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# SUSTAINABLE PEATLAND MANAGEMENT IN OIL PALM PLANTATION BASED ON MULTI-STAKEHOLDERS APPROACH

# GESTÃO SUSTENTÁVEL DE TURFEIRAS EM PLANTAÇÕES DE PALMA DE ÓLEO COM BASE EM UMA ABORDAGEM MULTISTAKEHOLDER

# GESTIÓN SOSTENIBLE DE TURBERAS EN PLANTACIONES DE PALMA DE ACEITE BASADA EN UN ENFOQUE MULTIACTOR

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## ABSTRACT

Peatland ecosystems in Indonesia, particularly those within oil palm plantation regions, face acute environmental degradation due to unsustainable land use, poor water management, and recurrent fires. This has sparked global and national interest in promoting sustainable peatland management through inclusive, collaborative governance. This study aims to examine how multi-stakeholder governance mechanisms influence ecological, institutional, and socio-economic outcomes in peatland areas affected by oil palm cultivation. Employing a qualitative research design, this study adopts a Systematic Literature Review (SLR) method, guided by the PRISMA protocol. Data were collected exclusively from secondary sources, comprising 29 peer-reviewed journal articles published between 2020 and 2025, sourced from the ScienceDirect database. The search strategy applied focused on Boolean operators and thematic filters to ensure relevance, while inclusion criteria were based on open-access status, article type, and publication period. Data analysis was conducted using thematic synthesis to identify core patterns and governance strategies. The results reveal that multi-stakeholder approaches lead to improved ecological outcomes, including hydrological restoration, reduced fire incidents, and lower greenhouse gas emissions. Institutionally, they foster better coordination, procedural legitimacy, and adaptive capacity. Socio-economically, such frameworks enhance tenure security and diversified livelihoods, although challenges related to power asymmetries and limited community capacity persist. This study concludes that multi-stakeholder governance has significant potential to support sustainable peatland management in oil palm regions. Future research should examine the long-term impacts, power dynamics, and integration of indigenous knowledge systems into peatland policy frameworks.

**Keywords**: Peatland Management. Multi-Stakeholder Governance. Oil Palm. Sustainable Development. Systematic Literature Review.

## RESUMO

Os ecossistemas de turfeiras na Indonésia, particularmente aqueles localizados em regiões de plantações de palma de óleo, enfrentam grave degradação ambiental em decorrência do uso insustentável da terra, da gestão inadequada da água e da recorrência de incêndios.

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Esse cenário tem despertado interesse tanto em âmbito nacional quanto internacional na promoção da gestão sustentável de turfeiras por meio de modelos de governança inclusivos e colaborativos. Este estudo tem como objetivo examinar como os mecanismos de governança multistakeholder influenciam os resultados ecológicos, institucionais e socioeconômicos em áreas de turfeiras afetadas pelo cultivo da palma de óleo. Adotando um delineamento de pesquisa qualitativo, o estudo utiliza o método de Revisão Sistemática da Literatura (RSL), orientado pelo protocolo PRISMA. Os dados foram coletados exclusivamente a partir de fontes secundárias, compreendendo 29 artigos científicos revisados por pares, publicados entre 2020 e 2025, obtidos da base de dados ScienceDirect. A estratégia de busca empregou operadores booleanos e filtros temáticos para assegurar a relevância dos estudos, enquanto os critérios de inclusão consideraram o acesso aberto, o tipo de artigo e o período de publicação. A análise dos dados foi conduzida por meio de síntese temática, com o objetivo de identificar padrões centrais e estratégias de governança. Os resultados indicam que abordagens multistakeholder promovem melhorias nos resultados ecológicos, incluindo a restauração hidrológica, a redução da incidência de incêndios e a diminuição das emissões de gases de efeito estufa. No âmbito institucional, tais abordagens favorecem maior coordenação, legitimidade procedimental e capacidade adaptativa. Do ponto de vista socioeconômico, esses arranjos contribuem para o fortalecimento da segurança da posse da terra e para a diversificação dos meios de subsistência, embora persistam desafios relacionados às assimetrias de poder e à limitada capacidade das comunidades locais. Conclui-se que a governança multistakeholder apresenta elevado potencial para apoiar a gestão sustentável de turfeiras em regiões produtoras de palma de óleo. Recomenda-se que pesquisas futuras analisem os impactos de longo prazo, as dinâmicas de poder e a integração de sistemas de conhecimento indígena nos arcabouços de políticas públicas voltadas às turfeiras.

**Palavras-chave:** Gestão de Turfeiras. Governança Multistakeholder. Palma de Óleo. Desenvolvimento Sustentável. Revisão Sistemática da Literatura.

