
Integrating Scenario-based Policy Tools for Sustainable Commodity Landscapes: A Case Study of Oil Palm and Arabica Coffee in North Sumatra, Indonesia

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Abstract

This article explores the integration of Targeted Scenario Analysis (TSA) into policy-making for sustainable commodity landscapes, focusing on oil palm and Arabica coffee in Man ailing Natal, North Sumatra, Indonesia. Using a mixed-methods approach that combined scenario modeling, stakeholder interviews, and institutional analysis, we compare outcomes under Business-As-Usual (BAU) and Sustainable Ecosystem Management (SEM) pathways. The SEM scenario revealed significant ecological and economic benefits, including reduced deforestation, improved farmer incomes, and better biodiversity outcomes. However, we also identify institutional fragmentation, symbolic stakeholder participation, and knowledge asymmetries that limit TSA's transformative potential. The study argues that TSA can be a powerful tool for sustainability transitions when embedded in reflexive, participatory, and coordinated governance frameworks. Policy recommendations include embedding TSA into spatial planning cycles, strengthening local capacity, and enhancing participatory scenario co-production to align with Indonesia's Forest and Other Land Use (FOLU) Net Sink 2030 targets.

Keywords: Targeted Scenario Analysis, sustainability policy, landscape governance, stakeholder engagement, sustainable agriculture, North Sumatra, institutional mapping.

1. Introduction

The province of North Sumatra in Indonesia represents a complex socio-ecological frontier where the imperative for agricultural development intersects with the challenges of environmental sustainability. With fertile landscapes and a population heavily reliant on smallholder farming, the region is a critical node in Indonesia's production of high-value commodities, particularly oil palm (*Elaeis guineensis*) and arabica coffee (*Coffea arabica*). However, unregulated expansion and weak governance have contributed to deforestation, biodiversity loss, and marginal socioeconomic gains for rural producers. These issues underscore the urgency of reimagining commodity-driven land use within a framework that simultaneously promotes ecological integrity and rural prosperity.

To address this multidimensional challenge, the Government of Indonesia, with support from the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), and the Food and Agriculture Organization (FAO), has introduced the Targeted Scenario Analysis (TSA) as part of the broader Food System, Land Use, and Restoration (FOLUR) Project. TSA is an economic policy tool designed to evaluate alternative development pathways by comparing the outcomes of business-as-usual (BAU) approaches against those of Sustainable Ecosystem Management (SEM) scenarios (Alpizar & Bovarnick, 2013). In doing so, it integrates ecological, economic, and social indicators to inform evidence-based decision-making and facilitate strategic planning for sustainable commodity governance.

This article presents the results of a TSA conducted in North Sumatra, with a specific focus on Mandailing Natal District. The district was selected due to its dual significance as a production center for oil palm and arabica coffee and its proximity to ecologically sensitive areas, including Batang Gadis National Park and zones designated as High Conservation Value (HCV). The TSA evaluates two contrasting scenarios: a BAU trajectory marked by unsustainable land use and minimal regulatory oversight, and a SEM pathway that advocates for regulated expansion, adoption of agroecological practices, and integration of landscape-level conservation planning.

The objectives of this study are threefold: (1) to quantify the long-term trade-offs between BAU and SEM approaches in terms of productivity, environmental degradation, and rural livelihoods; (2) to support provincial and district governments in integrating TSA findings into spatial and sectoral planning processes; and (3) to catalyze multi-stakeholder engagement by articulating a shared vision for sustainable landscape governance. Drawing on field data, spatial analysis, and stakeholder consultations, this study contributes to the growing body of research that positions integrated landscape approaches as a viable solution for reconciling development and conservation goals in tropical commodity frontiers.

This study also contributes to the expanding global literature on integrated landscape governance and scenario-based planning tools. Previous applications of similar tools have been documented in Latin America (Pereira, 2021), Sub-Saharan Africa (Sales et al., 2017; Zurek & Henrichs, 2007), and Southeast Asia (van Noordwijk et al., 2014), illustrating the adaptability of scenario

analysis to diverse policy environments. However, empirical studies that embed TSA into real-world governance cycles remain limited, particularly in decentralized contexts such as Indonesia. Our work thus seeks to address this gap by combining technical projections with institutional diagnostics and policy implications.

2. Study Area and Context

2.1 Geographic and Ecological Overview

North Sumatra Province (see Figure 1), encompassing approximately 72,981 km², is one of Indonesia’s largest and most ecologically diverse regions. Its landscape features a mosaic of lowland peatlands, fertile valleys, and montane rainforests, extending from coastal plains along the Malacca Strait to the rugged Bukit Barisan mountain range. This variation in topography and climate creates distinct agro-ecological zones suitable for a range of crops, with oil palm thriving in lowland areas and arabica coffee cultivated in cooler highlands.

