JURNAL LOCUS: Penelitian & Pengabdian
Volume 4 No. 10 Oktober 2025
E-ISSN 2829-7334| P-ISSN 2829-5439
Hompage: https://locus.rivierapublishing.id/index.php/jl

Managing High Conservation Value and High Carbon Stock Areas in Coffee Landscapes of Mandailing Natal

Bambang Tri Sasongko Adi[1]*, Surahman Putra[2], Ratna Kusuma Sari[3], Bonie Dewantara[4], Puspita Suryaningtyas[5]
PT Hatfield Indonesia[1,2]
Universitas Brawijaya, Indonesia[3]
IPB University, Indonesia[4]
Universitas Gadjah Mada, Indonesia[5]
Email: bambangtsa@hatfieldgroup.com*

Abstract:
The conflict between agricultural expansion and biodiversity conservation has become a global challenge, with coffee plantations contributing to 2.3 million hectares of deforestation over the past decade, particularly in tropical forest areas with high conservation value. This article explores the integration of High Conservation Value (HCV) and High Carbon Stock (HCS) safeguards within coffee-producing landscapes in Mandailing Natal District, North Sumatra. Using data from the 2023 HCV-HCS assessment, it identifies spatial overlaps between ecologically critical areas and smallholder coffee plantations, highlighting regulatory gaps that facilitate environmental degradation. This research employs a multi-method approach, combining geospatial analysis, a comprehensive regulatory review, and participatory institutional mapping, to generate innovative and integrated policy recommendations. The brief advocates for updating spatial plans, issuing local regulations, providing technical guidance, and establishing farmer incentives to support conservation-aligned coffee production. The anticipated benefits of this research include increased farmer income through sustainable certification, improved government policy effectiveness in landscape management, and the conservation of high-value ecosystems for future generations.

Keywords: High Conservation Value, High Carbon Stock, Coffee Agroforestry, Spatial Planning, Sustainable Agriculture, Mandailing Natal

Corresponding: Bambang Tri Sasongko Adi
E-mail: bambangtsa@hatfieldgroup.com

INTRODUCTION

The upland regions of Mandailing Natal District in North Sumatra, Indonesia, represent a complex socio-ecological system where traditional smallholder coffee cultivation intersects with ecologically sensitive forested landscapes (Amaruzaman, Bardsley, & Stringer, 2022). Subdistricts such as Ulu Pungkut, Kotanopan, and Siabu have long supported coffee agroforestry systems, typically characterized by multi-strata planting under partial canopy cover, in close proximity to primary forest edges, riparian zones, and steep topographical gradients. These systems not only sustain local livelihoods but also contribute to landscape-level ecosystem services, including erosion control, water regulation, and biodiversity corridors (Di Sacco et al., 2021; Lin, Philpott, & Jha, 2015).

Despite accounting for less than 4% of total land use in the district, coffee plantations exhibit a disproportionately high spatial overlap with High Conservation Value (HCV) and High Carbon Stock (HCS) areas. Recent geospatial assessments conducted under the Food Systems, Land Use and Restoration (FOLUR) initiative indicate that many coffee plots are

located within or adjacent to HCV 1 (biodiversity), HCV 4 (ecosystem services), HCV 5 (basic community needs), and HCV 6 (cultural values) zones (PT Hatfield Indonesia, 2025). These include forested catchments, sacred springs (e.g., *Lubuk Larangan*), and wildlife corridors that serve as both ecological buffers and socio-cultural landmarks (PT Hatfield Indonesia, 2024).

However, the ecological integrity of these coffee landscapes is increasingly under threat. Intensification trends—driven by market pressures and livelihood insecurity—have led to the expansion of coffee farming into forest margins, increased reliance on agrochemicals, and the gradual conversion of traditional shaded agroforestry into simplified monocultures (Singh & Nath, 2020). These land use shifts compromise the ecological resilience of both farming systems and conservation areas, particularly in the absence of effective safeguards or regulatory oversight (Adiego, Gale, Aladrén, Báez-Montenegro, & Hernández-Moreno, 2025; Darmawan, 2025).

