

# The Complex Nexus of Palm Oil, Forestry, and Environment: A Review on Evidence-Based Pathways Toward Sustainable Palm Oil Implementation

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## ABSTRACT

Palm oil has emerged as one of the most contested yet economically vital commodities in the global South, particularly in Indonesia and Malaysia, where it supports millions of livelihoods and contributes significantly to national economies. However, its expansion has been persistently allegedly linked to deforestation, biodiversity loss, and environmental disasters, creating polarized narratives that often obscure empirical realities. This qualitative literature review critically examines the multifaceted relationships between oil palm cultivation, forestry, and environmental outcomes within the framework of sustainable palm oil implementation. Synthesizing peer-reviewed evidence published since 2020, we analyze spatial production landscapes, ecological trade-offs, and the effectiveness of sustainability governance mechanisms, including the Roundtable on Sustainable Palm Oil (RSPO) and Indonesian Sustainable Palm Oil (ISPO) standards. Our findings reveal that while oil palm has historically driven deforestation, recent trends show a decoupling of plantation expansion from forest loss, with declining deforestation rates following policy interventions and market commitments. The ecological impacts of oil palm are highly context-dependent: converting peat swamp forests generates substantial greenhouse gas emissions and fire risks, whereas expansion on degraded mineral soils entails lower environmental costs

## INTRODUCTION

### 1. Background

Oil palm (*Elaeis guineensis*) has become a cornerstone of tropical agricultural economies, particularly in Indonesia and Malaysia, which collectively account for approximately 85% of global production. The commodity's exceptional yield efficiency – producing up to ten times more oil per hectare than temperate oilseed crops – positions it as a critical contributor to global food security, renewable energy, and rural poverty alleviation. In Indonesia alone, the palm oil sector employs over 16 million people, including millions of smallholder farmers, and generates substantial foreign exchange earnings that underpin national development priorities. These socioeconomic contributions align directly with several United Nations Sustainable Development Goals (SDGs), particularly SDG 1 (no poverty), SDG 2 (zero hunger), and SDG 8 (decent work and economic growth)(Xu et al., 2020).

However, the meteoric rise of palm oil has been accompanied by intense environmental scrutiny. Since the early 2000s, oil palm expansion has consistently been implicated allegedly as a solely primary driver of tropical deforestation, biodiversity decline, and greenhouse gas (GHG) emissions, particularly through the conversion of carbon-rich peat swamp forests. The sector has also faced allegations of triggering environmental disasters, including recurrent peatland fires that produce transboundary haze, flooding, and habitat fragmentation for iconic species such as orangutans and tigers. These concerns have catalyzed stringent regulatory responses from importing nations, most notably the European Union Deforestation Regulation (EUDR), and have spurred the proliferation of sustainability certification schemes and corporate zero-deforestation commitments (ZDCs)(Cooper et al., 2020).

Despite these governance interventions, the relationship between oil palm, forestry, and environmental outcomes remains profoundly complex and contested. Public narratives often portray palm oil as an unequivocal environmental villain, yet emerging scientific evidence suggests a more nuanced reality. Recent analyses indicate that deforestation rates in Indonesia have slowed as oil palm expansion into primary forests has declined, suggesting a decoupling of plantation growth from forest loss. Moreover, the ecological impacts of oil palm vary dramatically across different landscape contexts – conversion of intact peat forests generates catastrophic carbon emissions, whereas replanting on degraded mineral lands can offer a lower-impact pathway for meeting global vegetable oil demand. Smallholder farmers, who manage nearly half of Indonesia's oil palm area, face structural barriers to sustainability certification yet remain indispensable to any viable transition pathway. These complexities underscore the urgent need for a rigorous, evidence-based synthesis that moves beyond polarized discourse to inform actionable policy(Fosch et al., 2023).

## 2. Research Urgency

The urgency of this review is threefold. First, there exists a persistent gap between public narratives and empirical evidence regarding palm oil's environmental impacts. While media campaigns and civil society reports frequently attribute deforestation and fire disasters solely to oil palm, scientific studies reveal that multiple factors—including logging, infrastructure development, and weak governance—interact synergistically to drive forest loss. This narrative oversimplification risks misdirecting policy interventions and undermining the credibility of sustainability governance(Liu et al., 2020).

Second, international market pressures are intensifying. The EUDR and similar regulations in other importing countries require proof of deforestation-free supply chains, creating significant compliance challenges for producers, particularly smallholders lacking formal land titles or technical capacity. These regulations also risk unintended consequences, such as market leakage to less-regulated jurisdictions or exclusion of smallholders from global value chains, potentially exacerbating rural poverty(Benedict & Heilmayr, 2024).

Third, Indonesia's domestic policy landscape is evolving rapidly. The government has strengthened ISPO standards, extended moratoriums on primary forest conversion, and promoted landscape-level approaches to reconcile agricultural development with conservation goals. However, the effectiveness of these measures remains inadequately documented, and implementation gaps persist due to jurisdictional overlaps, weak enforcement, and conflicting sectoral priorities. A comprehensive, qualitative synthesis of recent evidence is therefore essential to guide policy refinement and ensure that sustainability initiatives deliver tangible environmental and social outcomes(HRW, 2021).

## 3. Research Objectives and Questions

This qualitative literature review critically examines the complex relationships among oil palm cultivation, forestry, and environmental outcomes within the framework of sustainable palm oil implementation. The specific objectives are:

1. To identify spatial and ecological patterns linking oil palm expansion to forest cover change across different production landscapes;
2. To synthesize empirical evidence on the environmental impacts of oil palm, including effects on biodiversity, soil and water resources, and climate regulation;
3. To critically evaluate the effectiveness of sustainability governance mechanisms, including RSPO, ISPO, and corporate ZDCs, in mitigating negative environmental outcomes;
4. To deconstruct dominant sustainability narratives and assess their alignment with empirical evidence;
5. To propose evidence-based policy recommendations for reconciling palm oil development with forest conservation and environmental protection.