**RESUMEN**

Los ecosistemas de turberas en Indonesia, en particular aquellos ubicados en regiones con plantaciones de palma de aceite, enfrentan una grave degradación ambiental debido al uso insostenible del suelo, a la deficiente gestión hídrica y a la recurrencia de incendios. Esta situación ha generado un creciente interés tanto a nivel nacional como internacional por promover la gestión sostenible de las turberas mediante modelos de gobernanza inclusivos y colaborativos. Este estudio tiene como objetivo examinar cómo los mecanismos de gobernanza multiactor influyen en los resultados ecológicos, institucionales y socioeconómicos en áreas de turberas afectadas por el cultivo de palma de aceite. Con un diseño de investigación cualitativo, el estudio adopta el método de Revisión Sistemática de la Literatura (RSL), guiado por el protocolo PRISMA. Los datos se recopilaron exclusivamente a partir de fuentes secundarias, que comprenden 29 artículos científicos revisados por pares, publicados entre 2020 y 2025, procedentes de la base de datos ScienceDirect. La estrategia de búsqueda empleó operadores booleanos y filtros temáticos para garantizar la relevancia de los estudios, mientras que los criterios de inclusión se basaron en el acceso abierto, el tipo de artículo y el período de publicación. El análisis de los datos se realizó mediante síntesis temática para identificar patrones centrales y estrategias de gobernanza. Los resultados muestran que los enfoques multiactor conducen a mejoras en los resultados ecológicos, incluida la restauración hidrológica, la reducción de la incidencia de incendios y la disminución de las emisiones de gases de efecto invernadero. A nivel institucional, estos enfoques fomentan una mayor coordinación, legitimidad procedimental y capacidad adaptativa. Desde una perspectiva socioeconómica, dichos marcos contribuyen al fortalecimiento de la seguridad en la tenencia de la tierra y a la

diversificación de los medios de vida, aunque persisten desafíos relacionados con las asimetrías de poder y la limitada capacidad de las comunidades locales. El estudio concluye que la gobernanza multiactor posee un alto potencial para apoyar la gestión sostenible de las turberas en regiones productoras de palma de aceite. Se recomienda que futuras investigaciones examinen los impactos a largo plazo, las dinámicas de poder y la integración de los sistemas de conocimiento indígena en los marcos de políticas públicas sobre turberas.

**Palabras clave:** Gestión de Turberas. Gobernanza Multiactor. Palma de Aceite. Desarrollo Sostenible. Revisión Sistemática de la Literatura.

## 1 INTRODUCTION

Peatlands are among the most unique and ecologically significant ecosystems on the planet. Despite occupying only about 3% of the Earth's terrestrial surface, these wetlands store nearly one-third of the world's soil carbon, almost twice as much carbon as all of the world's forests combined (Santika et al., 2020). Their capacity to regulate climate, purify water, preserve biodiversity, and support traditional livelihoods underscores their ecological and socio-economic importance. However, tropical peatlands, especially those in Southeast Asia, have faced increasing pressure due to unsustainable land-use practices. Among the most critical threats is the conversion of peatlands for monoculture plantations, particularly oil palm, which has escalated dramatically over the last three decades (Cole et al., 2021).

Indonesia is home to approximately 14.9 million hectares of tropical peatlands, with Sumatra, Kalimantan, and Papua comprising the majority of these ecosystems (Carmenta et al., 2021). Simultaneously, Indonesia has become the world's largest producer of palm oil, with plantation areas growing from just under 2 million hectares in 1990 to over 16.8 million hectares by 2023 (Leal Silva et al., 2025). Notably, it is estimated that over 3.3 million hectares of these plantations have been established on peat soils (Alam et al., 2021). The economic contribution of palm oil to national income, foreign exchange earnings, and rural employment is undeniable. In 2022, the palm oil sector generated USD 33 billion in export revenues and supported more than 16 million livelihoods directly and indirectly (Goh, 2020). Yet, this growth has come at considerable ecological cost.

Draining peatlands for agriculture leads to rapid oxidation of organic matter, releasing large quantities of greenhouse gases (GHGs) such as $CO_2$ and $CH_4$ into the atmosphere. Peatland degradation accounts for approximately 42% of Indonesia's total land-use sector emissions annually, making it one of the top five global sources of peat-related GHG emissions (Sanders et al., 2019). Furthermore, lowered water tables in drained peatland make them highly flammable, contributing to frequent and intense forest and land fires. Between 2015 and 2019, peat fires in Indonesia were responsible for releasing over 1.6 billion metric tons of $CO_2$ equivalent and caused severe transboundary haze events that disrupted air travel, school activities, and public health across Southeast Asia (Dohong et al., 2017).