The province holds strategic significance in national agricultural production, particularly for oil palm, which accounts for over 1.35 million hectares, and arabica coffee, occupying around 31,000 hectares (BPS, 2024b). However, this productivity has come at a cost. Decades of unchecked expansion—especially in forest frontier areas—have resulted in significant land cover change, biodiversity loss, and carbon emissions, thereby undermining long-term ecological resilience (PT Hatfield Indonesia, 2025a).

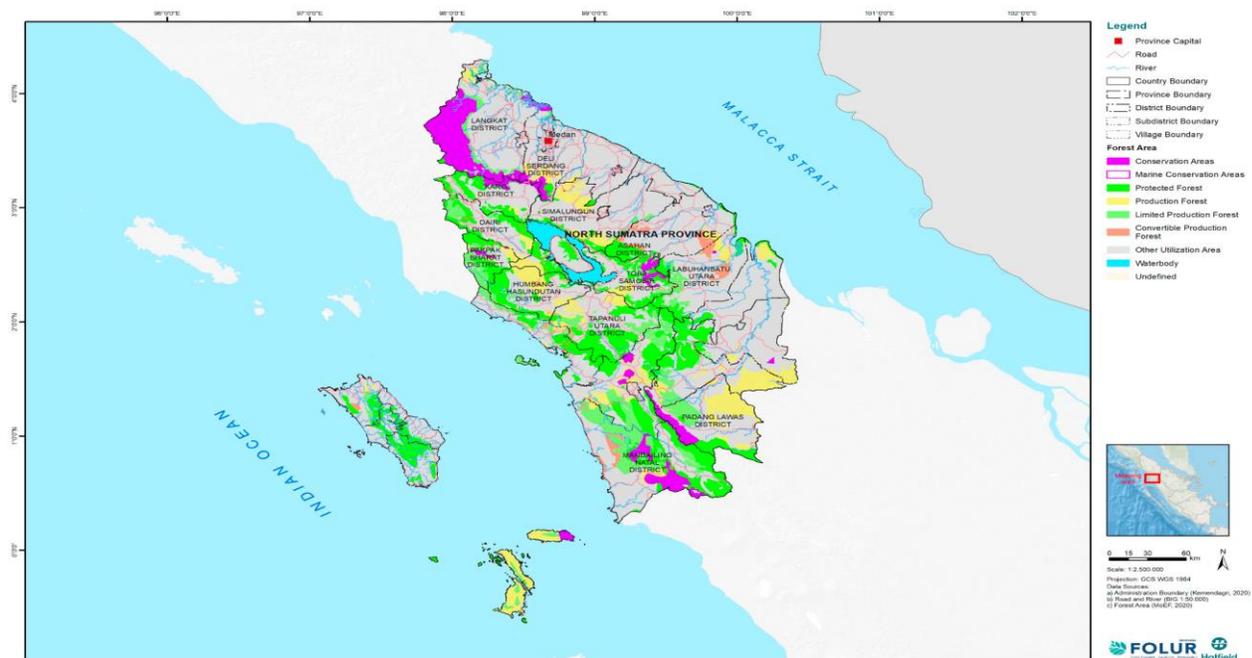


Figure 1. Map of North Sumatra Province.

2.2 Socio-Economic Profile

North Sumatra’s population exceeds 15.3 million, with a large proportion residing in rural districts and engaging in smallholder agriculture. Labor force participation rates are high in agricultural zones, where informal employment and underemployment remain widespread (BPS, 2024b). Despite the economic importance of the commodity sector, value chains for both oil palm and coffee remain weakly developed, marked by low farm-gate prices, limited post-harvest processing, and marginal inclusion in certified sustainable markets.

The disparity in economic returns between large estates and smallholders is particularly evident. While industrial-scale plantations benefit from mechanization and market integration, smallholders typically manage 1–2 hectares of land, often lacking access to quality inputs, credit, extension services, and secure tenure. These constraints are exacerbated in ecologically sensitive areas where commodity production intersects with conservation priorities.

2.3 Focus Area: Mandailing Natal District

The TSA was piloted in Mandailing Natal District, located in the southern part of North Sumatra. Spanning 6,134 km², the district contains a diverse land use matrix (see Figure 2), including natural forests, agroforestry systems, and conservation areas such as the Batang Gadis National Park. It serves as a microcosm of the broader tensions between agricultural expansion and ecosystem protection in Sumatra.