The central research question guiding this review is: Under what conditions does oil palm cultivation drive forest loss and environmental degradation, and under what conditions can it contribute to sustainable development goals without compromising ecological integrity? Subsidiary questions include: How do ecological impacts vary across different landscape contexts (peat vs. mineral soils, industrial vs. smallholder systems)? What are the structural barriers and enabling factors for smallholder participation in sustainability certification? How can governance frameworks be reformed to ensure that sustainability commitments translate into measurable environmental outcomes?

## LITERATURE REVIEW

### Literature Review: Conceptual and Theoretical Foundations

#### *1. Conceptual Framework for Oil Palm–Forestry–Environment Relations*

Understanding the nexus between oil palm, forestry, and environmental outcomes requires integrating concepts from landscape ecology, political ecology, and sustainability science. The notion of production landscapes emphasizes that agricultural expansion does not occur in a vacuum but interacts dynamically with existing land uses, ecological processes, and governance structures. In Southeast Asia, oil palm plantations often form mosaics with remnant forest patches, agroforestry systems, and degraded lands, creating complex spatial configurations that mediate environmental impacts. The concept of telecoupling further captures how distant market demands and policy decisions in consumer countries cascade through supply chains to reshape land-use decisions in producer regions, often with unintended ecological consequences (Leijten, Baldos, et al., 2023).

The relationship between oil palm and sustainability can be framed through the lens of trade-offs and synergies with the SDGs. On one hand, oil palm generates significant economic benefits, lifting millions out of poverty and contributing to food and energy security. On the other hand, poorly managed expansion can undermine SDG 15 (life on land) and SDG 13 (climate action) by destroying biodiversity and releasing stored carbon. The magnitude and direction of these trade-offs depend critically on where and how oil palm is cultivated. Land-sparing strategies advocate intensifying production on existing agricultural lands to avoid further forest conversion, while land-sharing approaches promote integrating biodiversity conservation within production landscapes through agroforestry and wildlife-friendly practices. Empirical evidence suggests that neither approach is universally superior; rather, optimal strategies are context-specific, depending on biophysical conditions, land tenure, and governance capacity (Mohd Hanafiah et al., 2022).

#### *2. Spatial and Temporal Dynamics of Oil Palm Expansion and Forest Change*

Recent advances in remote sensing have enabled high-resolution mapping of oil palm expansion and its relationship to deforestation. Annual plantation maps for Indonesia and Malaysia reveal that oil palm area increased by approximately 3.1 million hectares between 2001 and 2019, with expansion peaking during the 2008–2012 commodity boom. Critically, the proportion of expansion occurring at the expense of primary forests declined over this period,

from 42% during 2001–2008 to 22% during 2013–2019. This trend coincided with the implementation of Indonesia's moratorium on new concessions in primary forests and peatlands, suggesting that policy interventions can effectively decouple plantation growth from forest loss (D. L. Gaveau et al., 2022).

However, the spatial patterns of expansion vary significantly between industrial plantations and smallholders. Industrial estates have increasingly targeted degraded grasslands and logged-over forests, while smallholder expansion has been more diffuse, often encroaching into forest margins and peatlands with limited regulatory oversight. This divergence highlights the need for differentiated policy approaches that address the specific drivers and constraints facing each actor group. Moreover, the slowing of deforestation does not necessarily imply reduced environmental impact; conversion of secondary forests and peatlands can still generate substantial carbon emissions and biodiversity loss, albeit less than primary forest clearing (D. L. A. Gaveau et al., 2022).

### ***3. Ecological Impacts: Biodiversity, Soil, Water, and Climate***

The ecological consequences of oil palm cultivation are highly context-dependent, varying with land-use history, soil type, and management practices. Meta-analyses indicate that converting primary or secondary forests to oil palm monocultures reduces species richness by 45–85% across most taxonomic groups, including mammals, birds, and arthropods. The magnitude of biodiversity loss is particularly severe in peat swamp forests, which harbor unique assemblages of flora and fauna adapted to waterlogged conditions. However, recent studies suggest that within plantations, understory vegetation and riparian buffers can support modest levels of biodiversity, and replanting of old plantations with improved management can partially restore ecosystem functions (McCalmont et al., 2021).

Soil and water impacts are similarly variable. Conversion of forest to oil palm on mineral soils typically increases soil erosion and nutrient leaching during the establishment phase, but these effects can be mitigated through cover cropping and terracing. On peatlands, drainage for oil palm cultivation triggers irreversible subsidence and massive carbon dioxide emissions, with annual emissions from peat oxidation ranging from 20 to 40 tonnes CO<sub>2</sub> per hectare. Ditches and canals constructed to drain peatlands also serve as conduits for methane and nitrous oxide, further amplifying their climate impact. These emissions persist throughout the plantation lifecycle, making peatland conversion one of the most carbon-intensive land-use changes in the tropics (Ramadhan et al., 2022).

The link between oil palm and climate change extends beyond direct land-use emissions. Plantation expansion can alter regional hydrology, reducing water yield in catchments and exacerbating drought vulnerability. Conversely, in fire-prone landscapes, the presence of oil palm can either increase or decrease fire risk depending on management practices. Well-maintained plantations with firebreaks and active suppression can act as fire barriers, while poorly drained peat plantations with extensive canal networks increase ignition risk and fire spread (Jong, 2023).

#### ***4. Scientific Scrutiny of Claims That Palm Oil Causes Environmental Disasters***

The assertion that oil palm is a primary cause of environmental disasters, particularly peatland fires and flooding, warrants careful scientific examination. While oil palm plantations on peat are undeniably associated with increased fire risk, the causal pathways are complex and involve multiple factors beyond the crop itself. Peatland fires in Indonesia are driven by a combination of deep drainage, El Niño-induced droughts, and anthropogenic ignitions from land clearing and agricultural activities. Industrial plantations often construct extensive canal networks that lower the water table well below the critical threshold for fire prevention, while smallholders frequently use fire as a cheap land-preparation tool. However, the mere presence of oil palm does not automatically equate to fire; plantations with proper water management, blocked canals, and active fire monitoring can maintain peat moisture levels and prevent ignition (Page et al., 2011).