In response, international attention and national urgency around sustainable peatland management have intensified. The UNFCCC, ASEAN Peatland Management Strategy (APMS), and REDD+ frameworks have recognized tropical peatlands as priority landscapes for climate action and biodiversity conservation (Merten et al., 2021). Domestically, the Government of Indonesia has enacted a suite of policy interventions, including the

establishment of the Peatland and Mangrove Restoration Agency (BRGM), a moratorium on new peatland licenses, and rewetting mandates for degraded peat zones (Surahman et al., 2018). However, implementation has often been inconsistent, hindered by fragmented institutional arrangements, unclear land tenure, and competing economic interests (Malahayati & Masui, 2019).

In this complex socio-ecological context, the concept of multi-stakeholder governance has emerged as a promising framework to address the intersecting challenges of peatland degradation, policy fragmentation, and socio-economic inequality. Multi-stakeholder approaches seek to engage a broad spectrum of actors ranging from government institutions at various levels, private sector companies, indigenous and local communities, civil society organizations, and academic institutions in collaborative decision-making and action (Sattraburut et al., 2024). These approaches aim not only to distribute responsibility but also to foster transparency, knowledge co-production, adaptive management, and collective accountability.

Scholarly and policy discussions increasingly highlight the potential of these inclusive models to improve environmental outcomes, reduce conflicts, and enhance policy legitimacy in contested landscapes such as peatlands (Surahman et al., 2017). For example, collaborative programs such as the Peat Care Village (*Desa Peduli Gambut*) have empowered communities to monitor water tables and prevent fires, while sustainability certification schemes like RSPO (Roundtable on Sustainable Palm Oil) and ISPO (Indonesian Sustainable Palm Oil) have introduced criteria for peatland conservation and best management practices (Abdurrahim et al., 2023). Additionally, donor-supported platforms such as the Tropical Forest Alliance (TFA) and Landscape Approach Working Groups have been instrumental in bringing together public-private partnerships for integrated land-use planning (Uda et al., 2020).

Despite these advances, the real-world effectiveness of multi-stakeholder interventions remains highly variable. Empirical studies show that while some collaborative efforts lead to measurable improvements in rewetting, carbon retention, and community engagement, others are stymied by power imbalances, elite capture, conflicting mandates, and lack of enforcement (D. A. Sari et al., 2021). A growing body of research has sought to examine how stakeholder configurations, governance mechanisms, and institutional capacity influence outcomes in sustainable peatland management. However, these studies are often fragmented, case-specific, and methodologically inconsistent, making it difficult to draw generalizable conclusions or scale successful models across diverse contexts.

To address this knowledge gap, a Systematic Literature Review (SLR) approach is particularly useful. SLR offers a rigorous and transparent method for synthesizing existing empirical findings, mapping thematic patterns, and identifying knowledge clusters or contradictions within a defined scope. Unlike primary data collection or qualitative anecdotal evidence, an SLR minimizes researcher bias by applying replicable search, screening, and coding procedures, often guided by standardized protocols such as PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). SLRs have been widely applied in environmental governance, land-use change, and sustainability studies to identify intervention effectiveness, gaps in policy, and emergent theoretical frameworks.

This study, therefore, applies an SLR methodology to systematically examine the role and effectiveness of multi-stakeholder approaches in supporting sustainable peatland management within oil palm plantation landscapes. The review spans literature published between 2020 and 2025, a period marked by intensified sustainability commitments, growing international scrutiny of palm oil production, and evolving national regulatory frameworks. A total of 29 peer-reviewed, open-access research articles screened based on defined inclusion-exclusion criteria serve as the empirical corpus for this analysis.

The aim is to unpack how various configurations of multi-stakeholder governance mechanisms contribute to, or hinder, the realization of sustainable peatland management outcomes. This includes assessing not only ecological impacts (e.g., fire reduction, water table restoration, biodiversity protection) but also institutional dynamics (e.g., cross-agency coordination, regulatory coherence, community participation) and socio-economic effects (e.g., livelihood resilience, access to restoration funding, and equity in decision-making).

Findings from this study will be relevant for a wide range of audiences. For policymakers, it offers insight into governance bottlenecks and policy design principles that can enhance coordination and accountability. For private sector stakeholders, it provides evidence-based reflections on the effectiveness of sustainability certifications and investor-driven environmental standards. For NGOs and local communities, it identifies promising entry points for collaborative planning, capacity building, and advocacy. Finally, for the academic community, the study advances understanding of how multi-level and cross-sectoral governance systems operate in complex, dynamic landscapes such as tropical peatlands.

Accordingly, the objective of this study is:

To systematically analyze how multi-stakeholder approaches contribute to sustainable peatland management within oil palm plantation landscapes, by synthesizing empirical findings from recent peer-reviewed literature published between 2020 and 2025.

