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Original Research

Full-Chain Collaboration: Mechanism and Path Innovation for Value Realization of Soil and Water Conservation Ecological Products

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Abstract

The value realization of soil and water conservation ecological products is a core carrier of the Two Mountains Theory and a key path to convert ecological advantages into economic benefits. Currently, China faces whole-value chain disruptions due to fragmented cultivation and inconsistent accounting, while existing studies mostly focus on single links, lacking county-level micro-empirical research and multi-stakeholder interest coordination discussions. Based on life cycle theory, the Two Mountains theory, and collaborative governance theory, this paper constructs a five-link whole-chain framework (cultivation, accounting, trading, distribution, guarantee). Taking Malong District of Yunnan Province (a national soil and water conservation demonstration county) as the sample, it conducts an in-depth analysis combining its carbon sink trading practices and the 2026 integrated project of three small watersheds (106.95 km²). Results show that the framework can support the project's annual 488.41 million yuan ecological product value transformation. Addressing bottlenecks like poor link connection, this paper proposes an optimized path featuring five-link coordination, multi-agent participation, and all-dimensional guarantee, forming the replicable "Malong Experience". It provides a theoretical reference and practical paradigm for similar regions, facilitating the coordinated advancement of ecological civilization construction and rural revitalization.

Keywords: soil and water conservation, ecological products, value realization, whole-chain mechanism, Malong District

Introduction

China has explicitly proposed establishing and improving the value realization mechanism of ecological products, elevating it to the height of a national governance strategy. As a foundational project in ecological civilization construction, soil and water conservation generates ecological products with significant public goods attributes and positive externalities [1], serving as the core carrier for maintaining regional ecological security. The transformation of the value of soil and water conservation ecological products represents a major reform in the process of ecological civilization

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construction. It provides practical tools and material carriers for practicing the "Two Mountains" concept and opens up new paths for promoting the green development of soil and water conservation [2, 3].

However, the current value realization of soil and water conservation ecological products in China generally suffers from whole-chain fragmentation issues, including fragmented cultivation, insufficiently diverse path models [4], inconsistent accounting standards, transaction obstacles, unbalanced distribution, and inadequate guarantees [5]. These problems hinder the quantitative conversion of ecological benefits into economic gains, restricting the coordinated development of ecological protection and economic growth. Three research dimensions have been formed around the value realization of ecological products: theoretical foundations [6-8], accounting methods, and practical models [9-11]. In terms of theoretical expansion, recent studies have further explored the micro-mechanism of ecological value transformation from the perspectives of ESG framework, environmental regulation and green finance, providing new analytical paradigms for the market-oriented realization of ecological products [12, 13]; in terms of practical exploration, studies on small watershed management, agricultural carbon sink value realization and the digital empowerment of the ecological industry have provided multi-scenario empirical references for the whole-chain practice of ecological product value realization [14]. Nevertheless, three critical research gaps remain in the current academic field, which also constitute the core research questions addressed in this paper: (1) Most studies focus on single links of ecological product value realization, lacking systematic deconstruction and quantitative analysis of the "cultivation-accounting-transaction-distribution-guarantee" whole chain, and failing to clarify the linkage mechanism and collaborative logic between each link [15-17]; (2) Existing practical research is mostly oriented to macro policy interpretation, lacking micro-level empirical evidence and quantitative verification from county-level pilot areas, resulting in a serious disconnect between theoretical frameworks and on-site practical operations due to insufficient grassroots data support [18, 19]; (3) There is a lack of in-depth research on multi-stakeholder interest coordination mechanisms, which cannot effectively solve the core contradiction between the public goods attributes of soil and water conservation ecological products and market-oriented transactions, and fails to form a sustainable benefit distribution and collaborative governance model [20-22].

To address the above research questions, this paper sets the following core research purposes: (1) To construct a systematic whole-chain theoretical framework and accounting system for the value realization of soil and water conservation ecological products, and clarify the operational logic, theoretical support, and indicator system of the whole chain; (2) To take Malong District of Yunnan Province, a national soil and water conservation demonstration county, as the empirical sample, conduct an in-depth analysis of its practical foundation, current whole-chain operation status, and potential bottlenecks, and verify the applicability of the constructed theoretical framework; (3) To propose a targeted optimized path for whole-chain value realization, form a replicable and scalable practical paradigm, and provide theoretical reference and operable implementation schemes for similar regions to promote the value transformation of soil and water conservation ecological products.