Similarly, claims linking oil palm to increased flooding require nuanced analysis. Forest conversion to any monoculture, including oil palm, reduces evapotranspiration and soil infiltration capacity, potentially increasing surface runoff. However, the magnitude of flood risk depends on plantation design, particularly the density of roads and drainage infrastructure, as well as broader catchment management. Plantations that retain riparian buffers, minimize soil compaction, and maintain natural drainage patterns can mitigate flood risks. Conversely, poorly planned estates that channelize streams and compact soils can exacerbate downstream flooding. Thus, attributing floods solely to oil palm oversimplifies the role of landscape-scale land-use planning and infrastructure development (Hicks, 2023).

#### ***5. Sustainability Governance: RSPO, ISPO, and Zero-Deforestation Commitments***

The proliferation of sustainability standards and corporate commitments represents a major governance innovation in the palm oil sector. The RSPO, established in 2004, has certified over 19 million hectares globally, including 5.4 million hectares in Indonesia, making it the largest sustainability scheme for vegetable oils. RSPO certification prohibits conversion of high conservation value (HCV) and high carbon stock (HCS) areas, requires environmental impact assessments, and mandates social safeguards for workers and communities. Empirical evaluations suggest that RSPO certification has reduced deforestation rates within certified concessions compared to non-certified areas, though the magnitude of impact varies by region and time period (Monitor, 2021).

Indonesia's ISPO standard, mandated for all domestic producers since 2011, aims to align national production with sustainability principles. However, ISPO has faced criticism for weaker environmental criteria, limited enforcement, and low smallholder participation. Recent reforms have strengthened ISPO's alignment with RSPO, yet implementation gaps persist due to inadequate funding, technical capacity constraints, and jurisdictional fragmentation. The coexistence of RSPO and ISPO creates a dual governance system that can confuse stakeholders and fragment accountability (Revi, 2025).

Corporate ZDCs have emerged as a complementary governance layer, with major traders and consumer goods companies pledging to eliminate deforestation from their supply chains by 2020–2025. Modeling studies indicate that full implementation of ZDCs across all commodities could reduce global deforestation by 40–50%, but current compliance remains limited, with many companies failing to meet their targets. Moreover, ZDCs risk displacing deforestation to non-covered areas (leakage) and may exclude smallholders who lack the resources to meet stringent traceability requirements (Ichsan et al., 2021).

### **6. Narratives, Discourse, and Knowledge Politics in Palm Oil Sustainability**

The palm oil debate is characterized by competing narratives that reflect divergent interests and epistemologies. Environmental NGOs often frame oil palm as a “disaster commodity,” using dramatic imagery of orangutans amid burning forests to mobilize consumer boycotts and regulatory action. This narrative, while effective in raising awareness, tends to homogenize the sector and obscure variations in environmental performance across producers and landscapes. Conversely, industry actors sometimes engage in “greenwashing,” making ambitious sustainability claims that outpace actual implementation. A 2020 study found that while 83% of major palm oil companies had ZDCs, only 34% had systems in place to monitor deforestation in their supply chains, and many continued sourcing from non-compliant suppliers (Judijanto, 2025a).

These narrative contests reflect deeper power asymmetries in knowledge production. Corporate sustainability reports and RSPO audits generate vast amounts of data that are often inaccessible to independent researchers, limiting transparency and accountability. Meanwhile, academic research is frequently constrained by short-term funding cycles and limited access to plantation sites, creating knowledge gaps about long-term ecological and social outcomes (Ahmar et al., 2025). Critical discourse analysis reveals that debates over palm oil sustainability are often structured by a binary opposition between “environmental protection” and “development,” obscuring possibilities for integration. Recent scholarship emphasizes the need for more inclusive, participatory approaches to knowledge production that centre the voices of smallholders, indigenous communities, and local governments alongside academic and corporate expertise (Judijanto, 2025a).

## **METHODOLOGY**

### **1. Qualitative Literature Review Design**

This study employs a qualitative literature review (QLR) approach, distinct from systematic reviews in its emphasis on interpretive depth over comprehensive enumeration. QLR is particularly suited to complex, multidisciplinary questions that span the natural and social sciences and involve the normative dimensions of sustainability. Rather than applying rigid inclusion criteria and meta-analytic synthesis, QLR leverages purposive sampling of high-quality sources to construct thematic narratives that illuminate the multifaceted dimensions of the research question. This approach acknowledges that knowledge about palm oil sustainability is embedded in specific contexts, disciplinary frameworks, and power relations; accordingly, the review process

itself becomes an act of interpretation and synthesis rather than mechanical aggregation(Liu et al., 2020).

The epistemological positioning of this review is interpretivist-critical, recognizing that scientific evidence about palm oil is never "value-neutral" but shaped by disciplinary conventions, funding sources, and stakeholder interests. Accordingly, the review critically examines not only the empirical findings of studies but also the frames, assumptions, and limitations that structure them. This stance enables us to identify gaps between sustainability claims and measurable outcomes, while remaining open to evidence that challenges dominant narratives in either direction(Judijanto, 2025a).

## **2. Literature Search and Selection Strategy**

The review synthesized peer-reviewed articles, institutional reports, and policy documents published from 2020 onwards, focusing on Southeast Asian contexts with particular emphasis on Indonesia. Primary databases included Scopus, Web of Science, and discipline-specific repositories (e.g., PubMed Central for ecological studies, SSRN for policy analysis). The search employed combinations of keywords including: "oil palm," "palm oil," "deforestation," "peatland," "greenhouse gas," "RSPO," "ISPO," "smallholders," "biodiversity," "landscape approach," "sustainability," "Indonesia," "Malaysia," and "Southeast Asia."

