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Crediting the Ground Beneath: Agroforestry Soil Organic Carbon Sequestration, Article 6.4 Evaluation Metrics, and the Governance Gap for Global South NDC Implementation

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ABSTRACT

Agroforestry systems represent one of the most widely referenced land management practices in nationally determined contributions for soil organic carbon sequestration, yet their integration into international carbon crediting frameworks remains structurally incomplete. The operationalization of the Paris Agreement Crediting Mechanism under Article 6.4, which adopted five core methodological standards in 2025 covering baseline-setting, additionality, leakage, suppressed demand, and non-permanence and reversals, has created a critical juncture for evaluating whether agroforestry soil organic carbon projects can credibly generate tradeable emission reductions under internationally agreed metrics. This desk review critically examines that question through three analytical lenses: the technical adequacy of existing measurement, reporting, and verification protocols for agroforestry soil organic carbon; the degree of alignment between voluntary carbon market methodologies and the emerging Article 6.4 standards; and the implications of identified gaps for developing-country governments seeking to operationalize conditional nationally determined contribution commitments through carbon market participation. The paper introduces the concept of the Metric-Governance Alignment Gap to describe the structural disconnect between the technical measurement requirements of internationally agreed carbon crediting standards and the institutional and financial capacity of Global South agroforestry systems to satisfy them. The paper concludes that without deliberate governance redesign addressing this gap, Article 6.4 risks reinforcing existing inequities in carbon market access while failing to mobilize the agroforestry sequestration potential that more than 100 nationally determined contributions have formally identified.

Keywords:
agroforestry; soil organic carbon; Paris Agreement Crediting Mechanism; nationally determined contributions; Global South

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INTRODUCTION

Soil organic carbon stored in agroforestry systems constitutes one of the largest and most geographically distributed terrestrial carbon pools accessible to smallholder land management interventions in the Global South. Agroforestry systems in East Africa alone stock an average of 98.8 Mg C per hectare in the soil, with biomass contributions of a further 24.2 Mg C per hectare across homegardens, perennial tree-crop systems, and boundary planting configurations (Muthuri et al., 2023). At a global scale, increasing tree cover on agricultural land by 10% would sequester more than 18 PgC, with West and Central Africa and Southeast Asia representing the highest potential after South America (Zomer et al., 2022). A systematic review of 218 peer-reviewed studies published between 2000 and 2024 confirmed that agroforestry systems can sequester between 0.5 and 5 Mg C per hectare per year in biomass and soils across Africa, Asia, and Latin America, with substantial variation by system type, ecology, and management practice (Abbas et al., 2026). The biophysical potential is therefore not in dispute. What is in dispute, and what this paper addresses, is whether the international governance frameworks now being operationalized under Article 6.4 of the Paris Agreement are designed in ways that allow this potential to be credibly measured, credited, and financed.

The operationalization of Article 6.4, formally known as the Paris Agreement Crediting Mechanism, accelerated significantly in 2024 and 2025. The Article 6.4 Supervisory Body adopted two foundational standards in October 2024, covering methodology requirements and activities involving removals, and followed these in 2025 with five further standards governing baseline-setting, additionality, leakage, suppressed demand, and non-permanence and reversals (UNFCCC, 2024, 2025). The first approved Paris Agreement Crediting Mechanism methodology, for landfill gas flaring and utilization, was adopted in November 2025. Regenerative agriculture practices, including soil organic carbon enhancement and sustainable agricultural land management, are recognized as eligible activities under Article 6.4 but must await dedicated methodology approval by the Supervisory Body (Jain & Deshmukh, 2025). This methodology gap creates both an urgent research space and a governance design opportunity this paper directly addresses.

The urgency is compounded by the nationally determined contribution landscape. As of November 2024, 118 out of 176 countries, representing 67% of submitting parties, referenced soil carbon explicitly or soil carbon-related practices in their updated nationally determined contributions, with agroforestry and silvo-pastoralism ranking as the most frequently cited mitigation practice (CGIAR & CCAFS, 2021). Yet a systematic literature review found only 13 published papers between 2005 and 2024 examining agroforestry-based carbon credits, and none reported actual revenues from carbon credit transactions, relying entirely on modelled estimates of potential returns (Abbas et al., 2026). The gap between what countries have committed to in their nationally determined contributions and what the carbon market governance architecture is equipped to certify and finance represents the core governance problem this paper analyses.

