

Development Pathways and Best Practice Insights for Carbon Inclusion of Small-Scale Seedling Carbon Sinks

Hao Zheng, BinbinWu, Feiyang Qin, Aman Xie, Lina Zhang*
Southeast University Chengxian College, Nanjing, Jiangsu, China
**Corresponding Author*

Abstract: China has established a dual-layer carbon market system in which the national CCER operates in parallel with local carbon inclusion mechanisms, laying the institutional foundation for the value realization of agroforestry carbon sinks. However, traditional CCER mechanisms are characterized by high entry thresholds, lengthy accounting cycles, and substantial upfront costs, which are misaligned with the fragmented land parcels, rapid turnover, and dynamic carbon sink fluctuations inherent to the nursery industry, thereby excluding small-scale nurseries from carbon trading. This study selects four pilot programs—the Yixing Bamboo Forest Carbon Inclusion Initiative in Jiangsu, the Gaochun Agricultural Carbon Credit Scheme in Nanjing, the Carbon Sink Forestry Program in Guangdong, and the Lukou Carbon Sink Forest Project in Zhuzhou—and examines the market-oriented pathways for small-scale nursery carbon sinks from six dimensions: institutional standards, local regulatory oversight, aggregation of scattered resources, lightweight MRV monitoring, market absorption, and revenue operations. The findings indicate that leveraging the lightweight advantages of local carbon inclusion mechanisms—through the establishment of a dedicated carbon sink accounting system, the integration of fragmented resources, the adoption of annual sampling combined with remote sensing for monitoring, the expansion of carbon sink absorption channels, and the construction of a tiered revenue feedback mechanism—can effectively address challenges such as inadequate measurement adaptability, uneconomical project development, and limited trading channels. This paper ultimately develops a full-process framework encompassing project development, operations management, and revenue

distribution, providing a practical reference for the nationwide implementation of small-scale nursery carbon inclusion projects.

Keywords: Seedling Carbon Sink; Carbon Inclusion; Small-Scale Agroforestry; MRV Monitoring

1. Introduction

Under the backdrop of deepening the "dual-carbon" strategy, forestry carbon sinks, as a core pathway for enhancing carbon sequestration in terrestrial ecosystems, serve as a crucial lever for regional carbon neutrality construction and the improvement of ecological compensation systems [1]Zeng [2]through an examination of the rights structure of forest carbon sinks, Jing and Zhang [3]through an investigation of approaches to embedding forest carbon sink trading into carbon offset mechanisms, and Mu et al. [4] through a study of the mechanisms for incorporating forest carbon sinks into the CCER market, have all affirmed the importance of forest carbon sinks in achieving carbon emission targets. China's carbon market has progressively evolved into a dual-layer structure in which the national CCER voluntary emission reduction market and local carbon inclusion markets develop in coordination. Specifically, the CCER market primarily targets large-scale, long-cycle, contiguous arbor forestland carbon sink projects, offering advantages such as high standardization and strong national recognition. However, it is simultaneously constrained by rigid requirements including stringent entry conditions, a minimum project crediting period of 20 years, and high upfront development costs. Compared with traditional contiguous public welfare forests and commercial forests, the operational characteristics of the seedling industry are markedly different, typically featuring fragmented land parcels, short cultivation cycles of 1-3 years, frequent seedling

transplantation from nurseries, dynamic fluctuations in carbon stocks, and regular carbon losses. These characteristics are significantly mismatched with the CCER mechanism's rules of stable carbon sequestration, long-cycle holistic accounting, and large-scale contiguous project development. As a result, the vast number of small-scale nurseries, seedling cooperatives, and individual operators have long been excluded from the formal carbon trading system. The ecological value of seedling resources cannot be effectively converted into economic returns, constraining the development of small-scale low-carbon agroforestry industries.