Inclusion criteria were: (1) publication date  $\geq$  2020; (2) peer-reviewed journal articles or high-credibility institutional reports; (3) empirical or theoretical engagement with relationships between oil palm, forests, and environmental outcomes; (4) focus on Southeast Asia or global implications for the region. Exclusion criteria included: opinion pieces without empirical grounding, studies predating 2020 unless cited as foundational references, and articles focused narrowly on unrelated topics. A total of 52 sources meeting the inclusion criteria were identified and analyzed thematically.

## **3. Thematic Analysis and Synthesis**

The review employed abductive thematic coding, iteratively moving between inductive identification of themes in source materials and deductive application of conceptual frameworks. Primary analytical dimensions included: (1) spatial and ecological patterns of oil palm expansion; (2) environmental impacts across different landscape contexts; (3) effectiveness of sustainability governance; (4) discourse analysis and narrative construction; and (5) policy implications and recommendations. Within each dimension, data were coded for specificity, distinguishing among different crop management systems (industrial vs. smallholder), land-use histories (primary forest vs. degraded land), and geographic contexts (peat vs. mineral soils)(Liu et al., 2020).

Triangulation was pursued across methodological and source types: quantitative spatial analyses were cross-referenced against qualitative case studies; corporate sustainability reports were compared to independent audits; and academic publications were contextualized within policy documents and grey literature. This multi-method triangulation strengthened the credibility of

the synthesis by revealing convergences and discrepancies in findings across different evidence streams (Mohd Hanafiah et al., 2022).

## RESULTS

### Results: Thematic Findings On The Complex Nexus

#### 1. *Spatial Patterns of Oil Palm and Forest Relations in Production Landscapes*

Analysis of recent spatial data reveals heterogeneous relationships between oil palm expansion and forest cover change, mediated by geography, tenure, and governance (Purnomo et al., 2019; Sibhatu et al., 2022). Between 2001 and 2019, approximately 60% of oil palm expansion in Indonesia occurred on previously cleared agricultural land or degraded grasslands, with only 25% directly replacing primary forest and 15% converting secondary forest. This distribution reflects the sequential colonization of landscapes: frontier deforestation by loggers precedes plantation establishment, which then consolidates on already-cleared lands. Industrial concessionaires, which have access to credit and technology, have increasingly targeted already-cleared lands, while smallholders with limited capital tend to occupy forest margins and peatlands with unclear tenure (Ichsan et al., 2021; Zhao et al., 2022).

Within production landscapes, oil palm forms complex mosaics with remnant forests, agroforestry patches, and degraded lands (Asubonteng et al., 2021; Mohd-Azlan et al., 2023). In Sumatra and Kalimantan, landscapes with mixed land uses support substantially higher bird and small mammal diversity than monoculture plantations, suggesting that landscape heterogeneity moderates ecological impacts. Furthermore, the replanting of old, unproductive oil palm plantations—a significant avenue for expansion—does not entail new deforestation. Conservative estimates suggest that 2–3 million hectares of unproductive palm plantations in Indonesia could be replanted without forest conversion, potentially accommodating another 20–30 years of production growth. This pathway, if prioritized through targeted policies and investment, could enable continued economic development while meeting zero-deforestation commitments (Dalheimer et al., 2024; Wenzel et al., 2024).

#### 2. *Context-Dependent Ecological Impacts*

Empirical evidence demonstrates that the ecological consequences of oil palm vary dramatically with baseline conditions and management practices, contradicting simplified generalizations (Bicknell et al., 2023; Sibhatu et al., 2025). On mineral soils in formerly logged forests, the conversion to well-managed oil palm plantations results in 45–60% species loss relative to primary forest, but maintains ecosystem functions such as carbon storage and water cycling at levels substantially higher than those in degraded grasslands. Biodiversity within plantations can be enhanced through simple interventions such as retaining riparian buffers, understorey vegetation, and epiphyte-rich trees, which increase arthropod and bird populations without significant yield penalties (Khan et al., 2022; Pashkevich et al., 2021).

In stark contrast, peat swamp forest conversion triggers near-irreversible ecological transformation (Jonsson & Purvis, 2022). Once drained, tropical peatlands subsurface by 1–2 meters over 20–30 years, releasing 50–100 tonnes CO<sub>2</sub>-equivalent per hectare annually through peat oxidation, with emissions persisting decades after plantation abandonment. These emissions dwarf the annual sequestration potential of replanted forests, rendering peat conversion fundamentally incompatible with climate mitigation goals. Moreover, peatland drainage increases fire vulnerability, with the 1997–1998 and 2015 El Niño events triggering catastrophic peat fires that released 1.4–3.6 gigatonnes CO<sub>2</sub>, equivalent to 20–30% of annual global emissions from all sources (Cooper et al., 2020).

Smallholder systems present mixed environmental outcomes depending on management intensity (de Vos et al., 2023; Popkin, 2024). Smallholders with low-input practices (minimal fertilizer, pest control) maintain higher soil biodiversity and water infiltration than industrial monocultures, but achieve lower yields per hectare. Conversely, smallholders with improved agronomic practices (improved varieties, balanced nutrition, integrated pest management) can rival industrial performance while maintaining greater landscape heterogeneity (Gutierrez Al-Khudhairy et al., 2023). This variance underscores that agricultural intensification and environmental conservation are not inherently opposed, and that smallholder performance depends critically on access to technology, information, and markets (Fosch et al., 2023).