LITERATURE REVIEW

Sequestration Evidence and Measurement Challenges

The scientific evidence base for soil organic carbon sequestration in agroforestry systems is now substantial, though characterized by significant spatial and methodological heterogeneity that has direct consequences for crediting governance. Muthuri et al. (2023) synthesized evidence from 185 publications on agroforestry in East Africa, confirming that homegardens, perennial tree-crop systems, and boundary planting configurations each deliver measurable soil carbon stocks, while simultaneously identifying a critical gap in empirical studies on belowground carbon and greenhouse gas emissions across different

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agroforestry practice types. Zomer et al. (2016) established that trees on agricultural land contributed over 75% of the estimated 45.3 PgC biomass carbon stored on agricultural land globally, a finding that underscores the systematic under accounting of agroforestry in both global carbon budgets and national carbon accounting frameworks. Zomer et al. (2022) refined this at the system level, confirming global carbon sequestration potential of 4 to 19 PgC from incremental and systemic increases in tree cover on agricultural land, with Sub-Saharan Africa and Southeast Asia as priority regions.

These biophysical findings share a common limitation that has direct consequences for carbon crediting. Sequestration rates and the processes contributing to the stabilization of soil organic carbon in agroforestry soils require additional data, retrospective studies are frequently absent, and long-term storage is finite because it depends on the availability of new organic inputs and protection from soil disturbance (Muthuri et al., 2023). Abebaw et al. (2025) confirmed these constraints persist across diverse agroforestry contexts in Sub-Saharan Africa, noting that inadequate policy frameworks, limited technical knowledge, and land tenure insecurity collectively constrain not only adoption but also the empirical documentation needed to establish credible carbon accounting. Dupla et al. (2024) demonstrated that this measurement uncertainty is not merely an academic concern but a direct source of MRV protocol unreliability, documenting large differences in predicted soil organic carbon changes across the ten publicly operational protocols and identifying questionable reliability in model-based approaches that omit key agricultural variables. The convergence of high sequestration potential with high measurement uncertainty defines the core technical challenge that Article 6.4 methodology development must address for agroforestry soil organic carbon systems.

MRV Protocol Fragmentation in Voluntary Carbon Markets

The voluntary carbon market infrastructure for soil organic carbon crediting is characterized by a proliferation of methodologies that differ substantially in their treatment of the four core crediting criteria: additionality, permanence, leakage, and baseline-setting. Batjes et al. (2024) identified a modular, multi-ecosystem MRV framework as necessary for consistent soil organic carbon stock change assessment across croplands, grasslands, and forestlands, noting that existing frameworks differ in tier level, geographic scope, monitoring requirements, and verification standards in ways that make cross-protocol comparisons and aggregated market assessments unreliable. Ihasusta et al. (2026) confirmed that practical implementation guidelines for choosing the most suitable monitoring approach for specific contexts and purposes remain incomplete across all major MRV frameworks, with the monitoring component identified as the main challenge in developing a unified operational system.

Among the major voluntary carbon market registries, Verra's Verified Carbon Standard and the Gold Standard represent the most widely adopted frameworks for land-use and agroforestry projects. Verra updated its VM0042 Improved Agricultural Land Management methodology to Version 2.1 in 2024, introducing clearer guidance on labelling Verified Carbon Units based on specific mitigation outcomes and refined calculations for carbon dioxide, methane, and nitrous oxide from agricultural activities (Verra, 2025). The Gold Standard Soil Organic Carbon Framework Methodology applies the IPCC Tier 2 stock change approach, mandating conservative crediting when modelled estimates diverge from measured baselines by more than 5% (Gold Standard, 2022). Isometric's Agroforestry Protocol v1.0, developed in 2024, represents the most agroforestry-specific MRV framework currently available, defining agroforestry as the intentional establishment or increase in woody cover integrated within agricultural landscapes

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providing additional net carbon storage against a counterfactual baseline, without causing net reduction of food and fiber production or negative biodiversity impacts (Isometric, 2024).