This paper makes three key innovations compared with existing studies:

(1) Theoretical innovation: We pioneer a "five-link closed-loop" whole-chain theoretical framework for soil and water conservation ecological product value realization, with a three-dimensional coupled theoretical support system, filling the research gap of insufficient systematic whole-chain deconstruction.

(2) Empirical innovation: We conduct micro-empirical research based on a county-level pilot with both carbon sink trading practices and a complete whole-chain project design, bridging the theory-practice gap and supplementing scarce grass-roots empirical evidence in this field.

(3) Practical innovation: We propose an optimized whole-chain path and form the replicable "Malong Experience", with a full-process value chain accounting system. This provides an operable implementation paradigm for similar regions and addresses the core contradiction between ecological products' public attributes and market-oriented transactions.

As a national soil and water conservation demonstration county and a pilot county for integrated soil and water conservation projects in 2026, Malong District of Yunnan Province has taken the lead in completing the first and second batches of soil and water conservation carbon sink transactions in the province. It has accumulated practical experience in ecological product transactions, providing a vivid county-level sample for the monetization of ecological product value. The implementation plan for its 2026 integrated soil and water conservation project has been completed, covering three small watersheds (106.95 km^2). The plan systematically designs the whole-chain value realization path, offering a scarce sample combining "practical foundation + scheme design" for this research.

Materials and Methods

Core Connotation and Operational Logic of the Whole Chain

To coordinate ecological protection and value conversion, the whole chain for the value realization of soil and water conservation ecological products covers the five links – "cultivation-accounting-transaction-distribution-guarantee" – and forms a closed-loop

system of "ecological resources → ecological assets → ecological products → economic value" (see Fig. 1). Its core logic lies in "temporal connection + functional linkage": the cultivation link improves product supply through small watershed management and industrial integration, balancing ecological and economic attributes; the accounting link quantifies ecological benefits relying on the "physical quantity-functional quantity-value quantity" three-level model, building a bridge between supply and transaction; the transaction link balances public attributes and market efficiency through market-oriented platforms and government regulation, opening up monetization channels; the distribution link establishes a contribution-oriented sharing mechanism to realize benefit feedback; the guarantee link addresses connection bottlenecks through five major systems, maintaining sustainable operation. Each link forms a "forward-support–backward-feedback" linkage – for example, accounting results optimize cultivation schemes, and the fairness of distribution adjusts transaction pricing.

Theoretical Support System

Three theories form a three-dimensional coupled system of "logical support-value orientation-motivation guarantee". The Life Cycle Theory defines the temporal connection standards and linkage thresholds for each link, avoiding chain breakage and ensuring the efficiency of the entire process; the "Two Mountains" Theory clarifies the coordinated goal of ecology and economy, guiding the value orientation of each link to ensure the direction of green development; the Collaborative Governance Theory defines the power and responsibility lists of the government, market, village collectives, and farmers, constructing a collaborative promotion pattern to resolve interest conflicts.

Construction of the Whole-Chain Accounting System

Referring to the Accounting Methods for the Value of Soil and Water Conservation Ecological Products (Trial), an accounting system connecting the entire process is constructed.

Cultivation link: Conduct a survey of the baseline of ecological resources, establish a cultivation catalog list based on "small watershed + product type" [23], clarify product attributes, cultivation cycles, and technical standards, laying the foundation for accounting.

Accounting link: Adopt the "physical quantity-functional quantity-value quantity" three-level accounting model. For material supply products (e.g., characteristic agricultural products), the market value method is used; for regulatory service products (e.g., water conservation, carbon sinks), the replacement cost method is adopted, which is consistent with the mainstream accounting method for ecological regulatory service assets in frontier research [24]; for cultural service products (e.g., tourism and health preservation), the travel cost method is applied to ensure the accuracy of value quantification (see Table 1).

Transaction and distribution links: Taking accounting results as the core basis, determine the reference transaction price (e.g., the unit price of carbon sink transactions is based on carbon sink accounting results) and profit distribution ratio (e.g., the income of village collectives is not less than 15% of the total accounting value), realizing the implementation of quantitative results.