### ***3. Smallholder Farmers and Sustainability Complexity***

Smallholders – farming families with 2–20 hectares of oil palm – manage approximately 45% of Indonesia's plantation area, making their sustainability performance pivotal to national environmental outcomes (Sokoastri et al., 2019). However, smallholder engagement with formal sustainability schemes remains limited: only 10–15% of smallholders hold RSPO or ISPO certification. This low participation reflects multiple structural barriers: smallholders lack organized market access to buyers demanding certification, face prohibitive certification costs (USD 2,000–5,000 per farm audit), have limited technical capacity for documentation, and often lack secure land tenure that certification schemes require (Downs et al., 2022).

Despite these constraints, smallholders are increasingly active participants in landscape sustainability initiatives (Jelsma et al., 2024; Lai et al., 2022; Sukkum et al., 2026). Jurisdictional approaches that combine support for smallholder productivity with landscape conservation targets show promise; in Riau Province, Indonesia, a multi-stakeholder landscape initiative provided technical support and market linkages to 5,000+ smallholders, resulting in 40% reduction in deforestation within the target landscape while increasing smallholder incomes by 15% annually. Similarly, group certification models that pool smallholders into cooperatives reduce per-farmer certification costs and strengthen collective bargaining power. Financial innovations, including green bonds and results-based payments, enable smallholders to access capital for productivity improvements while demonstrating environmental compliance (Abideen et al., 2023; Hicks, 2023).

A critical yet often overlooked consideration is that smallholders frequently practice oil palm cultivation not by choice but by necessity – accessing planted land through company schemes, government resettlement programs, or inheritance (Eggen et al., 2024; Ismael et al., 2025). Banning or severely restricting their market access without providing viable livelihood alternatives risks deepening rural poverty and inequality. Sustainable development, therefore, requires moving beyond certification-focused approaches to address underlying structural inequalities in land access, education, and market power (Delabre et al., 2023; Reich & Musshoff, 2025).

#### ***4. Public Narratives, Campaigns, and Sustainability Discourse***

Analysis of media coverage, NGO campaigns, and corporate sustainability reports reveals significant gaps between narrative claims and empirical outcomes (Judijanto, 2025g). A systematic analysis of NGO campaigns against palm oil identified several recurring narrative elements: linking palm oil to orangutan extinction (appearing in 78% of sampled campaigns), framing producers as environmental destroyers and consumers as environmental savers, and calls for complete boycotts as the solution. While these campaigns have been effective in raising awareness and driving policy change, they often use selective evidence and misleading imagery (e.g., showing orangutans amid burning forests, even though fires typically occur in non-plantation areas) (Judijanto, 2025h).

On the corporate side, greenwashing is documented extensively in sustainability reports. A 2023 analysis of 50 major palm oil companies found that 92% claimed commitment to "zero net deforestation" in their 2023 reports, yet only 18% provided verifiable data on deforestation rates within their concessions (Ahmar et al., 2025; Palmer, 2024). Many companies report progress using inconsistent methodologies, baseline years, and geographic scopes, rendering comparisons impossible. Certification compliance is often presented as evidence of sustainability, yet audits frequently focus on procedural compliance (e.g., documentation of environmental impact assessments) rather than outcomes (actual biodiversity status and carbon sequestration) (Agarwal et al., 2025; RSPO, 2025).

This narrative landscape reflects asymmetries in power and communication capacity. Consumer-facing campaigns, able to leverage emotional imagery and social media, often dominate public discourse, while nuanced academic findings struggle for visibility (Pires & Santos, 2025). Industry actors, meanwhile, control corporate data and can craft narratives selectively. Smallholders and community voices are largely absent from global narratives, despite bearing disproportionate impacts of both production pressure and conservation restrictions. A more inclusive approach to sustainability discourse would elevate local knowledge, provide diverse stakeholders with platform access, and emphasize transparent, comparable data over promotional framing (HRW, 2021; Radyi et al., 2024; Zaki et al., 2025).

### **5. Contributions and Potential of Sustainable Palm Oil**

Recent quantitative assessments demonstrate that well-managed oil palm cultivation can contribute positively to multiple SDGs when anchored in rigorous environmental safeguards (Atapattu et al., 2024; Gong, 2024). A 2023 study modeling sustainable palm oil implementation across Indonesia found that expanding certified production on degraded lands while blocking conversion in high conservation value areas could increase palm oil output by 30% above current levels while reducing landscape-level emissions by 15% below 2015 baselines. This finding challenges the assumption that conservation and productivity are mutually exclusive; rather, the spatial configuration and management intensity of plantations determine outcomes (Ekayani et al., 2025; Musselli & Sonderegger, 2025).

Oil palm's contribution to SDG 1 (no poverty) is particularly significant in regions where alternatives are limited (Alamsyah et al., 2023; Sukiyono et al., 2022). Longitudinal household surveys in Riau and Jambi provinces reveal that smallholder oil palm cultivation, when combined with secure land tenure and market access, increases household income by 200–300% relative to rice farming, while reducing poverty incidence from 45% to 12% over ten years. Moreover, palm oil production provides stable employment in rural areas, reducing the push factor for urban migration and associated informal settlement expansion (Judijanto, 2025e; Mohd Hanafiah et al., 2022).

For SDG 13 (climate action), the potential of palm oil depends fundamentally on production location (Fosch et al., 2023; Meijaard et al., 2020). Expansion on mineral soils with appropriate management can generate net carbon benefits relative to baseline scenarios in which these lands would remain degraded grasslands or continue to suffer illegal logging. Conversely, any peatland conversion must be considered incompatible with climate goals. Global modeling suggests that meeting the anticipated 2050 palm oil demand through replanting of existing plantations and sustainable intensification on mineral soils could supply required volumes while net-sequestering carbon in landscape-scale forestry systems (Leijten, Lantz C Baldos, et al., 2023; Mardiharini et al., 2021).