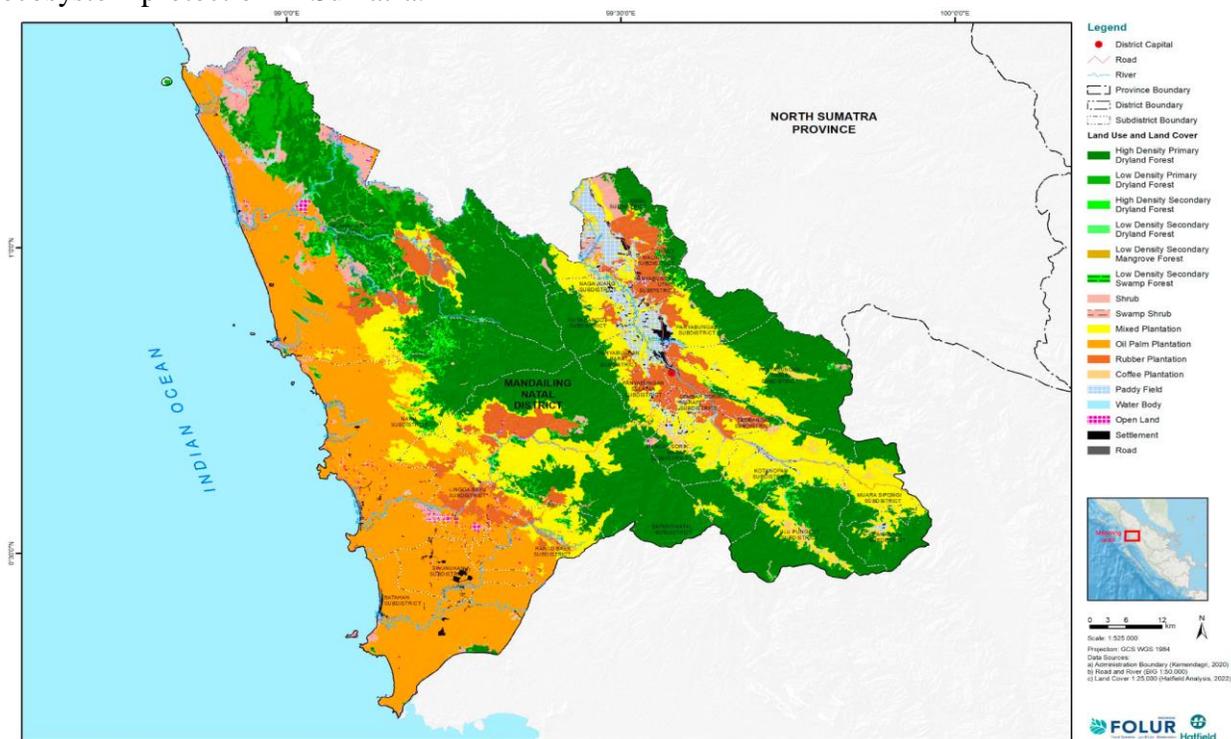


Figure 2. Map of Mandailing Natal land uses (2022).

Two subdistricts—Ranto Baek and Ulu Pungkut—were selected as focal landscapes based on their prominence in oil palm and coffee production, respectively. Ranto Baek is characterized by extensive oil palm plantations, covering over 9,200 hectares or 50% of its land area, with significant encroachment into secondary forests and peatlands. In contrast, Ulu Pungkut hosts approximately 1,160 hectares of arabica coffee, often situated within or adjacent to high-density primary forests, including ABKT zones that harbor critical biodiversity.

The juxtaposition of productive and conservation lands in both subdistricts illustrates the core dilemma facing land use planning in North Sumatra. Smallholders in these areas face structural barriers to adopting sustainable practices, including insecure land tenure, limited market access, and under-resourced extension systems (PT Hatfield Indonesia, 2025a; Suryadi et al., 2021).

2.4 Theoretical Foundations for Targeted Scenario Analysis

The Targeted Scenario Analysis (TSA) framework, developed by UNDP (Alpizar & Bovarnick, 2013), has emerged as a policy-relevant tool for quantifying the costs and benefits of environmental decisions within real-world planning contexts. At its core, TSA integrates social, economic, and ecological indicators into structured scenarios that compare business-as-usual (BAU) trajectories with more sustainable development alternatives. This approach aligns with the broader movement toward evidence-based decision-making in sustainability policy and landscape governance.

Recent scholarship has emphasized the need to frame TSA within the theory of Sustainable Agricultural Intensification (SAI), which advocates for productivity gains without expanding land use, while simultaneously enhancing ecosystem services and social inclusion (Pretty et al., 2018; Rockström et al., 2017). SAI provides a compelling conceptual foundation for the SEM scenarios modeled in this study, particularly in their emphasis on ecological zoning, reduced input reliance, and agro ecological diversification.

Additionally, the application of Good Agricultural Practices (GAP) as part of SEM reflects contemporary shifts in agricultural extension theory, which increasingly focus on co-production of knowledge and adaptive management. GAP, as defined by the FAO and reinforced in local certification systems (e.g., ISPO and SNI-GAP), is not merely a technical prescription but a process of continuous learning between farmers, extension workers, and regulators (de Olde et al., 2020). Embedding GAP within TSA modeling introduces practical entry points for linking scenario outputs to extension services and value chain incentives.