As an important supplement to the national unified carbon market, the local carbon inclusion mechanism, by moderately relaxing the rigid constraints on project scale, cultivation cycles, and measurement and accounting, aligns with the development characteristics of small-scale agroforestry operators, and represents the core pathway for achieving compliant market-based conversion of seedling carbon sinks. Multiple regions in China have already launched pilot programs for agroforestry carbon inclusion. Among them, four typical cases—the Yixing (Jiangsu) bamboo forest carbon inclusion project, the Gaochun (Nanjing) agricultural carbon ticket scheme, Guangdong's provincial-level forest carbon sink construction program, and the Zhuzhou Lukou collective forest carbon sink operation project—correspond to four representative scenarios: short-cycle commercial timber forests, small-scale farmland carbon sinks, a provincial-level macro carbon sink system, and southern collective forest household management. These cases cover the full chain of institutional design, technical monitoring, entity cultivation, market trading, revenue distribution, and long-term operation, providing mature scenario-based references and empirical support for the standardized development of small-scale seedling carbon sink projects.

Against this backdrop, this paper systematically analyzes the practical bottlenecks in the market-based development of small-scale seedling carbon sinks, drawing on the dual-layer carbon market theory and the empirical experience of four typical carbon inclusion pilot projects. From five dimensions—institutional development, resource integration, technological optimization, market expansion, and long-term operation—it synthesizes and develops a

standardized and replicable seedling carbon inclusion development framework. This study aims to open the value realization pathway for small-scale seedling ecological products, promote the low-carbon transformation of the small-scale seedling industry, and provide operational guidance and a reference paradigm for the implementation of similar agroforestry carbon inclusion projects nationwide.

2. Carbon Market Tiering Logic and Bottlenecks in Small-Scale Seedling Carbon Sink Development

2.1 Functional Positioning Differences between the Dual-Layer Carbon Markets

Drawing on the foundational theories of low-carbon economics and forest carbon sinks, the national CCER market functions as a nationwide, standardized voluntary emission reduction trading platform. Emission reductions from forestry projects that have been filed and certified by the competent authority can be used to offset a certain portion of enterprises' carbon emissions, and may also be traded on the market to generate carbon sink revenue [5]. In contrast, the local carbon inclusion market focuses on regional small-scale low-carbon scenarios, with inclusivity, lightweight implementation, and scenario-specific adaptation as its core features. Through customized accounting methodologies, simplified application procedures, and lower development thresholds, it effectively covers fragmented and short-cycle agroforestry carbon sink projects that are difficult to accommodate under the CCER mechanism. The two types of markets feature complementary functions, independent rules, and mutually exclusive ownership, together constituting a tiered and gradient market-based conversion system for China's ecological carbon sinks.

2.2 Core Pain Points in Small-Scale Seedling Carbon Sink Development

Drawing on the operational patterns of the seedling industry and the current carbon market institutional framework, three major bottlenecks currently constrain the market-based development of small-scale seedling carbon sinks. First, insufficient adaptability of the measurement and accounting system. Traditional forestry carbon sinks adopt a steady-state carbon sequestration accounting logic, which fails to incorporate the carbon loss caused by annual

seedling out-planting and transplantation replacement, and thus cannot accurately reflect the dynamically fluctuating carbon stock characteristics of the seedling industry. Second, inadequate economic viability of project development. The seedling industry is predominantly operated by individual smallholders and small-scale cooperatives, characterized by small individual land parcels and scattered spatial distribution. This makes it difficult to amortize the high costs of project development, third-party verification, and long-term operation and maintenance under the CCER model, rendering independent development by individual operators economically unfeasible. Third, an underdeveloped market trading system. Small-scale seedling carbon sinks have yet to establish standardized mechanisms for rights confirmation, registration, certification, and trading. The channels for compliant circulation of carbon assets are limited, market absorption pathways are narrow, and the realization of ecological value remains difficult.

3. Carbon Inclusion Marketization Pathways and Experience Analysis of Small-Scale Seedling Carbon Sinks

3.1 Institutional Framework and Localized Standard Development for Seedling Carbon Inclusion

Pilot practices of agroforestry carbon inclusion across various regions have demonstrated that specialized and localized accounting standards and regulatory systems are the core prerequisites for the effective implementation of small-scale carbon sink projects. Given the operational characteristics of the seedling industry—dynamic carbon sequestration, short cycles, and rapid turnover—an institutional framework tailored to seedling carbon sink development can be constructed from three aspects: specialized accounting standards, a localized regulatory structure, and a dual-layer market division of responsibilities.