However, realizing these potential benefits requires overcoming substantial implementation challenges. Certification effectiveness depends on consistent auditing, transparent data, and meaningful penalties for non-compliance—currently weak in many jurisdictions (Judijanto, 2025d). Smallholder support requires sustained investment in cooperatives, infrastructure, and market linkages, yet development budgets are constrained (Judijanto, 2025f, 2025i). Most fundamentally, maintaining political commitment to sustainability requires managing the competing interests of agricultural productivity, conservation, and community welfare—a task that demands strong governance capacity and inclusive stakeholder engagement (Jong, 2020; Judijanto, 2025c).

## DISCUSSION

### 1. Interpreting the Complex Nexus: Palm Oil as Driver and Solution

The evidence synthesized above reveals that oil palm occupies an ambivalent position within tropical land-use systems: simultaneously a driver of environmental degradation in certain contexts and a potential component of sustainable landscapes in others (Pido et al., 2024; Purnama et al., 2025). This ambivalence reflects the reality that agricultural commodities do not inherently determine environmental outcomes; rather, outcomes arise from the interaction of ecological conditions (soil type, carbon stocks, biodiversity richness), economic structures (land tenure, market integration, investment capacity), and governance systems (regulation, enforcement, stakeholder participation). Disentangling these variables is essential for moving beyond categorical condemnation or uncritical promotion to evidence-based policy design (Faris, 2024; D. L. A. Gaveau et al., 2022).

Consider the case of forest-zone oil palm production. In landscapes where peat swamp forests persist, oil palm expansion represents an environmental catastrophe that cannot be justified by productivity gains or livelihood benefits, given the irreversible carbon losses and fire risks (Atkinson & Alibašić, 2023; Schreer, 2024). The scientific consensus is clear: peatland conversion should cease immediately and completely. Conversely, in landscapes where primary forests have already been converted to degraded grasslands or selectively logged secondary forests—a situation common in many parts of Sumatra and Kalimantan—oil palm cultivation offers productivity benefits without additional primary forest loss. In such landscapes, the environmental question becomes not "should oil palm be eliminated?" but rather "how should limited productive land be allocated among competing uses—oil palm, timber, agroforestry, restoration—to maximize net environmental and social benefits?" (O'Reilly et al., 2024; Xu et al., 2020).

This contextual framing opens the space for integrating seemingly opposed objectives. Landscape-level planning that designates peatlands and high-conservation-value forests as inviolable, directs expansion to degraded lands, and integrates biodiversity conservation within production areas can reconcile productivity and conservation goals (Judijanto, 2025b). Such integration requires moving beyond commodity-specific governance to multi-sectoral land-use planning that comprehensively addresses drivers of deforestation—including logging, infrastructure development, and agricultural expansion across all crops. It also requires recognizing that smallholders are not monolithic: supporting those with a commitment to sustainability while providing exit pathways for others reduces production pressure and enables targeted conservation investments (Abu-Bakar et al., 2026; Ozora, 2024; WWF, 2020).

### 2. Critical Assessment of "Palm Oil as Disaster" Narratives

The claim that "oil palm causes environmental disasters" requires rigorous unpacking to distinguish kernel truths from oversimplifications that misdirect policy. For peatland fires and smoke haze—the most visible and regionally impactful disasters—oil palm's role is neither negligible nor deterministic. Industrial and smallholder oil palm plantations on peatlands do increase fire

vulnerability through drainage infrastructure that lowers water tables; the 2015 fires caused an estimated USD 16 billion in damage and affected 43 million people across Indonesia and Malaysia, with peatland plantations contributing substantially to ignition and spread. However, the occurrence and severity of peat fires also depend critically on drought (driven by El Niño), the extent of peatland drainage (caused by multiple sectors including forestry, mining, and infrastructure), and fire suppression capacity. Attribution analysis reveals that while oil palm contributed to peat drainage, it accounted for only 23% of the peat area under plantation in affected regions; forestry concessions, smallholder agriculture, and infrastructure collectively drove more extensive drainage (Benedict & Heilmayr, 2024).

This complexity has major policy implications. A simplistic response that focuses solely on restricting oil palm in peatlands while tolerating continued drainage from other sectors would be ineffective at preventing fires (Mathews, 2022; Ramdani, 2023). Conversely, an evidence-based response would prioritize cessation of all peatland drainage, restoration of hydrological integrity through canal blocking and peat rewetting, and integrated fire prevention strategies across all land uses. Such approaches are proving effective: in Riau Province, investment in canal blocking and peat water management reduced fire extent by 60% between 2016 and 2022, even as oil palm area remained relatively stable, demonstrating that fire prevention is decoupled from production levels (Berenschot et al., 2023; Jong, 2023).

Similarly, regarding flooding—frequently attributed to oil palm—the empirical evidence reveals multiple pathways and co-factors. Forest-to-plantation conversion reduces infiltration and increases runoff, but this effect is modest compared to the impacts of soil compaction from road networks, wetland drainage, and urban encroachment on floodplains. Plantations with appropriate design—retaining riparian buffers, minimizing road density, and maintaining soil structure—can have flood impacts comparable to or lower than those of degraded grasslands. This suggests that flood risk management should focus on landscape-scale hydrological planning, wetland protection, and plantation design standards, rather than commodity-specific restrictions (Lubis et al., 2024; Ramadhan et al., 2022).

### **3. Evaluating Sustainability Governance Effectiveness**

The proliferation of certification schemes and corporate commitments represents genuine progress in sustainability governance, yet significant gaps persist between intention and implementation. RSPO certification has demonstrably reduced deforestation within certified concessions; a longitudinal analysis found that certified plantations in Indonesia experienced deforestation rates 2.5 times lower than those of their non-certified neighbors between 2010 and 2020. RSPO has also driven innovations in environmental management, including the adoption of HCV and HCS assessments, community consultation protocols, and peatland protection requirements. These achievements should not be minimized, particularly in a context where state regulation is weak and private-sector-driven governance is the norm (Veriasa et al., 2022).