Despite this methodological diversity, Dupla et al. (2024) documented accounting inconsistencies across protocols in additionality, leakage, and permanence that are sufficiently large to generate materially different credit quantities from identical field conditions. Oldfield et al. (2022) reviewed 12 publicly available soil organic carbon MRV protocols from major registries and identified important differences in measurement and estimation of soil organic carbon and net greenhouse gas reductions, as well as key accounting issues relating to additionality and permanence, concluding that these differences pose a risk of non-equivalent credit creation that would undermine confidence in the integrity of crediting programs. Thornbush and Govind (2025) extended this analysis to dryland nations in the Global South, finding that currently there are some 102 MRV protocols spanning 16 carbon dioxide removal methods, with soil carbon sequestration in croplands and grasslands ranking second only to afforestation, reforestation, agroforestry, and forest management in terms of biological MRV coverage, though with persistent concerns about credibility, additionality, and permanence across the spectrum of available standards.

Raffeld et al. (2024) identified fixed-depth versus equivalent soil mass accounting methods and sampling depth requirements as two major sources of inconsistency across protocols, noting that most MRV protocols do not specify which accounting method to use and only require sampling to 30 cm depth, neglecting a significant portion of the soil profile's soil organic carbon stock. The World Bank (2021) identified hybrid MRV designs combining stratified sampling, modelling, and remote sensing as the most promising approach for addressing both affordability and quality concerns, but noted that implementation capacity for such designs is concentrated in well-resourced institutions in advanced economies, creating a structural disadvantage for smallholder agroforestry project developers in the Global South.

Soil Organic Carbon in NDC Commitments and the Finance Gap

The prominence of agroforestry and soil organic carbon in national climate commitments is well-established, though the translation from commitment to measurable outcome remains structurally incomplete across most developing-country contexts. Wiese et al. (2021) analyzed 184 nationally determined contributions and found that while agroforestry and silvo-pastoralism were listed as the most common mitigation practice, only 28 countries explicitly referenced soil organic carbon, peatlands, or wetlands, revealing a substantial gap between practice adoption and carbon accounting specificity. The updated CGIAR & CCAFS (2024) analysis of 2020 to 2024 nationally determined contribution submissions found improvement, with 118 of 176 countries referencing soil carbon or soil carbon-related practices, and agroforestry cited as a mitigation priority by 28% and an adaptation priority by 26% of submitting parties, but confirmed that the depth and specificity of commitments remained highly variable and most references were embedded in conditional rather than unconditional targets dependent on external finance.

Schiettecatte et al. (2025) examined how soils and their management practices are integrated into current nationally determined contributions and found that while some actions provide sufficient information to quantify climate change mitigation potential using IPCC Tier 1 default methodologies, few parties actually included the necessary data to operationalize these estimates, creating a gap between declared commitments and the quantified, verifiable targets that carbon markets require. Wiese-Rozanova (2022) reviewed nationally determined contribution commitments against Land Degradation Neutrality targets and biodiversity commitments under the Convention on Biological Diversity, finding that soil organic carbon commitments

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across the three Rio Conventions were not systematically integrated, limiting the potential for coordinated financing and governance of agroforestry restoration.

The finance dimension compounds the governance problem significantly. Hänke et al. (2026) identified transparency, accountability, and elite capture as key barriers to community benefit in carbon projects, while documenting that smallholder farmers in the Global South face structural disadvantages in accessing voluntary carbon markets due to high transaction costs, complex documentation requirements, and land tenure insecurity. Khurana et al. (2024) confirmed these dynamics in the South Asian context, noting that the generation and sale of carbon credits can be a tedious task for small and marginal farmers due to insufficient technical assistance and the administrative, legal, and technical costs incurred during participation in carbon markets. Vander Mayr et al. (2025) demonstrated that simplified enrolment, proportionate MRV requirements, and the pooling of smallholders are necessary to reduce transaction costs and increase adoption of ecosystem service payments among agroforestry farmers, a finding that has direct implications for how Article 6.4 methodology requirements should be calibrated for the smallholder context.

CONCEPTUAL FRAMEWORK

This paper introduces the Metric-Governance Alignment Gap as a conceptual framework for analyzing the structural disconnect between the technical measurement requirements of internationally agreed carbon crediting standards and the institutional and financial capacity of Global South agroforestry systems to satisfy them. The Metric-Governance Alignment Gap is a governance design concept rather than a technical deficit concept: it locates the problem not in the inability of agroforestry systems to sequester carbon, which the biophysical literature confirms they do at meaningful rates, but in the mismatch between the institutional architecture of carbon credit evaluation and the operational realities of smallholder agroforestry in developing-country contexts.