3.1.1 Developing a dedicated carbon sink accounting methodology for seedlings

The current CCER general methodology does not set carbon loss correction factors for scenarios such as vegetation harvesting, transplantation, and annual turnover, making it difficult to accommodate the high-frequency turnover characteristics of the seedling industry.

Multiple domestic carbon inclusion pilot projects have developed accounting experience featuring category differentiation and scenario customization. For example, Guangdong's forest carbon sink construction program explicitly distinguishes between public welfare afforestation and commercial afforestation scenarios, and has developed differentiated measurement standards for short-cycle vegetation cultivation and low-efficiency forest transformation [6]. Yixing City (Wuxi, Jiangsu) has issued a dedicated Carbon Inclusion Bamboo Forest Carbon Sink Project Development Methodology, which innovatively adds carbon loss correction parameters for harvesting and transplantation, filling the institutional gap left by traditional forestry carbon sink accounting that overlooks carbon losses [4]. The Nanjing Gaochun agricultural carbon ticket mechanism, in turn, sets differentiated loss parameters by crop category, constructing a lightweight, highly adaptable dedicated measurement model.

Drawing on the above pilot experiences, seedling carbon sink development needs to break away from the traditional steady-state carbon sequestration measurement mindset, develop a dedicated carbon inclusion methodology suited to the characteristics of the seedling industry, and establish a core accounting formula of "above-ground biomass + below-ground root carbon sequestration - annual out-planting carbon loss" to objectively reflect the dynamic changes in seedling carbon stocks. At the same time, in line with the 1–3 year short-cycle cultivation pattern of seedlings, annual independent measurement and certification rules should be established to enable year-by-year carbon sink accounting, year-by-year rights confirmation, and year-by-year trading, precisely matching the industrial rhythm of annual seedling cultivation and annual out-planting.

3.1.2 Establishing a localized three-tier operational supervision framework

Mature carbon inclusion pilot projects across various regions have generally established a three-tier localized supervision system consisting of "government competent authorities + official operation platforms + online trading portals", enabling standardized management of the entire project lifecycle. Specifically, Wuxi City has established the Taihu Carbon Inclusion Center, which relies on the "Carbon Fashion" digital mini-program to complete carbon sink certification, registration, public disclosure, and

traceability management. Nanjing City leverages the Rural Property Rights Trading Center to facilitate the compliant circulation and transaction settlement of agricultural carbon tickets. Guangdong Province's forestry competent authorities coordinate the province-wide construction of carbon sink projects, implementation of standards, and industry regulation [6].

Therefore, seedling carbon inclusion projects can establish a localized supervision system by drawing on this mature framework. First, district/county-level forestry and ecological environment authorities can jointly set up a dedicated carbon inclusion management office, responsible for project filing, rule implementation, ownership supervision, and industry guidance. Second, accredited third-party DOE (Designated Operational Entity) institutions within the jurisdiction can be commissioned to carry out annual verification, carbon sink estimation, data validation, and report preparation. Finally, a district-level online listing and trading platform can be established, creating a full-chain closed-loop supervision process for seedling carbon sinks covering "filing → estimation → verification → issuance → trading → traceability". This effectively mitigates cross-regional ownership conflicts and regulatory gaps, ensuring compliant project operation.

3.1.3 Clarifying the exclusive division of labor between the dual-layer markets

The dual-layer carbon market mechanism stipulates that CCER and local carbon inclusion projects have independent ownership and are subject to exclusive declaration, strictly prohibiting duplicate rights confirmation and duplicate offsetting of the same land parcel, thereby ensuring the uniqueness and compliance of carbon assets. The Nanjing Gaochun carbon ticket project explicitly requires registered operating entities to sign exclusive commitment agreements, preventing the same land parcel from being simultaneously registered for both CCER and local carbon inclusion projects, thus providing a paradigm for compliant management of small-scale agroforestry carbon sinks. Seedling carbon sink projects need to clarify ownership boundaries during the initial land rights confirmation phase, uniformly incorporate compliant nursery land parcels into the district-level carbon sink resource pool, and explicitly stipulate that the land shall only

participate in local carbon inclusion trading. This approach eliminates the risk of duplicate reporting and duplicate accounting at the institutional source, solidifying the foundation for compliant project operation.