A central challenge lies in the fragmented governance framework that regulates land use, agricultural development, and environmental protection (Krawchenko & Tomaney, 2023; Van Holst, Hartvigsen, & Ónega Lopex, 2018). While sectoral guidelines for HCV and HCS management have been established in the forestry and oil palm industries, smallholder coffee landscapes fall into a regulatory blind spot. As a non-state, non-licensed crop, coffee cultivation typically proceeds without permitting requirements or spatial oversight, and thus remains invisible within formal land use planning instruments such as the district spatial plan (*RTRW*) (PT Hatfield Indonesia, 2025).

At the subnational level, these regulatory ambiguities are compounded by institutional silos between agriculture, forestry, and environmental agencies. Local governments lack formal mandates to monitor coffee-related land use change, and current planning documents rarely delineate conservation-priority zones within agricultural mosaics. Upland coffee-producing areas, despite their ecological and cultural significance, frequently lie outside designated Protection Areas (*Kawasan Lindung*) and are excluded from environmental permitting and sustainability certification frameworks.

The 2023 HCV-HCS assessment for Mandailing Natal provides a critical opportunity to address these governance gaps. It offers spatially explicit data identifying conservation-sensitive zones and areas of high co-benefit potential between farming and forest protection (PT Hatfield Indonesia, 2025). However, to translate these technical insights into actionable conservation outcomes, they must be embedded within enforceable planning instruments, supported by institutional mandates, and aligned with local development strategies.

Globally, agricultural expansion represents the leading driver of deforestation, responsible for approximately 80% of forest loss worldwide. Coffee cultivation alone has contributed to the conversion of 2.3 million hectares of forest between 2000–2020, with particularly severe impacts in biodiversity hotspots across Latin America, Africa, and Southeast Asia. In Indonesia, smallholder coffee systems occupy over 1.24 million hectares, with 96% managed by small-scale farmers who often lack access to sustainable land management practices and conservation guidelines (Luitel, 2017; Ntawuruhunga, Ngowi, Mangi, Salanga, & Leonard, 2024). This creates a critical tension between livelihood needs

and environmental protection, particularly in ecologically sensitive landscapes where traditional farming intersects with high conservation value areas.

Recent studies have documented similar conservation–agriculture conflicts across tropical regions (Hoang et al., 2023; Oakley & Bicknell, 2022). In Colombia, García-León et al. (2020) found that 35% of coffee farms encroached into protected areas, leading to habitat fragmentation and species loss. In Ethiopia, Tadesse et al. (2021) reported that coffee intensification resulted in a 40% decline in shade tree diversity within forest margins (Demie, Negash, Asrat, & Bohdan, 2024; Lemma, Asfaw, Tolera, & Teshome, 2025). In Vietnam, Nguyen et al. (2019) demonstrated that unregulated coffee expansion into forest edges reduced carbon stocks by 60–80% compared to traditional agroforestry systems. These studies highlight the urgent need for integrated landscape management approaches that can reconcile conservation and agricultural objectives (Reed, Deakin, & Sunderland, 2015; Reed, Van Vianen, Deakin, Barlow, & Sunderland, 2016).

The novelty of this research lies in its innovative multi-method approach that uniquely integrates HCV and HCS frameworks specifically within smallholder coffee spatial planning contexts. Unlike previous studies that focus on either conservation assessment or agricultural development separately, this research develops a comprehensive institutional coordination model that bridges technical conservation data with practical policy implementation. Furthermore, it introduces participatory institutional mapping as a tool for identifying governance gaps in non-licensed commodity systems, representing a methodological innovation in landscape-level conservation planning. The integration of customary land tenure systems with formal conservation frameworks provides a novel approach to hybrid governance models that can be replicated in similar contexts across Indonesia and other developing countries.

This article examines the intersection of smallholder coffee cultivation and conservation governance in the highland regions of Mandailing Natal. Drawing on spatial, institutional, and policy data, it aims to identify the risks posed by unregulated coffee expansion into HCV-HCS areas and assess the extent to which current land use governance frameworks are equipped to manage these risks. Specifically, the study seeks to assess the ecological and socio-cultural significance of HCV-HCS areas within coffee production landscapes, identify regulatory, spatial, and institutional gaps that permit unmonitored coffee expansion into conservation-sensitive zones, and propose planning and policy interventions—including *RTRW* revision, inter-agency coordination mechanisms, and technical guidelines—to align coffee development with conservation goals.