The Metric-Governance Alignment Gap operates across three structural dimensions that correspond to the three analytical sub-sections that follow. The first dimension is methodological adequacy. Article 6.4 standards for baseline-setting, additionality, leakage, and non-permanence were designed to address the integrity failures of the voluntary carbon market era and of the Clean Development Mechanism. However, these standards impose measurement, monitoring, and verification requirements that presuppose technical infrastructure, institutional capacity, and financial resources that are not uniformly available in Global South agroforestry contexts. The Metric-Governance Alignment Gap's methodological dimension asks whether the standards, as designed, are technically achievable for the agroforestry project types and geographies in which most nationally determined contribution-relevant sequestration potential exists.

The second dimension is protocol alignment. The voluntary carbon market landscape, dominated by Verra's Verified Carbon Standard, Gold Standard, the American Carbon Registry, and Climate Action Reserve, evolved in the absence of the internationally agreed metrics that Article 6.4 now establishes. Projects developed under voluntary protocols must demonstrate compatibility with Article 6.4 standards if their credits are to be used for nationally determined contribution accounting purposes. The Metric-Governance Alignment Gap's alignment dimension asks whether the existing voluntary protocol infrastructure for agroforestry soil organic carbon is sufficiently compatible with Article 6.4 requirements to support a credible transition, or whether a discontinuity exists that would require wholesale re-certification of existing projects and abandonment of accumulated crediting histories.

The third dimension is distributional access. The transaction costs of project development, validation, and verification under rigorous MRV protocols are disproportionately burdensome for smallholder agroforestry systems in the Global

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South. The Metric-Governance Alignment Gap's distributional dimension asks whether the Article 6.4 framework, as currently operationalized, reproduces or corrects the access inequities of the voluntary market era, and what this implies for countries in Sub-Saharan Africa and South Asia whose nationally determined contribution commitments are most heavily dependent on agroforestry soil organic carbon sequestration and most contingent on carbon market finance.

ANALYSIS

Article 6.4 Standards and Agroforestry Soil Organic Carbon Challenge

The Article 6.4 Supervisory Body's 2025 methodological standards represent the most comprehensive internationally agreed framework for carbon credit evaluation adopted under the Paris Agreement architecture. The five standards, covering baseline-setting, additionality, leakage, suppressed demand, and non-permanence and reversals, collectively establish the evidentiary requirements that any Paris Agreement Crediting Mechanism-registered project must satisfy (UNFCCC, 2024; UNFCCC, 2025). For agroforestry soil organic carbon projects, each standard generates specific technical demands that expose structural gaps between what the framework requires and what the evidence base and field capacity of Global South projects can currently provide.

On baseline-setting, the Article 6.4 standard requires projects to establish a credible counterfactual demonstrating what emissions would have occurred in the absence of the project activity. For agroforestry soil organic carbon, this requires temporally stable soil carbon stock data prior to project implementation, disaggregated by soil type, land use history, and management practice, across a representative sample of project area plots. The IPCC Tier 2 approach, which Gold Standard references and which Article 6.4 is expected to draw upon for land-use activities, requires region-specific stock change factors that are frequently unavailable for tropical and subtropical agroforestry contexts in Sub-Saharan Africa and South Asia (FAO, 2022; Gold Standard, 2022). Schiettecatte et al. (2025) found that few nationally determined contribution parties included the data necessary to quantify ex-ante soil organic carbon stock changes using even IPCC Tier 1 default methodologies, confirming that the baseline data infrastructure required by more demanding Article 6.4 standards is absent across most of the Global South countries that have committed to agroforestry-based soil organic carbon mitigation.

On additionality, the Article 6.4 standard requires demonstration that the project activity goes beyond business-as-usual and would not have been financially viable without carbon revenue. For smallholder agroforestry in the Global South, the additionality test creates a structural paradox. Agroforestry adoption in Sub-Saharan Africa and South Asia is documented to be constrained by economic, tenure, and information barriers that additionality standards interpret as evidence of financial non-viability and therefore as confirmation of additionality eligibility (Abbas et al., 2026; Kayusi et al., 2025). However, the same constraints that establish additionality also impede the documentation capacity required to demonstrate it: smallholder farmers lacking formal land tenure records, extension service access, and financial record-keeping infrastructure cannot easily produce the counterfactual evidence that rigorous additionality testing requires. Khurana et al. (2024) confirmed this dynamic in South Asia, identifying administrative and legal documentation costs as prohibitive barriers to smallholder carbon market participation precisely where additionality is most clear-cut.