3.2 Integration Mechanism of Decentralized Seedling Resources and Cultivation Path of New Business Entities

Fragmented operation plots, insufficient scale of individual plots, and scattered business entities are the core bottlenecks restricting the large-scale development of small and micro seedling carbon sinks. The three pilot projects — Yixing Bamboo Forest, Gaochun Agricultural Carbon Ticket, and Zhuzhou Lukou Carbon Sink Forest — have effectively solved the fragmentation problem through the model of resource integration and centralized development, forming a directly transplantable resource aggregation and entity cultivation mechanism.

3.2.1 The platform coordinates and integrates scattered plots to lower the development threshold

The Zhuzhou Lukou Collective Forest Carbon Sink, Yixing Bamboo Forest Carbon Incentive, and Nanjing Gaochun Agricultural Carbon Ticket projects all face common problems: small-scale business entities, insufficient individual plot size, and high costs of scattered development. All regions adopt the implementation model of "platform overall coordination and integration, centralized large-scale development": in Yixing, the state-owned Yangxian Tourism Group coordinates and integrates tens of thousands of mu of scattered bamboo forest resources in its jurisdiction, and packages them into standardized carbon sink project units; in Gaochun, relying on village-level collective economic cooperatives to collect scattered farmers' farmland resources, unified management and centralized declaration are realized; in Lukou, the state-owned forest farm acts as the main body to integrate the scattered forest farmers' operation plots, so as to achieve large-scale operation and maintenance [7].

Aiming at the pain points of the seedling industry, such as the predominance of small individual growers, scattered nursery plots, and uneconomical independent development, we can rely on village collective economic organizations and specialized seedling cooperatives as the

unified entities for application and operation. These entities will centrally collect basic documents including farmers' land transfer contracts, annual seedling cultivation ledgers, and seedling out-of-nursery certificates, and uniformly carry out ownership verification, plot surveying and mapping, and document archiving, so as to integrate fragmented nursery resources into standardized carbon sink project units. Fixed costs in the early stage of the project, such as development, third-party verification, and platform operation and maintenance, are shared uniformly by the coordinating platform. This enables farmers to participate with zero upfront investment and zero technical threshold, fundamentally solving the uneconomical problem of scattered development of small and micro seedling carbon sinks.

3.2.2 Strictly screen land plot ownership and consolidate the data foundation

An empirical study in Lukou, Zhuzhou shows that for operation plots with clear property rights and no ownership disputes, farmers have a stronger willingness to participate in carbon trading, and the project operation enjoys higher stability. Therefore, during the collection stage of seedling carbon sink resources, it is necessary to strictly carry out compliance screening of land use, clearly distinguish between commercial nursery land and ecological public welfare forest land, and only include plots with complete property rights, clear ownership, no disputes and compliant operation into the project reserve pool. Meanwhile, an electronic dynamic ledger for plots should be established to systematically record core data such as seedling varieties, planting scale, tending management and annual out-of-nursery volume, so as to provide complete data support for subsequent carbon sink measurement, annual verification and traceability management.

3.2.3 Implement the household-based management and protection mode to diversify operational risks

Existing studies show that for individual farmers, independently operating carbon sink projects features high technical thresholds and high risk costs, leading to low willingness to participate [8]. In contrast, the mode of cooperative joint operation and group joint management and protection is more suitable for small and micro agricultural and forestry business entities. Drawing on the pilot experience, the seedling carbon sink project can implement the

division-of-labor operation mode of "unified development by cooperatives, household-based management and protection by farmers": cooperatives are in overall charge of professional work such as project application, technical docking, verification coordination, market trading and fund settlement; farmers are mainly responsible for basic management work including seedling tending, field management and daily plot maintenance. This mode features clear rights and responsibilities and diversified risks, effectively reduces the technical pressure and market risks of individual farmers, and significantly improves the participation enthusiasm of small and micro business entities and project stability.