Guarantee link: Establish a "quarterly monitoring-annual accounting-dynamic update" mechanism, combining satellite remote sensing and ground monitoring station data to adjust accounting parameters in real time, supporting the dynamic optimization of the whole chain.

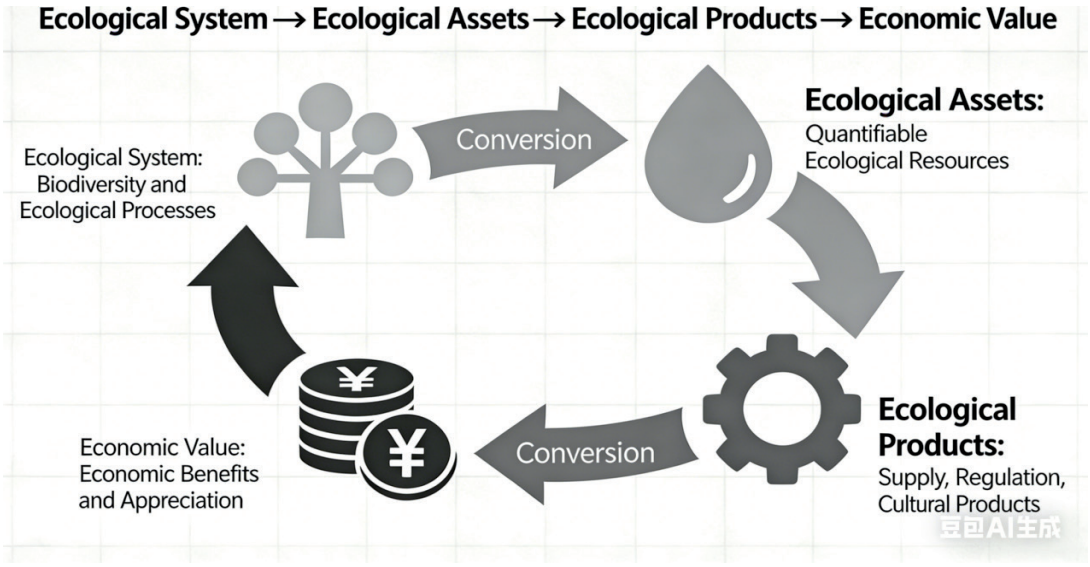

Fig. 1. Closed-loop system of the whole chain for the value realization of soil and water conservation ecological products.

Table 1. Three-level accounting model for soil and water conservation ecological products.

Accounting Level	Core Indicators	Accounting Methods	Applicable Product Types
Physical Quantity	Grain yield, forest coverage rate, carbon sink capacity, etc.	Field monitoring method, remote sensing inversion method	All types
Functional Quantity	Water conservation capacity, soil retention capacity, tourism reception volume, etc.	Equivalent method, supply-demand balance method	Regulatory services, cultural services
Value Quantity	Product market price, replacement cost, travel expenses, etc.	Market value method, replacement cost method, travel cost method	Material supply, regulatory services, cultural services

Study Area

The 2026 integrated soil and water conservation project in Malong District covers three small watersheds with a total area of 106.95 km², involving 23,000 households in 12 villages across three towns. Based on traditional soil erosion control, the project systematically arranges work in each link around the whole-chain value realization of soil and water conservation ecological products. It proposes nine ecological product cultivation catalogs, defines cultivation directions, models, and paths, completes the preliminary accounting of the baseline value (488.41 million yuan per year), clarifies profit distribution principles, and constructs five major guarantee systems. According to the project benefit prediction, after the implementation of the project, the soil and water conservation function level of the ecosystem in the project area will reach Grade B, realizing the transformation and transaction of two ecological products, directly generating economic benefits exceeding 14 million yuan, and increasing the per capita income of residents in the project area by 1,265 yuan.

The relevant practices and scheme designs of the whole chain are as follows:

Cultivation link: Adopt a three-dimensional cultivation model of "small watershed + characteristic industry + ecological function", and make precise layouts based on the differences in resource endowments of each small watershed. Relying on the water resource advantages of the Chemabi Reservoir, the Tianwanzi and Huangtupo small watersheds cultivate composite products of tourism and health preservation + flue-cured tobacco planting + water conservation, with supporting facilities such as popular science facilities, greening around villages, and non-point source pollution control. Focusing on plateau characteristic apple planting and carbon sinks, the Sege small watershed improves the supply capacity of ecological products through sloping farmland management, afforestation, and grass planting.