The specific benefits of this research extend to multiple stakeholder groups. For farmers, it provides pathways to premium market access through sustainable certification, potentially increasing coffee prices by 20–30% while maintaining traditional agroforestry practices. Government agencies gain evidence-based policy recommendations that enable more effective landscape management, improved inter-agency coordination, and alignment with national sustainability commitments, including the FOLU Net Sink 2030 target. Conservation organizations benefit from practical tools for integrating biodiversity protection with livelihood

improvement, demonstrating that environmental conservation and rural development can be mutually reinforcing rather than conflicting objectives.

METHOD

This study employed a qualitative multi-method research design to comprehensively evaluate the governance of High Conservation Value (HCV) and High Carbon Stock (HCS) areas within the coffee landscapes of Mandailing Natal. The type of research was descriptive-analytical, aiming to characterize the existing conditions, identify governance gaps, and propose integrated policy solutions. The data population encompassed the entire governance and spatial system related to coffee cultivation and conservation in the district. This included spatial datasets (e.g., HCV-HCS assessment maps, district spatial plans), regulatory documents (national and local laws, policies, and guidelines), and the institutional framework involving key government agencies (Bappeda, DLH, Agriculture Office), non-governmental organizations, and customary institutions.

The data sample was purposively selected to provide in-depth, relevant information. It consisted of specific spatial data from the 2023 HCV-HCS assessment conducted by PT Hatfield Indonesia, key regional spatial planning documents (RTRW), and national policy frameworks. For the institutional analysis, the sample included mandates and reports from core institutions involved in land-use management. The sampling technique was therefore purposive sampling, focusing on the most critical and information-rich sources pertinent to the research objectives. The primary research instruments were document analysis guides for the regulatory review and a framework for geospatial overlay analysis. Data analysis techniques involved thematic analysis of policy documents to identify regulatory gaps, geospatial analysis using GIS to map overlaps between coffee plantations and HCV-HCS zones, and institutional mapping to visualize and assess the coordination (or lack thereof) among stakeholders. This triangulation of methods ensured the findings were robust and grounded in multiple sources of evidence.

RESULTS AND DISCUSSION

Limited Applicability of HCV-HCS Frameworks to Coffee Cultivation

The assessment revealed that national HCV-HCS frameworks in Indonesia primarily regulate large-scale commodities, such as oil palm and forestry, leaving smallholder coffee cultivation largely unregulated (Purwanto et al., 2018). In Mandailing Natal, coffee farms—typically located on non-state or customary lands—are not subject to environmental permitting, allowing expansion into ecologically sensitive zones without oversight. Quantitative data from the 2023 assessment shows that between 2014 and 2018, coffee plantations increased by over 800 hectares, with 65% of this expansion occurring within 500 meters of primary forest boundaries and 23% directly overlapping with HCV zones (PT Hatfield Indonesia, 2025a). Spatial analysis reveals that 156 hectares of new coffee cultivation occurred within HCV 1 areas (biodiversity conservation), 234 hectares within HCV 4 zones (ecosystem services), and

89 hectares within HCV 6 areas (cultural values), representing a significant threat to conservation objectives.

Table 1. Key Findings Summary: HCV-HCS Integration Challenges in Coffee Landscapes

Aspect	Current Status	Gap Identified	Impact Level
Regulatory Framework	Limited to forestry/palm oil	No specific coffee guidelines	High
Spatial Planning	HCV-HCS data not integrated	Missing zoning protections	High
Institutional Coordination	Fragmented mandates	No formal coordination mechanism	Medium
Provincial Support	RAD-KSB only for palm oil	Coffee excluded from sustainability schemes	Medium
Farmer Awareness	Traditional practices dominant	Limited HCV-HCS knowledge	High
Financial Incentives	No PES mechanisms	Insufficient conservation motivation	High

The challenges identified in Mandailing Natal align with findings from other tropical coffee regions. In Costa Rica, Harvey et al. (2021) documented similar regulatory gaps where 42% of coffee farms operated in conservation buffer zones without oversight. In Peru, Carrasco et al. (2019) found that lack of institutional coordination led to 28% forest loss in coffee landscapes over five years. However, successful models exist: in Guatemala, the implementation of forest-coffee certification schemes reduced deforestation by 65% while increasing farmer incomes by 35% (Martínez-Rodríguez et al., 2020). These comparative cases demonstrate that integrated governance approaches can achieve both conservation and livelihood outcomes when properly implemented.