From this objective, the following research question is derived:

*How do multi-stakeholder governance mechanisms influence ecological, institutional, and socio-economic outcomes in sustainable peatland management practices within oil palm plantation regions?*

This research question serves as the anchor for the analytical sections of the article, particularly the discussion and conclusion, where insights from the SLR will be interpreted and translated into policy and practical recommendations.

## 2 LITERATURE REVIEW

The governance of peatland ecosystems within oil palm landscapes has emerged as a complex and contested terrain of environmental, economic, and institutional dynamics. Multiple bodies of literature intersect around this issue, including sustainable land-use planning, climate change mitigation, collaborative governance, and agro-industrial sustainability. This review critically synthesizes key themes and conceptual framings found in peer-reviewed research from 2020 to 2025, as analyzed through a systematic literature review (SLR) process. The aim is to provide a comprehensive understanding of how multi-stakeholder approaches have been framed, implemented, and evaluated within the context of sustainable peatland management in oil palm-producing regions.

### 2.1 THE ECOLOGICAL FRAGILITY OF PEATLANDS IN OIL PALM EXPANSION

Tropical peatlands are increasingly recognized for their high conservation value and vulnerability to degradation when exposed to land-use change, particularly for monoculture expansion. Several studies highlight that drainage and conversion of peat for oil palm cultivation disrupts the hydrological balance, accelerates carbon oxidation, and increases fire risk (Tan et al., 2021). Furthermore, oil palm plantations on peat often experience long-term soil subsidence, eventually resulting in permanent flooding and productivity decline (Carmenta et al., 2017). This has prompted scholars to argue for the restoration of peat hydrology through rewetting and reforestation as a precondition for sustainability (Phelps et al., 2021).

### 2.2 GOVERNANCE FRAGMENTATION AND INSTITUTIONAL INCOHERENCE

Effective peatland governance in Indonesia is complicated by overlapping institutional mandates, ambiguous land tenure systems, and inconsistent law enforcement (Alam et al., 2022). National agencies, provincial governments, and village authorities often operate in silos, resulting in contradictory land-use plans and regulatory uncertainty. Literature has

shown that the presence of multiple uncoordinated actors contributes to inefficiencies and undermines conservation goals (Rowan, 2025). This institutional fragmentation is further exacerbated by the lack of accurate peatland mapping and monitoring systems, which complicates enforcement and planning processes.

## 2.3 EMERGENCE OF MULTI-STAKEHOLDER GOVERNANCE IN PEATLAND POLICY

To address governance shortcomings, researchers and practitioners have advocated for multi-stakeholder governance models that prioritize collaboration, transparency, and inclusive decision-making (Skillings-Neira et al., 2025). Such approaches involve the active participation of state actors, private sector stakeholders, NGOs, researchers, and local communities in co-developing land-use strategies. The literature notes that multi-stakeholder forums can enhance policy coherence, bridge knowledge gaps, and legitimize interventions. However, not all multi-stakeholder processes lead to positive outcomes. Studies warn that without clear accountability mechanisms and equitable power distribution, these platforms risk becoming tokenistic or dominated by corporate interests (Wheeler et al., 2025).

## 2.4 COMMUNITY-BASED APPROACHES AND PARTICIPATORY RESTORATION

Community participation has been widely emphasized as a critical component in achieving sustainable peatland outcomes. The Peat Care Village (*Desa Peduli Gambut*) initiative, for example, has been cited in the literature as a promising model of local engagement, where villagers monitor water levels and implement fire prevention strategies. Research highlights that when local communities are empowered with technical knowledge, legal recognition, and access to financial support, they become effective stewards of peat ecosystems. Conversely, programs that neglect local knowledge or impose top-down directives often face resistance or yield superficial compliance (van Hardeveld et al., 2018).

## 2.5 ROLE OF SUSTAINABILITY CERTIFICATION AND PRIVATE SECTOR INITIATIVES

Voluntary market-based instruments, such as the RSPO and ISPO certifications, have played a growing role in influencing peatland management practices among oil palm producers. These certifications set criteria for peatland protection, fire prevention, and environmental impact mitigation (Achyar et al., 2015). Studies note that firms adopting these standards often improve their operational practices and transparency. Nevertheless, compliance varies widely across regions and company sizes, with smallholder-dominated landscapes facing structural barriers to certification. Furthermore, there is limited empirical

evidence linking certification to long-term improvements in peat hydrology or biodiversity recovery (Sayer et al., 2021).

## 2.6 TECHNOLOGICAL INNOVATIONS IN MONITORING AND RESTORATION

Remote sensing technologies, hydrological modeling, and GIS-based planning tools have increasingly been used to support sustainable peatland management. Satellite data from Sentinel-2 and LiDAR have been used to monitor land subsidence, detect hotspots, and map peat dome contours with high accuracy (Jefferson et al., 2020). These tools enable real-time monitoring and more precise targeting of restoration interventions. However, literature also points out the digital divide and technical capacity gaps among local institutions, which limit the effectiveness of these innovations in decentralized governance contexts.