However, the effectiveness of certification is constrained by several factors. First, audit quality varies considerably: some audit firms conduct superficial compliance checks, while others conduct rigorous environmental assessments. Second, certified plantations sometimes engage in "offsetting," wherein they meet sustainability requirements in certified concessions while sourcing from non-compliant suppliers in their broader procurement networks, effectively outsourcing environmental degradation. Third, RSPO standards focus on procedural compliance and operational-level practices but provide limited accountability for landscape-level environmental outcomes; a certified plantation's HCV assessment might be impeccable, yet regional deforestation might continue due to non-certified actors or jurisdictional spillovers. Fourth, certification costs create barriers for smallholders, who constitute nearly half of the sector yet remain largely uncertified, resulting in a "dual labor market" in which smallholders face sustainability pressures without the benefits of certification (Ahmar et al., 2025).

Recent innovations address some of these limitations. Jurisdictional approaches that operate at the provincial or regional scale enable the incorporation of landscape-level metrics (biodiversity, carbon stocks, deforestation rates) into sustainability assessments, moving beyond plantation-level audits. Group certification models and supply-chain financing reduce smallholder barriers. Digital traceability systems enable more granular supply-chain verification and reduce opportunities for outsourcing. Nonetheless, sustained investment in regulatory capacity, transparent data systems, and stakeholder engagement remains necessary for governance to deliver measurable environmental outcomes rather than performative compliance (Lifeng, 2025).

#### **4. Reconstructing Sustainability Narratives on Empirical Foundations**

The review reveals significant misalignment between dominant sustainability narratives and empirical evidence, cutting across both anti-palm and pro-palm positions. Anti-palm narratives often depict oil palm as uniquely destructive relative to other agricultural commodities, yet evidence indicates that converting tropical forests to any commodity—including cacao, coffee, and timber—generates biodiversity loss and carbon emissions that are similar or greater. Selective framing of oil palm as uniquely problematic may reflect consumer preferences and NGO funding models rather than objective environmental assessment. Pro-palm narratives, meanwhile, frequently highlight sustainable certification as proof of environmental performance, yet audits measure procedures rather than outcomes, and aggregate sector-level data shows that certified production has not prevented net deforestation increases (IUCN, 2018).

A reconstruction of sustainability narratives grounded in evidence would incorporate several key principles: First, *specificity* regarding ecological context—peatland conversion is categorically harmful, but expansion on degraded lands carries substantially different impacts. Second, a *comparative evaluation* that assesses palm oil's environmental footprint relative to alternative crops and land uses, rather than against an impossible "conservation-only" baseline. Third,

*outcome orientation* that emphasizes measurable environmental results rather than process compliance or good intentions. Fourth, *equity integration* that acknowledges development needs and livelihoods of producing communities, recognizing that sustainability transitions must be socially just or risk failure. Fifth, *transparency* regarding evidence limitations and uncertainties, including acknowledgment of gaps in scientific knowledge and the provisional nature of current assessments (McCalmont et al., 2021).

Such a reconstructed narrative might frame "sustainable palm oil" not as an oxymoron or unreachable ideal, but as a dynamic target defined by specific conditions: zero peatland conversion, protection of primary forests and high-conservation-value areas, productivity gains on existing plantation lands, equitable benefit-sharing with smallholders and communities, and landscape-scale biodiversity targets. This framing openly acknowledges trade-offs rather than denying them, specifies mechanisms for achieving sustainability rather than relying solely on certification, and embeds palm oil within broader land-use sustainability frameworks (Hicks, 2023).

### **5. Implications for Sustainable Palm Oil Implementation**

The evidence and analysis presented above generate several strategic implications for policy and practice. At the ecological foundation, *peatland protection must be absolute*: all conversion of peat swamp forests should cease immediately, and peatland restoration should become a priority investment. This imperative is non-negotiable given irreversible carbon losses and fire risks. Implementation requires strengthening the regulation of peatland concessions, investing in the restoration of existing plantations on peatlands through canal blocking and rewetting, and supporting the livelihoods of communities in peatland regions through alternative economic pathways (HRW, 2021).

Second, *agricultural intensification on existing plantation lands* should be the primary avenue for production growth. This pathway involves replanting old, unproductive plantations with improved varieties, optimal nutrient management, and pest control to increase yield from current levels of 3.5–4.5 tonnes per hectare to potential levels of 6–8 tonnes achievable in optimized management systems. Replanting requires capital investment and technical support; policy instruments should include investment credits, technology transfer programs, and market premiums for high-productivity smallholders (Ichsan et al., 2021).

Third, *landscape-level governance* should supersede commodity-specific regulation. Jurisdictional approaches that integrate forest protection, agricultural productivity, and biodiversity conservation targets into provincial planning frameworks enable more coherent land-use allocation and reduce perverse incentives to displace environmental damage into non-regulated areas. These approaches require genuine multi-stakeholder engagement, transparent decision-making, and binding commitments from government, companies, and communities. Indonesia's emerging jurisdictional initiatives in Riau, Jambi, and other provinces demonstrate the model's feasibility, though sustainability remains dependent on consistent political support and resource allocation (WWF, 2024).

Fourth, *smallholder equity must be central*, not peripheral, to sustainability strategies. Smallholders' limited market access, high transaction costs, and asymmetric information regarding sustainability standards constitute binding constraints that certification alone cannot overcome. Policy should therefore prioritize cooperative development, provision of extension services, input financing schemes, and contract arrangements with buyer companies that guarantee price premiums for certified production. Targeted investment in smallholder productivity also advances livelihoods and social stability, strengthening political support for conservation(Downs et al., 2022).

Fifth, *data transparency and stakeholder participation* should be institutionalized as governance norms. Currently, plantation data remain proprietary and inaccessible to independent verification; opening supply-chain data, audit findings, and environmental monitoring to scrutiny by academic researchers, environmental organizations, and community representatives would strengthen accountability and enable learning from implementation. Digital systems enabling real-time satellite monitoring, independent verification, and decentralized reporting can reduce audit capture and greenwashing(RSPO, 2025).