Another relevant strand of literature situates TSA within the broader field of participatory scenario planning (PSP). PSP emphasizes the importance of inclusive stakeholder engagement, not only to enhance legitimacy and uptake of scenarios, but to surface local knowledge, power asymmetries, and context-specific governance challenges (Gupta et al., 2025; Sonnino, 2023). In the Indonesian context, where decentralization has created layered decision-making processes,

TSA offers an operational framework to navigate multi-level governance while maintaining analytical rigor.

Recent reviews of scenario-based tools in the Global South stress that success depends on institutional readiness, the clarity of scenario framing, and integration with planning cycles such as spatial planning and strategic environmental assessments (Adeyemi & Olaniyi, 2024; Côte et al., 2019). These lessons underscore the necessity of complementing TSA with institutional diagnostics and regulatory reform to ensure lasting impact.

3. Methods

3.1 Analytical Framework: Targeted Scenario Analysis (TSA)

This study employed the Targeted Scenario Analysis (TSA) framework as its central methodological approach. TSA is an economic policy tool developed by UNDP to quantify and communicate the comparative benefits of sustainable land use practices relative to business-as-usual (BAU) trajectories (Alpizar & Bovarnick, 2013). The framework is designed to integrate economic, environmental, and social indicators into scenario-based modeling that informs policy and investment decisions.

The rationale for selecting TSA lies in its ability to integrate both technical and participatory elements within a single framework, uniquely suited for complex land-use decisions. Compared to conventional cost-benefit analysis (CBA) or environmental impact assessments (EIA), TSA enables the visualization of long-term trade-offs between ecological, economic, and social outcomes. While tools like System Dynamics or Agent-Based Models offer finer modeling granularity (Callegari & Feder, 2024; Marvuglia et al., 2022; McGarraghy et al., 2022), they lack the participatory appeal and policy relevance necessary for subnational planning in Indonesia. TSA bridges this gap by offering a user-friendly interface for multi-stakeholder engagement while retaining analytical rigor, which proved instrumental in aligning diverse institutional actors in Mandailing Natal.

In this study, TSA was applied to evaluate two contrasting development scenarios in North Sumatra's commodity landscapes:

- **BAU Scenario:** Unregulated agricultural expansion, limited governance enforcement, and low adoption of sustainable practices.
- **Sustainable Ecosystem Management (SEM) Scenario:** Regulated growth, ecological zoning, adoption of Good Agricultural Practices (GAP), and institutional reforms.

TSA served not only as an analytical tool but also as a participatory framework to foster stakeholder engagement and consensus-building among government, farmers, and civil society.

3.2 Study Area and Data Collection

The analysis was conducted in Mandailing Natal District, focusing on two representative subdistricts: Ranto Baek (oil palm) and Ulu Pungkut (arabica coffee). These areas were selected

based on land use intensity, ecological sensitivity, and smallholder prevalence. Data were collected between January and October 2024 using a mixed-methods approach:

- Quantitative data were derived from government statistics (BPS, 2024b, 2024a), remote sensing-based land cover maps, and economic modeling outputs from PT Hatfield Indonesia (2025a, 2025c).
- Qualitative data included focus group discussions with farmers, key informant interviews with local government and extension workers, and stakeholder workshops held under the FOLUR initiative.

3.3 Spatial and Land Use Analysis

A geospatial assessment was carried out to identify land cover change, commodity expansion, and overlap with High Conservation Value (HCV) or ABKT zones. Land use classification was based on Landsat-8 imagery for the year 2022, using supervised classification techniques validated through ground-truthing in both Ranto Baik and Ulu Pungkut (Fardinatri et al., 2024). Fragmentation and slope-based risk analysis were performed using QGIS 3.22 and SAGA GIS to determine vulnerability to erosion and biodiversity loss, particularly in coffee landscapes within montane forests.

3.4 Socio-Economic Profiling

Socio-economic profiling was based on household surveys conducted with 120 randomly selected smallholders (60 per subdistrict). Indicators included average landholding size, crop yields, income levels, access to extension services, and participation in farmer organizations. These data were triangulated with regional poverty statistics, extension records, and cooperative registries (PT Hatfield Indonesia, 2025c). Special attention was given to gender roles in production and marketing, using disaggregated data collected during interviews and workshops (Azzahra et al., 2017; Neilson & Pritchard, 2010).

3.5 Scenario Modeling and Policy Gap Assessment

Scenario modeling involved extrapolating commodity expansion trends under BAU and SEM assumptions until the year 2050. This included projections of:

- Plantation area growth;
- Yield and productivity improvements;
- Forest loss and carbon stock changes; and
- Economic returns for smallholders.

Cost-benefit analysis (CBA) was conducted to assess net benefits across scenarios, drawing from methods outlined by Paoli et al., 2013 and Jelsma et al. (2017). Environmental externalities—such as carbon sequestration, erosion control, and water regulation—were monetized using proxy values based on regional and global ecosystem service estimates (Brockhaus et al., 2012). Policy gap analysis was informed by document review (e.g., spatial planning plans, Provincial Action plan for sustainable development, oil palm/coffee certification guidelines) and

institutional mapping to identify areas of misalignment between national, provincial, and district-level regulations (Obidzinski et al., 2012; Soedomo et al., 2018).