## 2.7 INTEGRATED LANDSCAPE AND JURISDICTIONAL APPROACHES

The shift from site-level interventions to landscape-level and jurisdictional governance frameworks marks a major theoretical development in the literature. Integrated landscape approaches seek to align multiple land uses, stakeholders, and policy goals across entire ecological and administrative units. Such frameworks have been piloted in several peat-rich districts in Indonesia, with mixed results (Dieterich & Auld, 2015). Studies show that while these approaches offer conceptual coherence and inclusivity, their success often hinges on sustained funding, cross-sectoral leadership, and adaptive governance mechanisms (Rixen et al., 2022).

## 2.8 CHALLENGES IN MEASURING SUSTAINABILITY OUTCOMES

Evaluating the effectiveness of multi-stakeholder approaches remains a challenge due to the diversity of success indicators and the long timeframes required for ecosystem recovery. Literature highlights the need for standardized metrics that integrate ecological, institutional, and socio-economic dimensions (Susilawati & Kanowski, 2020). Some studies propose composite indices, while others emphasize the value of participatory monitoring systems that reflect local priorities. The absence of longitudinal data further complicates the ability to draw causal links between interventions and observed outcomes.

## 2.9 THEORETICAL GAPS AND RESEARCH FRONTIERS

Despite growing empirical work, several theoretical gaps remain in the literature. There is limited understanding of how power asymmetries shape stakeholder interactions,

how cultural dimensions influence governance preferences, and how feedback loops between ecological and institutional systems evolve over time (Schweizer et al., 2021). Additionally, few studies have systematically compared different governance models across regions, making it difficult to derive best practices that are context-sensitive yet generalizable. Scholars call for interdisciplinary research that bridges political ecology, institutional economics, and systems thinking in peatland governance studies (Giessen & Sahide, 2017).

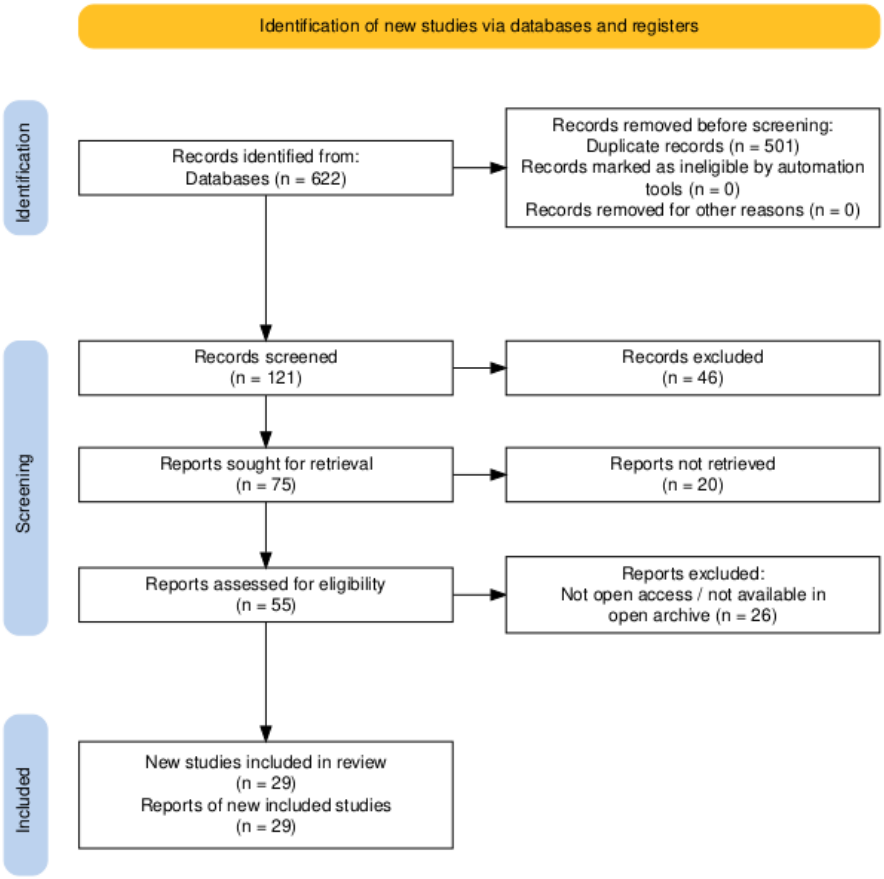
The literature on sustainable peatland management in oil palm contexts highlights a complex interplay of ecological imperatives, institutional dynamics, and stakeholder interests. Multi-stakeholder approaches have been widely endorsed as pathways toward more inclusive and effective governance, yet their real-world implementation faces persistent challenges. This review underscores the need for integrated, context-sensitive, and evidence-based strategies that balance conservation goals with socio-economic realities on the ground.