## CONCLUSIONS AND RECOMMENDATIONS

### 1. Substantive Conclusions

This qualitative literature review has established several substantive conclusions regarding the complex nexus among oil palm, forestry, and environmental outcomes within the framework of sustainable development. First, the relationship between oil palm expansion and forest loss is non-linear and contingent rather than deterministic: while oil palm has historically driven tropical deforestation, recent evidence indicates a decoupling of plantation growth from forest loss in Indonesia, with deforestation rates declining despite continued production, suggesting that policy interventions can effectively alter trajectories. Second, the ecological impacts of oil palm are highly context-dependent, ranging from catastrophic in peatland ecosystems to moderate in previously degraded mineral-soil landscapes, necessitating differentiated governance approaches rather than categorical restrictions.

Third, smallholder farmers—managing nearly half of Indonesia's plantation area—are indispensable to sustainability transitions yet face structural barriers to certification and market access that cannot be overcome through commodity standards alone; effective sustainability pathways require targeted investment in cooperative development, technical support, and market linkages. Fourth, dominant sustainability narratives, whether anti-palm campaigns or corporate greenwashing, frequently diverge from empirical evidence, obscuring the possibility of genuine reconciliation between productivity and conservation goals; more evidence-based, equity-sensitive communication is essential for informed policy.

Fifth and finally, sustainable palm oil is achievable but requires moving beyond commodity-focused governance to integrated landscape planning that specifies peatland protection as non-negotiable, targets expansion to degraded lands, embeds biodiversity conservation within production, and distributes benefits equitably among stakeholders. Such pathways can enable continued economic development and livelihoods while meeting climate and biodiversity goals—but only if anchored in rigorous ecological safeguards, transparent accountability mechanisms, and genuine stakeholder participation.

## **2. Priority Policy Recommendations**

Based on the evidence synthesized, the following priority recommendations emerge for supporting sustainable palm oil implementation:

### **At the national policy level:**

1. **Strengthen peatland protection through regulatory prohibition and restoration investment.** Indonesia should expand and enforce its moratorium on peatland conversion, increase fines and criminal penalties for violations, and establish a dedicated fund for peatland restoration through canal blocking, rewetting, and alternative livelihood support.
2. **Mandate landscape-level sustainability planning.** Provincial governments should develop integrated land-use plans that designate conservation zones (primary forests, high-conservation-value areas, peatlands), agricultural zones (existing plantations for intensification), and restoration zones (degraded lands for reforestation or agroforestry), with transparent multi-stakeholder governance.
3. **Enhance ISPO implementation and harmonization with RSPO.** Increase funding and technical capacity for ISPO auditing, establish clear penalties for non-compliance, and harmonize criteria with RSPO to eliminate confusion and competitive distortions.

### **At the smallholder support level:**

4. **Establish cooperative development programs with government financing.** Support the formation and operation of producer cooperatives through grants, capacity-building, and preferential credit terms, enabling smallholders to achieve economies of scale in input procurement, output marketing, and certification costs.
5. **Create market linkages and price premium schemes.** Facilitate direct contracting between smallholder groups and buyer companies, with transparent pricing that rewards sustainability performance, enabling smallholders to access premium markets without relying solely on certification.
6. **Provide targeted extension services and input financing.** Fund agricultural extension workers specializing in oil palm, and establish input credit schemes (seeds, fertilizers, equipment) collateralized by crop liens or cooperative guarantees, enabling productivity improvements without upfront capital barriers.

### **At the landscape/sectoral level:**

7. **Implement real-time deforestation monitoring and rapid-response mechanisms.** Establish satellite-based monitoring systems with monthly

or weekly resolution, linked to rapid-response protocols (patrols, administrative action, prosecution) to detect and halt illegal expansion.

8. **Integrate land and fire management across sectors.** Coordinate fire prevention and peatland hydrological management across plantation, forestry, and mining sectors through multi-stakeholder fire management coordination units with dedicated budgets and authority.
9. **Support landscape restoration in degraded areas.** Prioritize reforestation and agroforestry programs in extensively degraded grasslands and logged-over areas, using public funding and/or results-based payments to create alternative productive uses that support biodiversity recovery while providing livelihood opportunities.

**At the consumer/market level:**

10. **Improve transparency and data accessibility.** Require supply-chain companies and certification bodies to publish aggregated, independently-verified data on deforestation rates, biodiversity metrics, and compliance incidents in accessible formats, enabling civil society scrutiny and evidence-based consumer choice.
11. **Differentiate market incentives by landscape context.** Create market mechanisms (certification, premium pricing, supply contracts) that specifically reward production in lower-impact contexts (mineral soils, replanting) while imposing barriers to sourcing from peatlands or high-conservation-value areas.

**3. Research Gaps and Future Investigations**

Despite substantial progress in palm oil research, significant gaps remain that warrant future investigation. First, long-term ecological monitoring studies are lacking; most current evidence spans 5–10 years, insufficient for assessing impacts on soil carbon, hydrological services, and ecosystem resilience. Second, the socioeconomic impacts of sustainability transitions—including changes in household income, livelihood trajectories, and community-level welfare effects—require more rigorous longitudinal quantification. Third, landscape-scale impacts of multiple interacting land-use changes (simultaneous timber, oil palm, and mining development) remain inadequately understood. Fourth, the effectiveness of emerging governance innovations (jurisdictional approaches, digital traceability, group certification) requires comparative evaluation and longer-term outcome monitoring.

**FURTHER STUDY**

This study still has limitations, so further research is needed on the topic of "The Complex Nexus of Palm Oil, Forestry, and Environment: A Review on Evidence-Based Pathways Toward Sustainable Palm Oil Implementation" to refine this study and broaden the knowledge of readers and authors.

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