4. Results

4.1. Land Use Change and Commodity Expansion

Under the Business-as-Usual (BAU) scenario, the total oil palm plantation area in North Sumatra is projected to increase by 24.2% by 2050, driven by unregulated expansion into forest margins and areas of high conservation value. Ranto Baek subdistrict (see Figure 3) exemplifies this trend, where oil palm already dominates more than half of the land area (PT Hatfield Indonesia, 2025c). In contrast, the Sustainable Ecosystem Management (SEM) scenario curtails expansion to only 5.1%, focusing instead on yield improvement within existing cultivated zones through Good Agricultural Practices (GAP) and land zoning mechanisms.

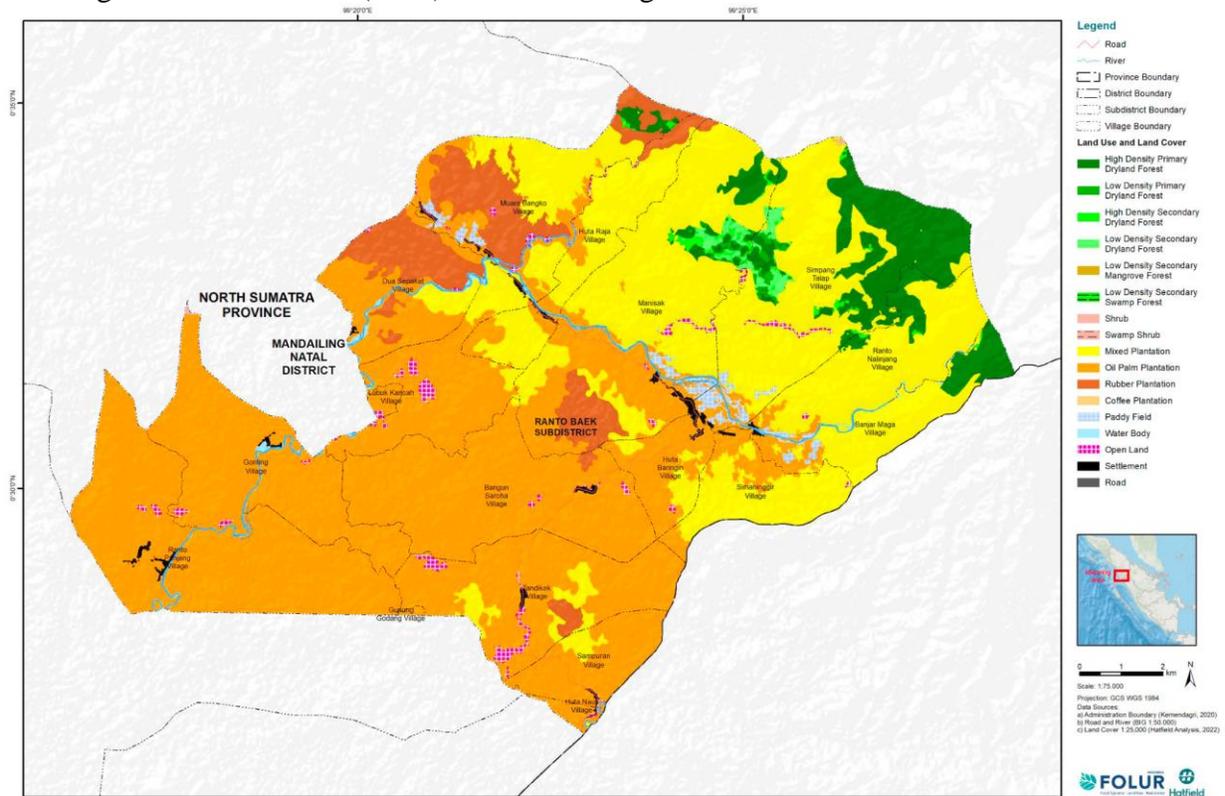


Figure 3. Map of Ranto Baek Subdistrict showing oil palm distribution.

For arabica coffee, the BAU trajectory shows similar concerns, with plantations projected to expand into montane forests and HCV zones, especially in Ulu Pungkut subdistrict (see Figure 4). The SEM scenario instead promotes agroforestry-based intensification, preserving forest cover and reducing erosion risks on steep slopes.

4.2. Economic Impacts and Smallholder Livelihoods

The comparative economic analysis reveals that SEM outperforms BAU across all key metrics. Under the SEM scenario:

- Oil palm smallholder incomes increase by 38%, compared to only 5% under BAU.
- Arabica coffee farmers experience income gains due to better yields, reduced post-harvest loss, and access to premium markets through certification.
- Improved productivity under SEM—without expanding land—drives a higher return per hectare, supported by replanting, certified inputs, and better farmer training (Jelsma et al., 2017; PT Hatfield Indonesia, 2025b).