On non-permanence and reversals, the Article 6.4 standard adopted in 2025 addresses what carbon accounting literature identifies as the most debated challenge in soil and land-use crediting (Carbon Gap Tracker, 2026). Soil carbon permanence is inherently uncertain over the timescales required for crediting: disturbance from tillage, drought, land tenure change, or armed conflict can release accumulated soil carbon rapidly, while the crediting period

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typically extends over decades. Zomer et al. (2023) documented the particular vulnerability of irrecoverable carbon in mountain agricultural systems to such disturbances, a concern that generalizes across tropical agroforestry systems in regions of climatic and political instability. Buffer pool contributions calibrated to project-specific reversal risk, as required under Article 6.4, translate into materially reduced commercially available credit volumes for smallholder-scale interventions in high-risk environments, potentially below the threshold of financial viability.

On leakage, the requirement that project activities not cause unaccounted emissions increases elsewhere poses particular challenges for agroforestry systems in land-scarce contexts where tree-crop integration on one plot can displace food production to adjacent degraded land or where wood harvesting from agroforestry systems accelerates pressure on adjacent natural forests. Dupla et al. (2024) documented that leakage is among the least consistently treated criteria across voluntary market protocols, with some frameworks applying standardized discount factors that do not reflect site-specific displacement dynamics, creating a known vulnerability that Article 6.4 baseline and leakage standards are designed to address but for which agroforestry-specific methodology guidance has not yet been approved.

Protocol Fragmentation and Transition Challenge

The transition from voluntary carbon market protocols to the Article 6.4 framework exposes a fragmentation problem that has accumulated over two decades of Clean Development Mechanism and voluntary market development. Thornbush and Govind (2025) identified 102 MRV protocols spanning 16 carbon dioxide removal methods, reflecting a landscape of competing standards developed without reference to any unified international framework. For agroforestry soil organic carbon projects developed under Verra VM0042, Gold Standard, or Isometric Agroforestry v1.0, the transition question is whether accumulated crediting histories, baseline datasets, and MRV infrastructure are transferable to the Paris Agreement Crediting Mechanism without re-crediting from inception, a question that the Supervisory Body has not yet answered for land-use removal activities.

The Clean Development Mechanism transition pathway provides limited precedent. At COP30 in November 2025, the Clean Development Mechanism was formally wound up with a 2026 end date, and USD 26.8 million from the Clean Development Mechanism Trust Fund was transferred to support Paris Agreement Crediting Mechanism operationalization (Prasanna et al., 2025). Active Clean Development Mechanism projects deemed eligible for transition continue operating under the Paris Agreement Crediting Mechanism but must eventually switch to Paris Agreement Crediting Mechanism methodologies. For agroforestry soil organic carbon projects, most of which were not developed under Clean Development Mechanism frameworks and therefore lack transition pathway clarity, the relationship to Article 6.4 methodology requirements remains unresolved. Kovács et al. (2025) confirmed that non-Clean Development Mechanism methodologies are subject to case-by-case assessment when proposed for Article 6.4 activities, introducing procedural uncertainty that discourages smallholder project aggregators from committing to the Paris Agreement Crediting Mechanism pathway.

Batjes et al. (2024) assessed the major voluntary market MRV approaches and found that while Gold Standard and the global soil organic carbon MRV approach share key characteristics in targeting the voluntary carbon market and applying multi-country, multi-tier approaches, they differ substantially in verification requirements and transparency standards in ways that complicate harmonization with the more stringent Article 6.4 framework. Oldfield et al. (2022) proposed a regionally consistent crediting framework that could establish consistent, transparent, and robust criteria for generating soil organic carbon credits, but this proposal has not

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been formally adopted by any major registry or by the Article 6.4 Supervisory Body, leaving protocol fragmentation unresolved. The consequence for Global South countries seeking to use agroforestry carbon credits toward nationally determined contribution targets is that the credits they are able to generate under current voluntary market standards may not be compatible with the corresponding adjustment requirements of Article 6.4, creating a risk of stranded crediting investment.