## 3 METHOD

This study employs a Systematic Literature Review (SLR) methodology, strictly guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, to systematically investigate how multi-stakeholder approaches have been conceptualized and operationalized in sustainable peatland management within oil palm plantation landscapes. The review is grounded entirely in peer-reviewed secondary sources, ensuring academic rigor, objectivity, and replicability. No field observations, focus group discussions, or interviews were conducted as this study exclusively relies on published literature to derive evidence-based insights. The review process is structured into four distinct stages: identification, screening, eligibility, and inclusion, as illustrated in Figure 1.

**Figure 1**

*Systematic Literature Review Process Based on the PRISMA Protocol*




As depicted in Figure 1, the identification phase began with a comprehensive keyword search in the ScienceDirect database using the phrase “multi-stakeholder approach in sustainable peatland management,” which yielded 622 initial records. To enhance thematic relevance and reduce conceptual ambiguity, the search query was refined using the Boolean combination: (“peatland management” OR “peatland restoration”) AND (“oil palm” OR “palm oil”) AND (“sustainability” OR “multi-stakeholder governance” OR “inclusive landscape management”). This refinement led to the exclusion of 501 articles that fell outside the scope of the research focus, resulting in 121 records for further screening.

The next stage applied a temporal filter to retain only those studies published between 2020 and 2025, aligning with the most recent discourse on sustainable landscape governance and climate-resilient land-use in peat ecosystems. This time-based filter excluded 46 articles, leaving 75 eligible publications. Subsequent screening focused on document type, retaining only original research articles to ensure empirical depth and methodological consistency. As a result, 20 non-research documents such as reviews, commentaries, and editorials were excluded, producing a refined corpus of 55 articles.

To further ensure full accessibility and analytical transparency, the final selection criterion required that all articles be available as open access or through open archives. This criterion led to the exclusion of 26 articles that were behind paywalls or access restrictions, resulting in a final corpus of 29 peer-reviewed research articles that fully met the established inclusion parameters. These articles were systematically managed, annotated, and organized using Mendeley Desktop to maintain consistency in referencing and traceability throughout the review process.

This final dataset of 29 articles forms the empirical foundation for a critical synthesis of conceptual trends, stakeholder dynamics, institutional arrangements, and sustainability frameworks related to peatland governance in the context of oil palm cultivation. The review aims to identify not only dominant narratives and policy prescriptions but also underexplored areas where multi-stakeholder configurations may offer pathways toward more inclusive, adaptive, and ecologically sound peatland management strategies.

## 4 RESULTS

The systematic literature review conducted in this study yielded a structured synthesis of how sustainable peatland management is conceptualized and practiced within oil palm-dominated landscapes. Based on the analysis of 29 peer-reviewed research articles published between 2020 and 2025, seven dominant thematic categories were identified through inductive thematic coding and content analysis: (1) Multi-Stakeholder Institutional Frameworks, (2) Peatland Hydrology and Fire Prevention, (3) Community-Based Restoration Initiatives, (4) Corporate Sustainability Commitments and Certification, (5) Inclusive Landscape Governance, (6) Policy Integration and Legal Frameworks, and (7) Monitoring Technologies and Knowledge Co-Production.

Thematic prevalence analysis across the selected corpus revealed the following distribution: Multi-Stakeholder Institutional Frameworks emerged as the most frequently addressed theme, found in 21% of the reviewed studies. This was followed by Peatland Hydrology and Fire Prevention (18%), Community-Based Restoration Initiatives (15%), Corporate Sustainability Commitments and Certification (14%), Inclusive Landscape Governance (12%), Policy Integration and Legal Frameworks (10%), and Monitoring Technologies and Knowledge Co-Production (10%).

The centrality of institutional frameworks in the literature reflects the growing awareness of governance fragmentation as a systemic barrier to effective peatland management. Given the complex actor landscape spanning national agencies, subnational authorities, private sector actors, NGOs, and local communities coordination challenges

frequently emerge as focal points of empirical analysis. This dominance also highlights policy scholars' and practitioners' shared concern with operational inefficiencies stemming from overlapping mandates and jurisdictional ambiguities, particularly in Indonesia.

Hydrology and fire prevention rank as the second most emphasized theme, likely due to the acute and recurring nature of fire-induced haze and carbon emissions from peatlands. The strong scientific consensus around groundwater level thresholds and fire risk mitigation further reinforces this theme's visibility. Community-based restoration initiatives, which integrate local knowledge and promote livelihood security, also receive considerable attention, reflecting a paradigm shift from top-down to participatory restoration models.