Accounting link: Strictly follow the accounting methods of the Ministry of Water Resources, refine 23 accounting indicators in combination with regional realities, plan to build an accounting system relying on remote sensing and ground monitoring networks, and formulate parameter standards with reference to the accounting experience of implemented carbon sink transactions.

Transaction link: Build a dual-platform trading system of "public resource trading platform + rural property rights trading center", and clarify the seven-step transaction process: "target determination-property right confirmation-value evaluation-information release-subject selection-agreement signing-certificate issuance".

Distribution link: Follow the principle of combining "who invests, who owns, who operates, who benefits" and "distribution according to contribution", clarify profit distribution rules, and plan to ensure farmers' income through land leasing, wage employment, and equity dividends.

Guarantee link: Organizationally, establish a three-level responsibility system of "district-level coordination-township implementation-village-level execution"; policy-wise, issue supporting documents such as the Measures for the Administration of the Value Realization of Soil and Water Conservation Ecological Products in Malong District; financially, integrate central and local fiscal funds and social capital; technically, cooperate with Yunnan Agricultural University and Yunnan Provincial Soil and Water Conservation Monitoring Station to carry out technological R&D and training; supervision-wise, construct a multi-dimensional supervision system of "government supervision + third-party evaluation + public participation".

Results and Discussion

Construction of an Optimized Path for Value Realization in Malong District from a Whole-Chain Perspective

Combined with the theoretical framework, practical experience, and the 2026 project implementation plan, focusing on potential bottlenecks in the plan and existing problems in practice, an optimized path of "five-link collaboration, multi-subject participation, and all-dimensional guarantee" is constructed. With the goals of "smooth connection, unified standards, market vitality, fair distribution, and systematic guarantee",

it not only optimizes the scheme design but also guides the subsequent project implementation. The specific measures are as follows.

Cultivation Link: Optimize the Precision Cultivation Mechanism and Consolidate the Supply Foundation

Refine the cultivation catalog: Combine the resource endowments of small watersheds to optimize the nine ecological product cultivation schemes, emphasizing "one village, one product, one region, one characteristic". Improve the quality of tourism and health preservation in Tianwanzi, strengthen the composite products of flue-cured tobacco and water conservation in Huangtupo, and expand apple planting and build deep-processing bases in Sege.

Strengthen ecological empowerment: Deeply integrate soil and water conservation projects with product cultivation. Equip sloping farmland management with ecological planting technologies (e.g., soil testing and formulated fertilization, green pest control); design forest and grass measures to balance ecological functions and landscape value (e.g., planting native landscape tree species); integrate Yi ethnic cultural elements into popular science facilities to enhance product added value.

Promote large-scale development: Integrate scattered land resources through land transfer and village collective coordination to promote the large-scale cultivation of ecological products, reducing the operating costs of subsequent links such as transaction and accounting. For example, establish apple planting cooperatives in the Sege small watershed to achieve unified varieties, unified management, and unified sales.

Accounting Link: Improve the Standardized Accounting System and Build a Quantitative Bridge

Unify accounting standards: Align with the national and local accounting norms for ecological product value, improve regional accounting rules, and clarify the definitions, calculation methods, and data sources of 23 indicators to ensure the comparability and applicability of accounting results.

Innovate accounting technologies: Introduce blockchain technology to realize the traceability of accounting data, use artificial intelligence models to optimize accounting parameters, and improve accounting efficiency and accuracy; establish a "quarterly monitoring-annual accounting-dynamic update" mechanism, conduct annual value revaluation, and support the dynamic adjustment of the whole chain.

Strengthen the application of results: Incorporate accounting results into government performance appraisal, ecological compensation, and project approval links, promoting the transformation of accounting results from "data" to "assets".

Transaction Link: Innovate Market-Oriented Trading Models and Smooth Monetization Channels

Improve trading platforms: Upgrade the ecological product trading section of the local public resource trading platform, add functions such as online display, online bidding, contract filing, and fund supervision to realize the digitalization of the entire transaction process; establish an inter-regional trading cooperation mechanism, connect with ecological product trading markets in surrounding cities such as Kunming and Qujing, and join the Yunnan Provincial Ecological Product Trading Alliance to expand the trading scope.