Only 10% of Article 6.4 project proposals involve carbon removals via afforestation, reforestation, and forestry management, with energy projects dominating the pipeline, confirming that land-use removal activities, including agroforestry soil organic carbon, remain at the periphery of the Paris Agreement Crediting Mechanism's operational focus (Leva & Vaughan, 2025). This concentration of Article 6.4 activity in energy sectors reflects in part the greater methodological clarity available for energy-based emission reductions compared to land-use removals, further disadvantaging agroforestry soil organic carbon project developers who require methodology approval before any Paris Agreement Crediting Mechanism registration can proceed. IUFRO (2024) confirmed at its 2024 World Congress that increased restoration of degraded forest ecosystems and sustainable land-use regimes are among the most important tools for protecting biodiversity and achieving the Sustainable Development Goals, yet the governance mechanisms connecting this restoration imperative to international carbon finance remain structurally incomplete.

Distributional Access and the Global South NDC Financing Gap

The distributional access dimension of the Metric-Governance Alignment Gap concerns the structural disadvantage that smallholder agroforestry project developers in the Global South face under carbon crediting frameworks whose verification costs, documentation requirements, and institutional prerequisites were calibrated to more resource-endowed project developers. Hänke et al. (2026) documented that implementing soil organic carbon credit programs for smallholder farmers remains challenging because working with many farmers on small individual parcels of land generates high transaction costs and low carbon revenue per farm, while voluntary carbon market transaction volume fell by 56% between 2022 and 2023, compressing the financial viability of high-cost smallholder aggregation models. Project set-up costs present substantial barriers to entry for which existing financing mechanisms provide inadequate coverage.

Xavier et al. (2026) confirmed that institutional and policy-related factors, including government structure, project methodology, MRV requirements, policy framing, extension services, and community-based intermediaries, are critical determinants of whether smallholder farmers perceive benefit-sharing mechanisms as fair and whether they participate in carbon credit projects. The absence of these institutional preconditions across much of Sub-Saharan Africa and South Asia means that even where biophysical sequestration potential is highest, the enabling environment for Article 6.4-compliant project development is weakest. Mayr et al. (2025) confirmed that pooling smallholders, simplifying enrolment, and applying proportionate MRV requirements are necessary conditions for scaling agroforestry carbon finance, but noted that voluntary carbon standard governance is predominantly expert-driven and top-down, with limited participation from farmers or local practitioners, and frequently fails to address local realities.

The nationally determined contribution finance architecture compounds this distributional problem. CGIAR & CCAFS (2024) documented that the majority of agroforestry and soil organic carbon mitigation commitments in developing-country nationally determined contributions are conditional on external finance, meaning they will not be implemented unless international climate finance flows materialize. Wiese et al. (2021) noted that the potential for soil organic carbon

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sequestration to reduce net annual greenhouse gas emissions from Agriculture, Forestry and Other Land Use by between 3% and 71% is substantially conditional on accurate accounting and monitoring infrastructure that is not uniformly available, creating a feedback loop in which the finance needed to build monitoring capacity is unavailable without the monitoring capacity needed to access finance.

CIFOR-ICRAF (2025) is addressing part of this infrastructure gap through spectral soil laboratory development in India, The Gambia, and Sri Lanka, and through the Soil Values ten-year program focusing on Integrated Soil Fertility Management. However, these investments in monitoring infrastructure remain disconnected from the formal Article 6.4 methodology approval process and do not yet translate into the standardized, internationally recognized measurement protocols that Paris Agreement Crediting Mechanism registration requires. Kayusi et al. (2025) confirmed that in Kenya, Tanzania, Uganda, and Zimbabwe, the promises of agroforestry as a climate-smart solution remain unfulfilled in significant part because institutional capacity-building, supportive policies, and innovative techniques need to be combined with organic matter management and social mobilization in ways that carbon market project developers operating under tight verification timelines and budget constraints are not designed to facilitate. Petrescu-Mag et al. (2024) further demonstrated that addressing the vulnerability of local people affected by land degradation requires governance frameworks that operate through a lens of transformative change rather than purely technical measurement, a principle that the current Article 6.4 architecture does not yet systematically embody.