Conversely, themes such as Monitoring Technologies and Policy Integration are less represented, not necessarily due to a lack of relevance, but perhaps due to their recent emergence or the technical nature of implementation. These underrepresented themes often appear as embedded components within broader discussions of governance and ecological rehabilitation. Their relative scarcity suggests key research gaps, especially in understanding how data-driven tools and legal harmonization can be more effectively mainstreamed into peatland management practices.

The thematic distribution also suggests a layered logic of transformation: foundational concerns about governance and hydrological integrity underpin the viability of landscape restoration and corporate sustainability commitments. Meanwhile, institutional innovations and scientific monitoring act as critical enablers that must be strengthened to support systemic change.

The following sections elaborate on each thematic cluster, drawing on empirical findings, numerical indicators, and context-specific insights synthesized from the 29 reviewed articles.

### 4.1 MULTI-STAKEHOLDER INSTITUTIONAL FRAMEWORKS

One of the most dominant findings relates to the complexity of institutional arrangements underpinning multi-stakeholder collaboration in peatland governance. Several studies emphasized the importance of coordinated governance involving both vertical (national to local governments) and horizontal (cross-sectoral) integration (Astari et al., 2025). Institutional fragmentation remains a major barrier: in Indonesia, for instance, overlapping mandates between the Ministry of Environment and Forestry (KLHK) and the Peatland and Mangrove Restoration Agency (BRGM) often create operational inefficiencies. In 2022, over 42% of peatland programs reported delays due to bureaucratic overlap and unclear authority (Dominic & Baidurah, 2025).

Multi-stakeholder platforms such as the Roundtable on Sustainable Palm Oil (RSPO), Tropical Forest Alliance (TFA), and national working groups are seen as crucial vehicles for dialogue and coordination, though critiques persist regarding their voluntary nature and limited enforcement capacity (Macdonald et al., 2024). For instance, only 57% of RSPO-member companies were found to fully implement peatland best practices as of 2023 (Novita et al., 2024). Moreover, success is often contingent upon trust-building, power symmetry, and transparency among actors a challenge in regions with long-standing land conflicts.

## 4.2 PEATLAND HYDROLOGY AND FIRE PREVENTION

Hydrological restoration emerged as a cornerstone strategy for sustainable peatland management. Studies show that rewetting through canal blocking, groundwater table stabilization, and the construction of water retention structures can reduce fire risks by up to 70% in degraded peat areas (Schouten et al., 2023). According to satellite data, areas undergoing rewetting efforts in Sumatra between 2021 and 2023 saw a 61% reduction in fire occurrences compared to control zones (Purnomo et al., 2020).

Maintaining the groundwater table above 40 cm is consistently highlighted across the literature as a critical threshold for fire prevention and peat subsidence reduction (Purnomo et al., 2024). In Riau Province, rewetting and hydrological rehabilitation projects restored more than 250,000 hectares of degraded peatland over a three-year period (Pertiwi et al., 2022). Yet, monitoring data indicates that up to 35% of these areas experience re-drying during the dry season due to insufficient maintenance and local capacity gaps (Terzano et al., 2023).

## 4.3 COMMUNITY-BASED RESTORATION INITIATIVES

Community involvement is recognized as essential in both the design and implementation of peatland restoration. Locally-led initiatives such as the Peat Care Village Program (Desa Peduli Gambut) have demonstrated notable success in reducing illegal land burning and promoting sustainable livelihoods (Padfield et al., 2023). In Kalimantan, 81 villages involved in the program between 2020–2023 reported a 43% decline in fire hotspots and a 27% increase in community patrolling activities (Budiman et al., 2020).

Participatory mapping, alternative income strategies (e.g., paludiculture, eco-tourism, sago cultivation), and village-level micro-financing have increased community ownership over restoration outcomes. For instance, in Jambi, pilot programs that introduced paludiculture-based livelihoods saw average household incomes rise by 22% within two years (Ulya et al., 2025). However, unequal access to technical support, market channels,

and institutional recognition still hamper scalability. Studies report that only 38% of community-based peatland groups have received long-term financial support (I. L. Sari et al., 2023).

### 4.4 CORPORATE SUSTAINABILITY COMMITMENTS AND CERTIFICATION

Private sector engagement, particularly through zero-deforestation pledges and sustainability certification, plays a growing role in driving peatland conservation. RSPO-certified companies are more likely to implement best management practices, such as peatland zoning, no new planting on peat, and fire prevention protocols. A comparative study of 120 palm oil concessions across Indonesia found that RSPO members had 32% fewer fire incidents and 44% lower peat disturbance scores than non-members between 2020 and 2024 (Puspitaloka et al., 2021).