3.3 Scenario Adaptation and Optimization of Lightweight MRV Monitoring Technology for Small and Micro Situations

The traditional CCER mechanism adopts a full-coverage forest inventory mode conducted once every five years, which features a long monitoring cycle and high labor and material costs, making it difficult to adapt to the operational characteristics of small and micro seedlings with short-cycle iteration and fragmented distribution. The lightweight MRV monitoring system innovatively constructed in the Yixing and Gaochun carbon inclusion pilots can effectively meet the operational needs of small and micro agricultural and forestry projects, and can be directly applied to the normalized, low-cost monitoring and accounting of seedling carbon sinks.

3.3.1 Sampling monitoring + remote sensing verification to replace full-coverage inventory

The traditional full-coverage manual census mode for forest carbon sinks is time-consuming, labor-intensive, costly and poorly operable, failing to meet the practical needs of long-term operation and maintenance of small and micro seedling projects. Both the Yixing Bamboo Forest Carbon Inclusion project and the Gaochun Agricultural Carbon Ticket project adopt the lightweight technical solution of "field sampling monitoring of sample plots + annual UAV remote sensing verification". Every year, representative nursery sample plots are selected for field biomass measurement, and UAV remote sensing technology is combined to accurately calculate the total plot area and vegetation coverage, replacing the traditional full-coverage manual inventory mode. This

monitoring method can greatly reduce operation and maintenance costs, adapt to the capital and technical conditions of small and micro seedling business entities, and ensure the authenticity, accuracy and traceability of carbon sink measurement data.

3.3.2 Annual dynamic accounting to match short-cycle iteration

Traditional forest carbon sinks carry out overall accounting in long cycles, which cannot adapt to the operation rhythm of seedlings with rapid iteration in 1-3 years and annual batch out-of-nursery. Drawing on the logic of annual net carbon sink accounting in Yixing bamboo forests, the seedling carbon sink can implement an independent annual accounting mechanism, calculate the total carbon sequestration of plots and the carbon loss from out-of-nursery seedlings year by year, account for the annual net carbon sink increment, and issue traceable carbon inclusion vouchers on an annual basis. Through dynamic and normalized annual right confirmation and trading, it accurately matches the operation law of the seedling industry with short cycles and high turnover, realizing the continuous appreciation and normalized monetization of small and micro seedling carbon sink assets.

3.4 Develop Diversified Market-Based Consumption Channels

Relying on the market operation experience of four major carbon inclusion pilots, and combining the current regional carbon inclusion trading scenarios and policy orientation, this paper constructs a five-in-one diversified consumption system for seedling carbon sinks, which integrates "enterprise agreement procurement, ecological restoration offset, zero-carbon activity deduction, government guaranteed procurement and green finance empowerment". This system effectively solves the practical problems of single trading channels and difficult monetization of seedling carbon sinks.

3.4.1 Long-term agreement procurement by local enterprises

Long-term agreement procurement by local enterprises is the most stable core consumption channel for seedling carbon sinks. Local manufacturing and cultural tourism enterprises in Yixing purchase bamboo forest carbon inclusion quotas on a long-term and stable basis for corporate carbon neutrality certification,

ESG information disclosure and low-carbon brand building, with the market transaction price stably maintained at 40-70 yuan per ton. Chemical enterprises in Gaochun, Nanjing purchase agricultural carbon vouchers through bulk bidding, forming a normalized and large-scale transaction pattern. For seedling carbon sinks, we can focus on connecting with local industrial parks, upstream and downstream production enterprises in the seedling industry, and cultural tourism service enterprises. Targeting their demands for carbon neutrality performance, low-carbon creation and ESG management, long-term designated procurement agreements can be signed to consolidate the basic market foundation for carbon sink transactions.

3.4.2 Incremental offset demand in rigid scenarios

Ecological damage alternative restoration and large-scale zero-carbon activity offset constitute the rigid and incremental trading scenarios for seedling carbon sinks. On the one hand, ecological and environmental protection policies in many regions clearly stipulate that the ecological damage caused by enterprises' production and operation can be compensated by purchasing local compliant agricultural and forestry carbon sinks to complete alternative restoration, without on-site rectification, forming a stable rigid trading demand. On the other hand, public scenarios such as urban cultural and sports events, industry exhibitions, zero-carbon campus and low-carbon institution creation all need to purchase local carbon sinks to complete the carbon neutrality offset of activities, which can provide continuous incremental market space for seedling carbon sinks.