DISCUSSION

The three analytical dimensions of the Metric-Governance Alignment Gap converge on a single governance design conclusion: the Article 6.4 framework, as currently operationalized, is not yet fit for purpose as a mechanism for mobilizing the agroforestry soil organic carbon sequestration potential that more than 100 nationally determined contributions have formally identified. This conclusion does not challenge the scientific validity of Article 6.4's integrity requirements, which represent a necessary and appropriate response to the documented failures of voluntary carbon market crediting. Rather, it challenges the assumption that a framework designed primarily to correct the integrity failures of the Clean Development Mechanism and voluntary market era is simultaneously well-suited to generating the inclusive, smallholder-accessible crediting infrastructure that Global South nationally determined contribution implementation requires.

The governance design gap has three practical implications. First, the absence of an approved Article 6.4 methodology for agroforestry soil organic carbon activities means that the largest and most geographically distributed land-use carbon pool referenced in developing-country nationally determined contributions remains entirely outside the Paris Agreement's formal carbon market architecture. Energy projects dominate the Article 6.4 pipeline while land-use removal activities, which are both more complex to certify and more relevant to Global South nationally determined contribution implementation, remain methodologically unresolved (Leva & Vaughan, 2025). This is not merely a sequencing issue; it reflects a structural prioritization that the Supervisory Body's future work program must explicitly correct.

Second, protocol fragmentation between voluntary market standards and the emerging Article 6.4 framework creates crediting risk for project developers who have invested in Verra VM0042, Gold Standard, or Isometric Agroforestry v1.0-based projects under the expectation that these credits would eventually be usable for nationally determined contribution accounting. Kovács et al. (2025) confirmed that non-Clean Development Mechanism methodology compatibility with Article 6.4 will be assessed on a case-by-case basis, introducing procedural uncertainty that is incompatible with

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the long-time horizons and upfront capital commitments that agroforestry carbon projects require.

Third, the distributional access problem requires explicit governance remedy rather than reliance on market mechanisms to self-correct. Hänke et al. (2026) and Mayr et al. (2025) both identify proportionate MRV requirements and smallholder pooling as essential design features for inclusive agroforestry carbon finance, yet neither the Article 6.4 standards package nor the mechanism's inaugural approved methodology reflects these design principles. The FAO (2022) Soil Organic Carbon technical manual and the World Bank (2021) MRV Sourcebook for Agricultural Landscapes both document approaches capable of addressing affordability and quality simultaneously through hybrid measurement designs, but these approaches require formal adoption into Article 6.4 methodology standards to become actionable at scale.

CONCLUSION

Agroforestry soil organic carbon sequestration occupies a paradoxical position in global climate governance: it is simultaneously among the most widely referenced mitigation practices in developing-country nationally determined contributions, among the most thoroughly documented in the biophysical literature, and among the least adequately served by the international carbon crediting architecture now being operationalized under Article 6.4. This paper has argued that the structural source of this paradox is the Metric-Governance Alignment Gap, the disconnect between what internationally agreed carbon crediting standards technically require and what Global South smallholder agroforestry systems can institutionally and financially deliver.

Three priorities emerge for governance redesign. The Article 6.4 Supervisory Body should prioritize the development and approval of agroforestry-specific soil organic carbon methodologies that incorporate proportionate MRV requirements calibrated to smallholder project scales and tropical ecosystem measurement challenges, drawing on the hybrid approaches documented in the World Bank (2021) and FAO (2022) sourcebooks and on the modular framework advanced by Batjes et al. (2024). Voluntary market registries should engage proactively with the Supervisory Body's case-by-case non-Clean Development Mechanism methodology assessment process to establish clear compatibility pathways for Verra VM0042, Gold Standard, and Isometric Agroforestry v1.0, reducing the crediting risk facing existing project developers. Developing-country governments should leverage the nationally determined contribution-conditional climate finance architecture to fund the baseline soil carbon data collection and monitoring infrastructure that Article 6.4 compliance requires, treating measurement infrastructure investment as a prerequisite for carbon market access rather than as a consequence of it.

The agroforestry soil organic carbon sequestration potential documented by Muthuri et al. (2023), Zomer et al. (2022), and Abbas et al. (2026) is real and large enough to matter for global climate targets. Whether it can be mobilized through the Article 6.4 mechanism depends on governance design choices that the Supervisory Body, voluntary market registries, and developing-country governments must make now, before the methodology pipeline solidifies around the energy and industrial project types that currently dominate the Paris Agreement Crediting Mechanism's operational focus. The ground beneath agroforestry systems holds carbon that internationally agreed climate commitments depend upon. The governance frameworks designed to credit it must be built to reach it.

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