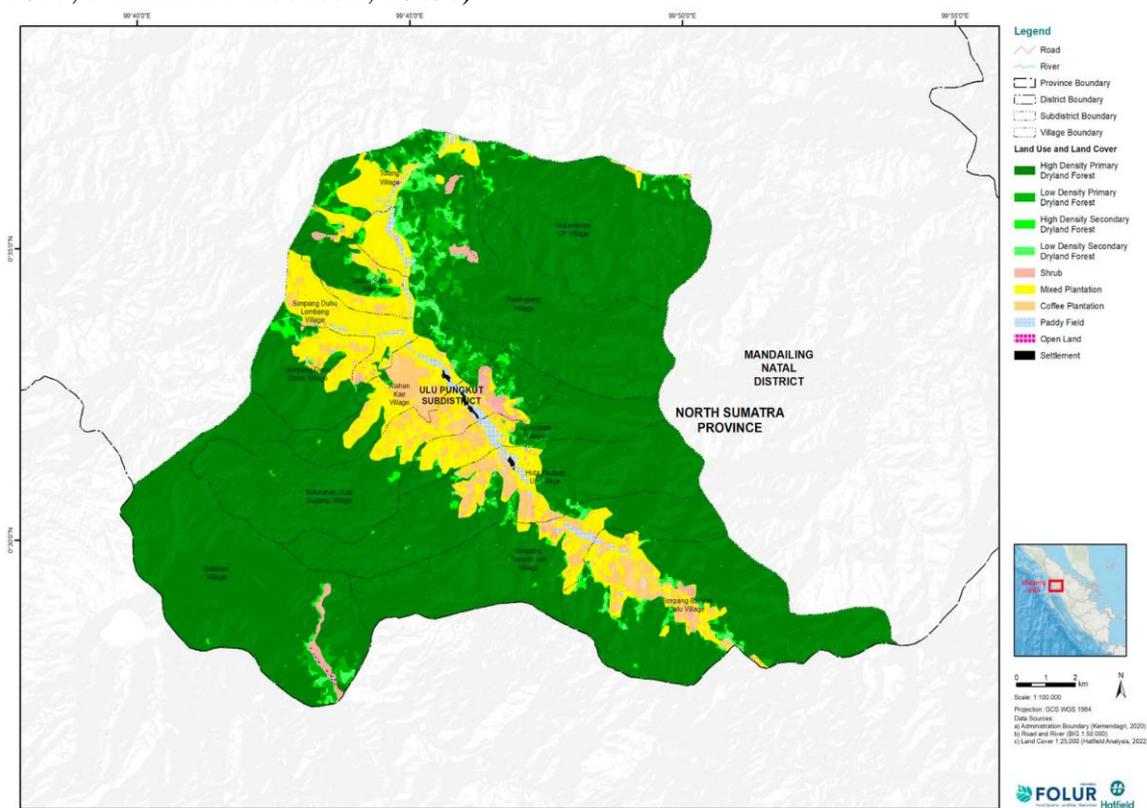


Figure 4. Map of Ulu Pungkut Subdistrict showing coffee plantation distribution.

Additionally, SEM scenarios support higher employment quality, especially for women involved in harvesting and post-harvest tasks. This is linked to the formalization of farmer groups and training access (Azzahra et al., 2017).

In addition to income increases, field interviews with smallholders in Ulu Pungkut revealed a shift toward collective marketing through cooperatives, with one group reporting a 12% increase in average selling price due to certification-related premiums in 2024. Similarly, a farmer group in Ranto Baik adopted GAP-supported practices—such as leguminous cover cropping and composting—that reduced input costs by an estimated IDR 1.5 million (USD 100) per hectare

per season (PT Hatfield Indonesia, 2025b). These micro-level transformations validate the aggregate gains projected in the SEM scenario and demonstrate tangible shifts in practice among early adopters (Parvathi et al., 2019; Sonnino, 2023).

4.3. Environmental Integrity and Carbon Stock Dynamics

Under the BAU scenario, North Sumatra is projected to lose over 18,000 hectares of natural forest by 2050 (see Figure 5), much of it in ecologically sensitive areas. This degradation significantly reduces ecosystem services including carbon sequestration, biodiversity conservation, and water regulation. The SEM scenario, by contrast, stabilizes forest cover through:

- Spatial planning integration of HCV maps
- Restoration of over-aged plantations and degraded areas
- Introduction of Payment for Ecosystem Services (PES) as a conservation incentive

Carbon stock modeling further supports SEM, showing a net increase in landscape-level carbon storage by 2050, compared to a decline under BAU (Fardinatri et al., 2024; PT Hatfield Indonesia, 2025b).