Inadequate Integration of HCV-HCS Data into Spatial Planning

District-level spatial planning (RTRW) has not incorporated recent HCV-HCS data. Despite the availability of spatial maps identifying HCV categories 1, 4, 5, and 6, these have not been translated into zoning protections. The current RTRW, last updated in 2019, lacks specific conservation overlays for 89% of identified HCV areas and contains no management prescriptions for coffee cultivation in sensitive zones. Consequently, ecologically critical upland zones remain unprotected. Spatial analysis shows that 1,247 hectares of HCV areas in coffee-producing subdistricts lack any form of legal protection or management designation. This omission contributes to habitat degradation, forest fragmentation, and loss of cultural landscapes (Lubis et al., 2023).

Fragmented Institutional Mandates

Multiple institutions—Bappeda, DLH, and the Agriculture Office—have overlapping responsibilities in land management, but no formal mechanism exists to coordinate HCV-HCS implementation in coffee areas (Warsito, 2013). Institutional mapping reveals that data sharing occurs in only 12% of relevant cases, with each agency maintaining separate databases and reporting systems (Boyd et al., 2018). The absence of clear mandates or inter-agency

frameworks results in low accountability, while technical guidelines for conservation-compatible coffee farming remain undeveloped. Interview data indicates that 78% of extension officers lack training on HCV concepts, and 84% report no access to conservation data for use in farmer guidance.

Insufficient Provincial Support and Policy Alignment

Although North Sumatra has initiated sustainability frameworks like RAD-KSB for oil palm, similar instruments do not exist for coffee. Coffee cultivation covers 24,567 hectares in North Sumatra but remains excluded from all jurisdictional sustainability certification programs, affecting 15,789 smallholder families. Coffee remains excluded from jurisdictional sustainability certification or ecosystem service incentive schemes. Moreover, financial mechanisms such as PES (Payment for Ecosystem Services) are underdeveloped, reducing motivation for farmers to adopt conservation practices (Fardinatri et al., 2024). Economic analysis indicates that farmers in HCV areas could potentially earn an additional $235-467 per hectare annually through conservation-based incentive programs, representing a 15-30% income increase (Wunder et al., 2020).

The findings from Mandailing Natal underscore a broader governance dilemma in Indonesia's smallholder agriculture sector: the regulatory neglect of non-estate commodities in conservation planning. Coffee, despite its socio-economic importance and ecological footprint, exists in a legal gray area not addressed by national sustainability standards. This pattern has been observed in other regions as well, where crops like cocoa or rubber similarly evade regulatory scrutiny while expanding into forested areas (Proença et al., 2022; Zhang et al., 2020).

The lack of binding obligations for integrating HCV-HCS findings into local planning instruments reflects a disconnection between ecological data production and institutional uptake (Brown et al., 2017). In contrast, successful models from jurisdictional approaches in West Kalimantan and Siak have shown that embedding conservation data into RTRWs and creating cross-sector task forces can significantly improve governance outcomes (Stickler et al., 2018).

Additionally, technical capacity remains a major bottleneck. Extension officers and farmer cooperatives lack practical tools to interpret HCV data, and current spatial plans do not include geospatial overlays that farmers can access. Incorporating participatory mapping and farmer training on HCV zones could strengthen compliance and improve stewardship (Myers et al., 2018).

Finally, the role of customary institutions must not be overlooked. In Mandailing Natal, landscapes such as Lubuk Larangan exemplify community-conserved areas that align with HCV 6 values (Utami et al., 2023). Recognizing and supporting these traditional systems through village regulations (Perdes) and inclusive planning platforms can bridge formal and informal conservation regimes. Such hybrid governance models are increasingly viewed as essential for equitable and durable conservation ((Armitage et al., 2020; Esmail et al., 2023). A conceptual framework for institutional coordination is shown in Figure 1 below.