Enrich trading products: On the basis of existing carbon sinks, tourism and health preservation operation rights, and planting operation rights, develop new trading products such as water conservation income rights, ecological management and protection services, and soil and water conservation certified products. For example, package the water conservation functions of the three small watersheds and transfer the water conservation income rights to surrounding water-consuming enterprises.

Standardize trading processes: Refine the operational norms of each transaction link, clarify the time limits and requirements for links such as property right confirmation (issuance of property right certificates by natural resources departments), value evaluation (entrustment of third-party evaluation institutions), and information disclosure (publicity period of no less than 7 working days); establish a transaction risk prevention and control mechanism, conduct strict audits on the qualifications of transaction subjects and ecological protection responsibilities to ensure compliant and orderly transactions.

Distribution Link: Optimize the Fair Distribution Mechanism and Gather Collaborative Momentum

Optimize the distribution ratio: Adjust the profit distribution ratio based on the contribution of each subject, appropriately increasing the proportion of farmers' income; implement the "minimum guarantee income + value-added dividend" model, where the minimum guarantee income for farmers is not less than 1.2 times the local per capita disposable income, and the value-added dividend fluctuates according to the annual transaction income.

Expand distribution channels: Encourage farmers to invest in ecological product operation projects with land operation rights and labor to participate in profit sharing; prioritize the use of village collective income for setting up ecological management and protection positions, absorbing farmers to participate in the cultivation and management of ecological products, and increasing wage income; establish an ecological public welfare fund to support needy farmers and reward ecological protection.

Strengthen distribution supervision: Establish a profit distribution disclosure system, publicly disclose distribution details (including transaction amount, distribution ratio, and list of farmers' income) through village collective public notice boards, government official websites, and WeChat public accounts for a publicity period of no less than 15 working days; introduce third-party institutions to conduct supervision and auditing of the distribution process to ensure fair and impartial profit distribution.

Guarantee Link: Improve the Systematic Guarantee System and Maintain Sustainable Operation

Strengthen district-level special class coordination, establish an inter-departmental consultation mechanism, set up full-time positions in towns, and form management teams in villages; issue special management measures and improve certification and branding policies; innovate green financial products, develop ecological product income right pledge loans, carbon sink pledge financing, and green bonds to lower the threshold for social capital participation; establish a fund circulation mechanism, allocating no less than 20% of transaction income to the re-cultivation of ecological products, forming a virtuous cycle of "investment-income-reinvestment"; deepen industry-university-research cooperation and carry out whole-chain technical training; construct a multi-dimensional supervision system, strengthen special inspections and third-party evaluations, and smooth public participation channels.

Core Existing Problems

Poor connection between links: Data such as planting area, output, and input costs in the cultivation link are not synchronized to the accounting system in real time, resulting in delayed accounting data; the lack of a linkage mechanism means that accounting results do not inversely guide the optimization of cultivation schemes, and transaction pricing does not fully refer to distribution needs; insufficient inter-departmental collaboration and unbroken data barriers between water conservancy, agriculture and rural affairs, and culture and tourism departments lead to disjointed connection between cultivation and tourism product development.

Insufficient standardization of accounting: The refinement of regionally characteristic indicators (e.g., added value of plateau characteristic agricultural products) is inadequate, and the lack of mutual recognition of accounting standards with surrounding regions affects inter-regional transactions; the frequency of accounting data updates (annual updates) fails to reflect changes in ecological product value in real time, resulting in insufficient capacity to support dynamic optimization.

Insufficient vitality of the trading market: Low market awareness of ecological products leads to limited enthusiasm for demand-side participation; the types of trading products are relatively single (mainly carbon sinks and tourism and health preservation), and the development of new products lags; inter-regional trading channels have not been fully opened, resulting in a narrow market radiation range.

Inadequate guarantee system: The technical support for accounting and transaction links is relatively weak, and grass-roots units lack professional accounting personnel; the innovation of green financial products is insufficient, and the motivation for social capital participation is limited; public participation channels are not smooth enough, and the participation rate needs to be improved.