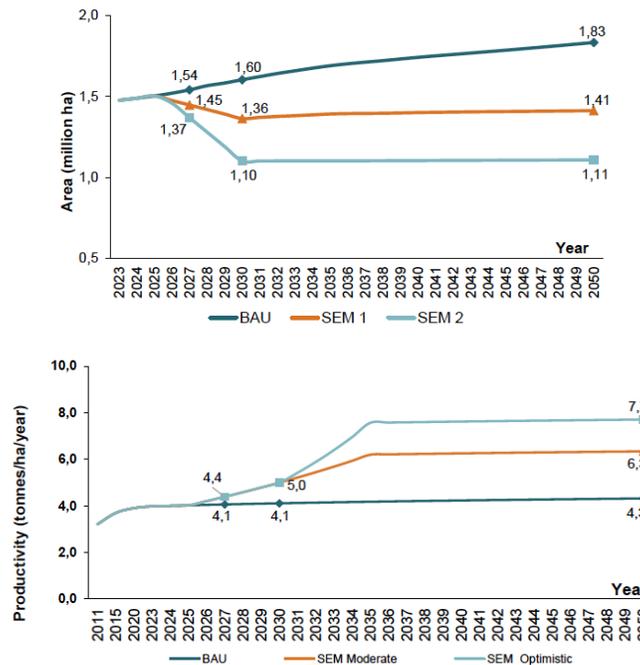


Figure 5. Projected area and productivity of oil palm plantation in North Sumatra.

4.4. Governance and Institutional Gaps

The SEM scenario implicitly assumes stronger institutional coordination. The analysis indicates that achieving SEM outcomes requires:

- Formalizing land rights via Smallholder Plantation Registration Certificate (SPRC). It is a formal recognition mechanism issued by the Ministry of Agriculture to document and legitimize smallholder plantations, especially oil palm. Formalizing land through SPRC helps protect smallholder claims, facilitates access to financing, and is a prerequisite for sustainability certification (e.g., ISPO/Indonesian Sustainable Palm Oil).
- Institutionalizing High Conservation Value Areas) zones in the Spatial Planning Document plans. Institutionalizing HCV in the spatila plan means integrating ecologically sensitive areas into official spatial plans to legally safeguard them from incompatible land uses, such as industrial plantations or mining.
- Expanding multi-stakeholder platforms to include civil society and farmer representatives. This recommendation addresses the procedural inclusion gaps identified in the TSA. While many district-level decision-making bodies exist, they are often dominated by government or private actors. Broadening representation to include civil society organizations (CSOs), indigenous groups, and farmer cooperatives can improve legitimacy, ensure accountability, and incorporate local knowledge into land-use planning.

These actions are presently hindered by fragmented planning, limited extension capacity, and uneven implementation of national sustainability frameworks at district levels (Brockhaus et al., 2012; Soedomo et al., 2018).

5. Discussion

This study demonstrates that integrating Targeted Scenario Analysis (TSA) into policy design for commodity landscapes provides important empirical and participatory insights into the trade-offs between development and sustainability. The comparative evaluation of Business-As-Usual (BAU) and Sustainable Ecosystem Management (SEM) scenarios for oil palm and Arabica coffee in Mandailing Natal revealed not only the ecological and economic implications of each pathway, but also highlighted broader issues of institutional readiness, stakeholder engagement, and policy coherence.

5.1 Enhancing Policy Coherence through Scenario Tools

TSA enabled structured forecasting that communicated the long-term impacts of competing land use strategies. Under SEM, both oil palm and Arabica coffee sectors demonstrated improved ecological and economic outcomes, such as reduced forest conversion, enhanced biodiversity protection, and higher income for smallholders. This aligns with global findings where scenario tools have informed trade-off assessments and prioritized interventions (e.g., Daily et al., 2000; Rockström et al., 2017).

However, successful uptake of TSA into district or provincial planning remains constrained by institutional silos and fragmented regulatory frameworks. For instance, while BAPPEDA

supports green planning, plantation agencies often prioritize expansion targets without incorporating ecological safeguards. This tension mirrors findings in other regions, where planning instruments like TSA are underutilized due to misalignment between central mandates and local capacity (Chen et al., 2025).

5.2 The Importance of Stakeholder Participation

The participatory process embedded in TSA, particularly during the socialization and training phases, revealed a gap between formal consultation and effective co-production. While representatives from local government and technical agencies participated actively, the role of indigenous communities, women farmers, and village authorities was largely symbolic.

This tokenistic participation limits the legitimacy and long-term viability of SEM pathways. Studies in participatory planning argue that transformative change requires more than inclusion; it demands shifting power relations to enable marginalized groups to shape outcomes (Chambers, 2017; Scoones et al., 2021). Future TSA applications in Indonesia must be reoriented toward deep participation, potentially integrating village-level forums, participatory mapping, and community-led scenario modeling.