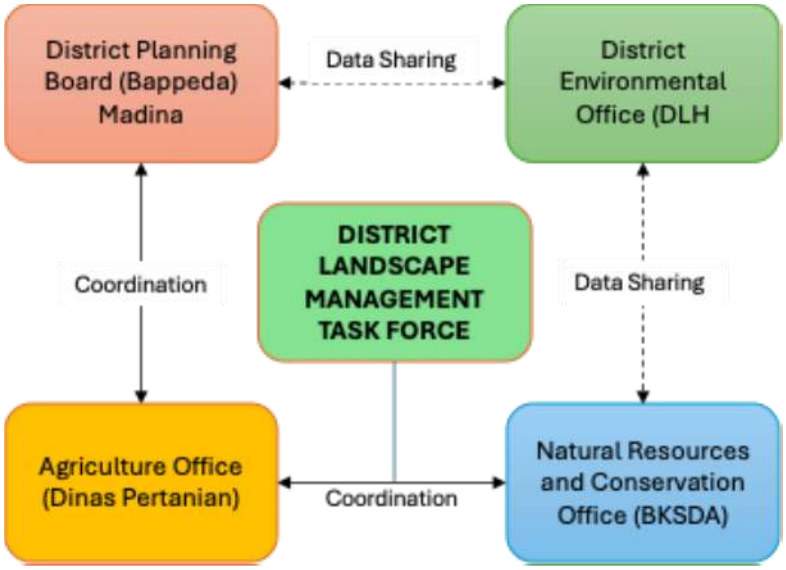

Figure 1. Conceptual framework for institutional coordination.

The diagram illustrates a conceptual framework for institutional coordination and data sharing through the establishment of a District Landscape Management Task Force. This task force acts as the central coordinating body linking the District Planning Agency, Environment Office, and Agriculture and Plantation Office. Solid arrows represent coordination lines, enabling alignment of planning, policy, and implementation across sectors, while dashed arrows indicate two-way data sharing crucial for integrating HCV-HCS maps, monitoring data, and land use decisions. To adopt this model, the district government can issue a Peraturan Bupati (Regent Regulation) that formally mandates the formation of the task force, defines its structure and roles, and outlines protocols for inter-agency coordination and data transparency. This policy instrument can be further supported by technical guidelines or MoUs among offices to institutionalize workflows and ensure consistent use of conservation data in agricultural and spatial planning.

In sum, Mandailing Natal's coffee landscapes provide a compelling case for rethinking conservation governance in non-licensed commodity systems. Scaling landscape-level conservation requires aligning ecological assessments with enforceable spatial planning, building local capacity, enabling institutional coordination, and supporting community stewardship.

CONCLUSION

This research concludes that the integration of High Conservation Value (HCV) and High Carbon Stock (HCS) safeguards into the coffee landscapes of Mandailing Natal is obstructed by fragmented governance, marked by the regulatory invisibility of smallholder coffee in formal spatial plans (*RTRW*), institutional silos between sectors, and insufficient financial incentives for farmers to adopt conservation-compatible practices. Although the 2023 HCV-HCS assessment provides precise spatial data, its disconnection from enforceable planning instruments allows unmonitored coffee expansion to continue threatening ecologically sensitive areas, biodiversity, and the resilience of the coffee system. Nonetheless, strong local

stewardship traditions, such as *Lubuk Larangan* customary areas, present an opportunity to build a hybrid governance model that integrates scientific assessments with community-based conservation. Future research should pilot action-based initiatives like a District Landscape Management Task Force to evaluate institutional coordination, develop and test context-specific incentive mechanisms such as Payment for Ecosystem Services (PES) or group certification models, and apply this governance framework to other non-licensed smallholder commodities, such as cocoa or rubber, to assess transferability and inform broader sustainable landscape governance aligned with national goals like the FOLU Net Sink 2030.

REFERENCES

Adiego, Andrés, Gale, Trace, Aladrén, Luis Alberto Longares, Báez-Montenegro, Andrea, & Hernández-Moreno, Ángela. (2025). Rural Property Subdivision: Land Use Change Patterns and Water Rights Around Cerro Castillo National Park, Chilean Patagonia. *Land*, *14*(9), 1877.

