carbon storage in arbor forests as the basis for compensation premiums; Anji has set differentiated coefficients for economic forests and bamboo forests.

4.3.2. Blockchain traceability

Full-process traceability: farmer confirmation information → on-chain management and protection data → smart contract accounting → direct bank transfer to social security cards. Longquan City has implemented on-chain distribution, eliminating the possibility of village collectives withholding funds, benefiting 30,000 farmers [6].

Multi-node supervision: The forestry department's entry of compensation standards, the financial department's disbursement records, the bank's payment statements, and the farmers' confirmation receipts are all stored on the blockchain for verification, and the discipline inspection commission can conduct random checks at any time. The forestry finance platform

in Wuping County, Fujian Province, has verified the effectiveness of blockchain tamper resistance and cross-departmental collaboration [7].

4.4. Expand channels for public participation and supervision

4.4.1. Establish a public opinion consultation and feedback mechanism

Establishing a normalized public participation mechanism for digital governance of public welfare forests: By setting up a policy suggestion channel on the platform, we continuously solicit farmers' opinions on improvements to management and protection plans and compensation standards. Before key policy revisions (such as adjustments to compensation standards), online drafts are released and comments are opened. The system conducts cluster analysis on the opinions to identify core issues. The practice in Jiangxi Province shows that this mechanism, by identifying concentrated demands such as "low compensation standards for economic forests," has driven a 20% increase in bamboo forest management and protection subsidies, significantly enhancing policy responsiveness and public recognition [8].

4.4.2. Improve the mechanism for information disclosure and social supervision

Digital governance of public welfare forests builds institutional trust through a dual transparency mechanism: regularly publicizing key performance data such as ecological indicator evolution, fund flow, and case disposal results, enhancing the visibility of the governance process; establishing a reward system for reporting violations [9] (which can be exchanged for physical items such as forest seedlings), encouraging deep public participation in supervision. This system design combines the improvement of information symmetry with behavioral incentives, laying a social cognitive foundation for the formation of a diversified co-governance pattern.

4.5. Safeguard measures for promotion implementation

Longquan City, Zhejiang Province, has developed replicable practical experience in the field of digital management of public welfare forests, which holds value for regional promotion. However, given the significant differences in resource endowments and management needs of public welfare forests across regions, it is necessary to emphasize adaptive optimization tailored to local conditions during the promotion process [10].

4.5.1. Adapt to the characteristics of regional resource endowments

When promoting the Longquan experience, it is necessary to systematically evaluate the core characteristics of public welfare forest resources in the target areas. For example, areas rich in forest resources can focus on learning from its technical approach in resource monitoring and multi-source data integration; ecologically fragile areas should refer to its mechanism for precise quantification of ecological benefits and dynamic adjustment of compensation standards. Through such targeted adaptation, it is ensured that the digital governance plan meets the actual needs of the local area.

4.5.2. Strengthen grassroots digital capacity building

To bridge the digital divide at the grassroots level, a systematic training mechanism needs to be established. The training content should cover core aspects such as digital platform operation, basic data analysis, and policy application, with a focus on enhancing the tool application and decision-making support capabilities of grassroots personnel. At the same time, the training design needs to emphasize practical exercises and analysis of typical cases, facilitating the transformation of knowledge into practice and effectively lowering the threshold for technology application.

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References

- [1] Aradottir A L, Hagen D. Chapter three-ecological restoration: Approaches and impacts on vegetation, soils and society [J]. *Advances in Agronomy*, 2013, 120(02):173-222.
- [2] Begemann A., Giessen L., Roitsch D., et al. Quo vadis global forest governance? A transdisciplinary delphi study. *Environmental Science and Policy*, 2021, 123:131-141.
- [3] Zhao Haiyan, Wu Xionghai, Wu Weijuan. Problems and countermeasures of information technology application in forestry. *China Forestry Industry* December 2006:29-31.
- [4] Xu Lanxia, Xu Cuixia. Several opinions on accelerating the pace of forestry informatization construction in our country; *Beijing Forestry Management Cadre College Journal of the Journal*, No. 3, 2003
- [5] Pan Y X, Zhang B Y, Wu Y, et al. Sustainability assessment of urban ecological-economic systems based on emergy analysis: A case study in Simao, China [J]. *Ecological Indicators*, 2021, 121:1-10.
- [6] Pattanayak K S, Wunder S, Ferraro J P. Show Me the Money: Do Payments Supply Environmental Services in Developing Countries? [J]. *Review of environmental economics and policy*, 2010, 4(2):254-274.
- [7] Sikor T, Martin A, Fisher J, et al. Toward an empirical analysis of justice in ecosystem governance [J]. *Conservation Letters*, 2015, 7 (06):524-532.
- [8] Xin Y M, Dong H Z, Zhao R W, et al. [Spatial structure characteristics of the main tree species in a mixed broadleaved Korean pine (*Pinus koraiensis*) forest in a mountainous area of eastern Liaoning Province, China]. [J]. *Ying yong sheng tai xue bao = The journal of applied ecology*, 2019, 30(9):2933-2940.
- [9] Peter M Atkinson and Paut J Curran. Choosing an Appropriate Spatial solution for Remote Sensing Investigation. *Photogrammetric Engineering & Remote Sensing*, 1997, 63(12):179~181.
- [10] Helen M Ridley, Peter Matkinson. Evaluation the Potential Forthcoming Commercial U. S. High-Resolution Satellite Sensor at the Ordnance Survey [J]. *Photogrammetric Engineering Remote Sensing*, 1997, 63(8):997~1005.