5.3 Economic Viability and Livelihood Transformation

SEM scenarios demonstrated clear gains in farmer income, particularly for Arabica coffee producers who benefited from shade-grown systems and certification premiums. These findings support the argument that sustainable agriculture need not compromise productivity and, in fact, may enhance resilience and profitability when supported by training and infrastructure (Milder et al., 2011; Pannell et al., 2013).

Nevertheless, these outcomes are contingent on access to services such as extension, inputs, and market linkages. In many districts, farmers remain excluded from value chain upgrades due to credit constraints and lack of cooperatives. Addressing this requires complementary investment in farmer organization, rural finance, and gender-sensitive training programs.

5.4 Governance Bottlenecks and Institutional Overlaps

The institutional mapping revealed overlapping mandates across forestry, plantation, and spatial planning agencies. This fragmentation undermines the coherence of TSA-informed planning and weakens accountability. Similar governance issues have been reported in Sumatra and Kalimantan, where decentralized authority has led to jurisdictional disputes and inconsistent land use enforcement (Moeliono et al., 2017).

There is an urgent need for inter-agency coordination platforms that can translate TSA outputs into actionable policy. Integrating TSA into the Spatial Planning Revision Process or Environmental Carrying Capacity Assessments could enhance uptake and legitimacy.

5.5 Comparative Lessons and Methodological Reflection

Compared to TSA applications in other regions—such as West Kalimantan (focused on palm oil and peat restoration) or the Philippines (coastal ecosystem management)—the North Sumatra case reflects moderate technical success but limited transformative impact. In those other cases, stronger NGO facilitation and clearer donor mandates improved scenario uptake.

Methodologically, this study confirms the value of TSA as a boundary object bridging technical modeling with policy discourse (Cash et al., 2003). However, its effectiveness depends on process design, including clarity of entry points, iterative stakeholder engagement, and transparent communication of uncertainty.

5.6 Implications for Sustainability Policy in Indonesia

Indonesia's national commitments—such as FOLU Net Sink 2030 and the Sustainable Development Goals—require subnational operationalization of integrated planning tools. TSA offers one such pathway, especially if institutionalized through provincial regulations or included in strategic environmental assessments (SEA).

Policy recommendations arising from this study include: (i) embedding TSA within formal planning cycles; (ii) capacity building for local agencies and farmer groups; (iii) establishing inclusive multi-stakeholder platforms; and (iv) aligning TSA outputs with licensing, permitting, and incentive schemes.

5.7 Transferability and Limitations

While the Mandailing Natal case demonstrates clear benefits of TSA integration, contextual differences may affect transferability. For example, the success of SEM pathways depends on pre-existing institutional networks and donor facilitation. Regions lacking organized farmer groups, local GIS capacity, or regulatory willingness may face delays in uptake. However, the TSA framework can be adapted through simplified scenario tools (e.g., participatory mapping or citizen science) in less-resourced areas (Sales et al., 2017). In Kalimantan and Papua, integrating TSA into village-level RPJMDes (village mid-term development plans) could provide a viable entry point (Rahmawati et al., 2023). Future research should pilot such context-sensitive adaptations and assess comparative effectiveness.

6. Conclusion

This study affirms the potential of Targeted Scenario Analysis (TSA) as a strategic policy support tool for guiding sustainability transitions in Indonesia's commodity landscapes. By applying TSA to oil palm and Arabica coffee sectors in Mandailing Natal, North Sumatra, we demonstrated its capacity to generate evidence-based scenarios that inform trade-offs between economic development and environmental protection. The Sustainable Ecosystem Management (SEM) pathway produced favorable outcomes across ecological, economic, and social

dimensions, indicating that integrated planning is not only feasible but also desirable from a multi-stakeholder perspective.

However, the broader institutional and political context in which TSA is implemented remains a critical determinant of its influence. The fragmented governance architecture, symbolic stakeholder engagement, and uneven knowledge hierarchies observed during this study reveal that technical tools alone cannot drive transformative change. For TSA to fulfill its transformative promise, it must be institutionalized in participatory, adaptive, and reflexive governance frameworks. This includes empowering local communities in scenario development, embedding TSA in provincial and district planning instruments, and linking outputs with budgetary and regulatory decisions.

The findings also emphasize the need for strong enabling conditions—such as cross-agency coordination, sustained donor support, and farmer access to services—to realize the benefits of SEM scenarios. Without these, even the most robust scenario modeling risks becoming an academic exercise rather than a catalyst for policy reform.

In sum, TSA holds significant potential for operationalizing sustainability goals like FOLU Net Sink 2030 and the SDGs. But this potential can only be unlocked if the process is democratized, institutional mandates are aligned, and knowledge systems are made more inclusive. Future research should continue to evaluate TSA applications across regions, adapt methodologies to local socio-political realities, and explore how scenario-based planning can be scaled while retaining legitimacy and accountability.

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