Optimization Countermeasures

(1) Strengthen link connection and improve whole-chain collaborative efficiency: establish a whole-chain data sharing platform to integrate data from cultivation, accounting, transaction, and distribution links, realizing real-time information sharing; construct a link linkage mechanism, where the cultivation link optimizes product supply according to accounting results, and the transaction link adjusts transaction schemes according to distribution needs, forming a collaborative pattern of "one link driving, multiple links linking"; conduct regular whole-chain review and evaluation to promptly identify and solve bottlenecks in link connection.

(2) Improve the accounting system and enhance the accuracy of value quantification: refine regionally characteristic accounting indicators, supplementing characteristic product accounting indicators in combination with Malong District's advantages in plateau characteristic agriculture and cultural tourism resources; promote the mutual recognition of accounting standards with surrounding regions and participate in the coordinated formulation of regional accounting standards to lay the foundation for inter-regional transactions; increase the frequency of accounting data updates, establishing a dynamic mechanism of quarterly monitoring and annual accounting to ensure real-time and accurate value data.

(3) Activate the trading market and broaden value monetization channels: strengthen the brand promotion of ecological products, promote Malong District's soil and water conservation ecological products through new media and exhibitions to improve market awareness; accelerate the development of new trading products, focusing on piloting transactions of water conservation income rights and ecological management and protection services; deepen inter-regional trading cooperation, establishing an ecological product trading cooperation alliance with cities such as Kunming and Qujing to expand the market radiation range.

(4) Improve the guarantee system and strengthen whole-chain support capacity: optimize the technical support system, form a whole-chain technical service team, and focus on strengthening technical guidance for accounting and transaction links; innovate green financial products, set up a risk compensation fund, and attract social capital participation; smooth public participation channels, establish an ecological product information disclosure system, and carry out ecological product experience activities to enhance public participation enthusiasm and initiative.

Conclusions

The value realization of soil and water conservation ecological products requires seamless collaboration across the five core links of "cultivation-accounting-transaction-distribution-guarantee", with the core goal of balancing ecological protection and high-quality economic development. This study constructs a "five-link closed-loop" whole-chain theoretical framework, revealing the three-dimensional coupling mechanism of the life cycle theory, the "Two Mountains" theory, and collaborative governance theory, which provides a systematic, holistic perspective for relevant research. Empirical analysis from Malong District shows that the 2024-2025 soil and water conservation carbon sink trading practices have verified the feasibility of the "accounting-transaction" collaborative mechanism in the framework; the whole-chain path designed for the 2026 integrated project can support an annual ecological product value transformation of 488.41 million yuan for the three small watersheds covered, and is expected to deliver dual ecological and economic benefits. The core replicable "Malong Experience" lies in the deep integration of practical operation and systematic scheme design, as well as precise product cultivation and standardized accounting system construction. The optimized path proposed in this study can improve the scientificity and operability of the project scheme, and provide a practical implementation paradigm for similar regions.

This study has several limitations to be addressed in future work. First, the empirical sample is limited to Malong District, a plateau mountainous county in southwest China, so the universality of the findings and the "Malong Experience" in regions with different geographical types, resource endowments, and development levels remains to be verified. Second, while we have built a whole-chain accounting system and completed baseline value accounting, sufficient quantitative empirical testing on the interaction mechanism and causal relationship between core variables of each link has not been carried out, leaving room for deeper quantitative research. In addition, the 2026 project is still in the preparation stage, so we cannot fully track and verify its long-term actual operation effects after completion, and the in-depth research on the interest game and participation willingness of multi-stakeholders is still insufficient.

In view of the above limitations and the development trend of this field, future research can be expanded in the following aspects. Multi-case comparative studies can be carried out in typical regions with different characteristics across China to verify and optimize the universality of the whole-chain framework and the "Malong Experience", and form differentiated implementation paths for different regions. Quantitative research can be deepened by introducing econometric and system dynamics models to test the interaction between core variables, and a long-term dynamic evaluation system for project implementation effects can be constructed. Meanwhile, future research can explore the application of digital technologies in the whole-chain management to improve the intelligent and refined management level, deepen the research on multi-stakeholder collaborative governance mechanism, and expand the research on innovative market-oriented trading models of ecological products to further broaden their value realization channels.

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Conflict of Interest

The authors declare no conflict of interest.

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