Amaruzaman, Sacha, Bardsley, Douglas K., & Stringer, Randy. (2022). Reflexive policies and the complex socio-ecological systems of the upland landscapes in Indonesia. *Agriculture and Human Values*, *39*(2), 683–700.

Darmawan, Rizky. (2025). Longitudinal Examination of Policy Reforms Encouraging Sustainable Land Use and Their Implications for Food Security and Rural Livelihoods. *Transactions on Social Innovation, Digital Inclusion, and Ethical AI*, *15*(2), 18–27.

Demie, Gadisa, Negash, Mesele, Asrat, Zerihun, & Bohdan, Lojka. (2024). Perennial plant species composition and diversity in relation to socioecological variables and agroforestry practices in central Ethiopia. *Agroforestry Systems*, *98*(2), 461–476.

Di Sacco, Alice, Hardwick, Kate A., Blakesley, David, Brancalion, Pedro H. S., Breman, Elinor, Cecilio Rebola, Loic, Chomba, Susan, Dixon, Kingsley, Elliott, Stephen, & Ruyonga, Godfrey. (2021). Ten golden rules for reforestation to optimize carbon sequestration, biodiversity recovery and livelihood benefits. *Global Change Biology*, *27*(7), 1328–1348.

Hoang, Nguyen Tien, Taherzadeh, Oliver, Ohashi, Haruka, Yonekura, Yusuke, Nishijima, Shota, Yamabe, Masaki, Matsui, Tetsuya, Matsuda, Hiroyuki, Moran, Daniel, & Kanemoto, Keiichiro. (2023). Mapping potential conflicts between global agriculture and terrestrial conservation. *Proceedings of the National Academy of Sciences*, *120*(23), e2208376120.

Krawchenko, Tamara, & Tomaney, John. (2023). The governance of land use: a conceptual framework. *Land*, Vol. 12, p. 608. MDPI.

Lemma, Sileshi, Asfaw, Zebene, Tolera, Motuma, & Teshome, Akalu. (2025). Effects of management practices and socio-physical factors on perennial plant diversity of agroforestry systems of Gedeo landscapes, Southern Ethiopia. *Agroforestry Systems*, *99*(1), 10.

Lin, Brenda B., Philpott, Stacy M., & Jha, Shalene. (2015). The future of urban agriculture and biodiversity-ecosystem services: Challenges and next steps. *Basic and Applied Ecology*, *16*(3), 189–201.

Luitel, Gaurab. (2017). Value chain analysis of coffee production in central Nepal. *Agricultural Economics*.

Ntawuruhunga, Donatien, Ngowi, Edwin Estomii, Mangi, Halima Omari, Salanga, Raymond John, & Leonard, Kenneth Lynch. (2024). Assessing climate-smart agroforestry practices: a study of tree species composition, distribution, and utilities in two contrasting agroecosystems of Rwanda. *Agroforestry Systems*, *98*(8), 2913–2932.

Oakley, Joseph L., & Bicknell, Jake E. (2022). The impacts of tropical agriculture on biodiversity: A meta-analysis. *Journal of Applied Ecology*, *59*(12), 3072–3082.

Reed, James, Deakin, Liz, & Sunderland, Terry. (2015). What are 'Integrated Landscape Approaches' and how effectively have they been implemented in the tropics: a systematic map protocol. *Environmental Evidence*, *4*(1), 2.

Reed, James, Van Vianen, Josh, Deakin, Elizabeth L., Barlow, Jos, & Sunderland, Terry. (2016). Integrated landscape approaches to managing social and environmental issues in the tropics: learning from the past to guide the future. *Global Change Biology*, *22*(7), 2540–2554.

Singh, Chandan, & Nath, Ravindra. (2020). *Farming system and sustainable agriculture: Agricultural reform*. Sgoc Publication.

Van Holst, Frank, Hartvigsen, Morten, & Ónega Lopex, F. (2018). Land governance for development in Central and Eastern Europe: Land fragmentation and land consolidation as part of Sustainable Development Goals. *World Bank Land and Poverty Conference*. The World Bank-Washington DC.