3.4.3 Value-added empowerment channel via green finance

Pledge financing of carbon sink usufruct is an important way to revitalize small and micro agricultural and forestry ecological assets and realize value appreciation. Relying on the carbon sink usufruct, the Yixing carbon inclusion pilot has set up public welfare trusts and launched green credit, effectively activating the financial attributes of ecological assets. For seedling carbon sinks, we can actively connect with local financial institutions, use the verified carbon inclusion vouchers as pledges to apply for green low-interest credit products such as special seedling cultivation loans and base upgrading and reconstruction loans, alleviate the financing

difficulties and high financing costs of small and micro seedling business entities, extend the value chain of the seedling industry, and realize the capitalization of ecological assets.

3.4.4 Government public welfare guaranteed procurement

Targeted public welfare procurement by the government is an important fallback channel for carbon sinks from vulnerable plots and scattered seedlings. Guangdong Province has incorporated carbon sink forestry construction into the provincial financial support system for low-carbon development, guiding the development of the carbon sink industry through fiscal incentives. In the process of building zero-carbon villages and low-carbon towns in Nanjing, the government makes targeted procurement of local agricultural and forestry carbon sinks to ensure the income of small and micro entities. Government guaranteed procurement can effectively absorb scattered and small-scale seedling carbon sink resources, stabilize the income expectation of small and micro business entities, and improve the overall operational resilience of the project.

3.5 Construct a Long-Term Sustainable Mechanism for Seedling Carbon Inclusion

A scientific and reasonable income distribution mechanism and closed-loop operation mode are the key support to ensure the long-term implementation and continuous iterative upgrading of seedling carbon inclusion projects. Drawing on the mature operation experience of carbon sink projects in Yixing, Gaochun, Guangdong and other regions, a long-term operation system featuring income feedback, quality and efficiency improvement and virtuous cycle can be constructed.

3.5.1 Hierarchical income distribution, balancing livelihood and operation & maintenance

After deducting 10%-15% of the transaction revenue of the Yixing Bamboo Forest Carbon Inclusion project for compliance costs such as platform operation and maintenance and third-party verification, 70% of the revenue is directly distributed to farmers engaged in forest land management, and the remaining 30% is included in the special ecological tending trust fund for forest land quality improvement and long-term operation and maintenance. The Nanjing Gaochun Agricultural Carbon Voucher project adopts a homogeneous distribution logic, effectively balancing farmers' income growth

and the sustainable operation of the project. The seedling carbon sink can follow this hierarchical distribution mode. After deducting necessary costs such as verification and platform operation and maintenance, most of the revenue is accurately distributed to management farmers according to the output proportion of seedling carbon sinks to ensure the farmers' operational income growth. The remaining special funds are used for nursery soil improvement, high-carbon-sequestration seedling variety introduction, tending technology optimization and annual monitoring and operation, forming a closed-loop fund management system.

3.5.2 Realize the virtuous cycle of "carbon sequestration - monetization - quality improvement"

Guangdong's carbon sink forestry continuously improves the carbon density of forest lands through low-efficiency forest transformation and fine variety iteration. Relying on the feedback of carbon sink revenue, Zhuzhou Lukou continuously expands the afforestation scale and optimizes the operation mode, realizing the dual improvement of ecological and economic benefits. The seedling carbon sink project can rely on the revenue feedback mechanism to continuously introduce high-carbon-sequestration seedling varieties, optimize scientific tending schemes and improve nursery soil conditions, so as to enhance the carbon sink output capacity per unit plot year by year, achieve the dual growth of annual carbon sink increment and market transaction revenue, and build a virtuous cycle of sustainable development featuring "ecological carbon increment - market monetization - industrial quality improvement - continuous carbon increment".

4. Conclusion and Prospect

Based on the institutional framework of China's two-tier carbon market, this paper focuses on the core characteristics of the small and micro seedling industry, namely short cycle, fragmented plots and normalized carbon loss. Drawing on the practical experience of four major agricultural and forestry carbon inclusion pilots in Yixing (Jiangsu), Gaochun (Nanjing), Guangdong and Zhuzhou, it systematically constructs a complete path system for the market-oriented development of small and micro seedling carbon sinks. The research shows that the local carbon inclusion mechanism is the core

carrier to solve the poor market adaptability of seedling carbon sinks. Through five implementation paths including institutional adaptation, resource integration, technical burden reduction, market channel expansion and closed-loop operation, it can effectively resolve the institutional mismatch between the traditional CCER system and the seedling industry, and break through the key bottlenecks in realizing the value of small and micro seedling ecological products. At the institutional level, it is necessary to develop a dedicated carbon sink accounting methodology for seedlings and a local regulatory system, clarify the exclusive application rules for the two-tier carbon market, and consolidate the compliance foundation. At the resource level, cooperatives and state-owned platforms should be relied on to integrate fragmented nursery resources and lower the development threshold for small and micro entities. At the technical level, the lightweight MRV mode combining sampling monitoring and remote sensing verification should be implemented to adapt to the dynamic annual accounting demand of seedlings. At the market level, a multi-scenario and full-coverage carbon sink consumption system should be built to realize the stable monetization and financial value appreciation of carbon sinks. At the operation level, a hierarchical income distribution mechanism focusing on farmers' benefits and supplemented by industrial quality improvement should be established to realize the coordinated development of ecology and industry.

At present, the market-oriented construction of China's seedling carbon inclusion is still in the pilot exploration stage, and the relevant standard system and operation mechanism need to be continuously improved. In the future, it is feasible to further refine the carbon sink accounting parameters for different seedling categories, optimize the digital dynamic monitoring system, innovate financial products and trading modes for seedling carbon sinks, and continuously improve the market-oriented institutional system for small and micro seedling carbon inclusion. The research results can provide strong practical support for the low-carbon transformation of regional

agriculture and forestry industries, rural ecological revitalization, and the implementation of regional "Dual Carbon" goals.

This work was supported by the project ""Seedling Carbon Gold": Exploration on the Value Realization Path of Rural Ecological Products Based on Carbon Sink Trading" under the Southeast University Chengxian College College Students' Innovation and Entrepreneurship Project (Project Number: XCX2026115).

References

- [1] Li Nuyun. Forest Carbon Sinks in China. Beijing: China Forestry Publishing House, 2007.
- [2] Zeng Cailin. The Legal Attributes of Forest Carbon Sink Rights and Their Normative Improvement. *China Population, Resources and Environment*, 2024(7): 58-65.
- [3] Jing Zhen, Zhang Xin. Innovative Research on Legal Guarantees for China's Carbon Offset Mechanism under the "Dual Carbon" Goals. *Journal of Arid Land Resources and Environment*, 2024(4): 1-12.
- [4] Mu Yali, Guo Jianlong, Yang Hongqiang. Research Progress and Issues on Forestry CCER Based on Dual-Correlation Markets. *Resource Development and Market*, 2024(4): 503-510.
- [5] Chen Yong, Huang Xianning, Dong Chuqiu. Policy Status and Pathway Recommendations for CCER Forestry Carbon Sink Projects. *Anhui Forestry Science and Technology*, 2022, 48(4): 39-42.
- [6] Xue Chunquan, Yang Jiazhi. On the Construction of Carbon Sink Forestry in Guangdong. *Guangdong Forestry Science and Technology*, 2014, 30(1): 56-59.
- [7] Tao Yaling. Research on Willingness and Economic Benefits of Carbon Sink Forest Management in Lukou District, Zhuzhou City. Changsha: Central South University of Forestry and Technology, 2021.
- [8] Hong Minghui, Hu Chenpei, Gu Lei. Farmers' Willingness to Participate in Forest Management Carbon Sink Trading under the REDD+ Mechanism. *Journal of Zhejiang A&F University*, 2017, 34(2): 207-214.