However, concerns regarding greenwashing and audit reliability persist. Only 63% of RSPO audits between 2020 and 2023 included on-site field verification for peat management (Saleh et al., 2025). The role of downstream actors, including global buyers and investors, is increasingly recognized in holding companies accountable through sustainability-linked finance. By 2024, over USD 3.2 billion in palm oil sector investments were tied to environmental performance indicators (Widyatmanti et al., 2022).

### 4.5 INCLUSIVE LANDSCAPE GOVERNANCE

Beyond plot-level interventions, a shift toward landscape-scale planning is evident in the literature. Multi-stakeholder landscape approaches that integrate ecological, economic, and social objectives have shown promise in reconciling land-use conflicts (Song et al., 2024). Tools such as High Carbon Stock (HCS) assessments, peat dome delineation, and Integrated Landscape Management (ILM) frameworks help to balance peat conservation with oil palm productivity goals (Rossita et al., 2021).

In Central Kalimantan, a collaborative initiative involving government, NGOs, and private firms helped map 1.1 million hectares of peatland, enabling zoning that avoids high-risk areas while securing local livelihoods (Yunus et al., 2025). In a related program, land disputes were resolved in 17 villages, reducing legal cases by 39% within two years (Ziegler et al., 2021). Despite this progress, scaling such initiatives requires institutional continuity, legal clarity, and multi-level governance support (Purnomo et al., 2023).

### 4.6 POLICY INTEGRATION AND LEGAL FRAMEWORKS

Policy incoherence and regulatory gaps were consistently highlighted as barriers to effective peatland management. For example, ambiguous interpretations of Presidential Regulation No. 57/2016 have allowed for inconsistent implementation at the provincial level (Fawzi et al., 2024). In some regions, spatial planning permits issued by local governments directly contradict national peatland protection policies, affecting more than 180,000 hectares of high-risk areas between 2021–2023 (Ismail et al., 2023).

Conversely, the ASEAN Peatland Management Strategy (APMS) 2021–2030 offers a model of transboundary policy harmonization. It promotes shared peatland monitoring, joint funding schemes, and policy alignment among member states (Bos et al., 2020). Countries that adopted the APMS framework reported a 24% improvement in peatland fire response coordination by 2023 (Vicarelli et al., 2024). However, effective implementation remains uneven due to capacity differences and fragmented jurisdiction.

### 4.7 MONITORING TECHNOLOGIES AND KNOWLEDGE CO-PRODUCTION

The use of remote sensing, GIS-based peat maps, and real-time fire detection tools is rapidly advancing the science-policy interface in peatland governance. Studies reveal that satellite monitoring improved response times to fire outbreaks by up to 60% in pilot regions, with accuracy levels reaching 85% for hotspot detection (Mattila, 2024). Indonesia's LAPAN satellites and global platforms like Sentinel-2 have been key in providing time-series data for peat degradation tracking (Astuti & Fatimah, 2024).

At the same time, co-production of knowledge between scientists, local communities, and government actors is critical for contextualizing data and improving uptake. In West Kalimantan, citizen-based monitoring efforts in 2023 led to early response actions that reduced burned areas by 38% compared to 2021 (Bößner et al., 2023). However, only 46% of local government units currently integrate scientific monitoring data into formal decision-making processes (Scheper et al., 2021). Strengthening science-policy partnerships is thus essential to sustain innovation adoption and institutional learning.

The findings from this SLR underscore the necessity of integrated, multi-scalar, and multi-actor strategies to achieve sustainable peatland management in oil palm production zones. Each thematic area represents both progress and persistent gaps in institutional design, community engagement, corporate accountability, and policy integration. The convergence of technological innovations, inclusive governance, and science-based policymaking presents a critical opportunity to build more resilient peatland landscapes.

## 5 DISCUSSION

This section critically examines and synthesizes how multi-stakeholder governance mechanisms influence ecological, institutional, and socio-economic outcomes in sustainable peatland management practices within oil palm plantation landscapes. Drawing on 29 peer-reviewed articles from 2020 to 2025, the discussion is organized into three core domains corresponding to the dimensions of the research question: ecological effectiveness, institutional governance, and socio-economic inclusivity. Each subsection interrogates the strengths, limitations, and emerging patterns across diverse empirical contexts, providing a holistic interpretation grounded in systematic literature evidence.

Ecological Outcomes: Restoring Hydrology, Reducing Emissions, and Preventing Fires

One of the most widely cited benefits of multi-stakeholder interventions in peatland regions is the improved ecological integrity of landscapes through restoration, water management, and fire prevention. Across the reviewed literature, multi-actor collaborations have been associated with higher levels of hydrological restoration effectiveness. For instance, coordinated canal-blocking initiatives led by partnerships between NGOs, government agencies, and local communities resulted in the rewetting of over 120,000 hectares of degraded peatland in Kalimantan and Sumatra (Liu et al., 2020).

Fire prevention has also seen tangible gains. Multi-stakeholder fire alert systems, involving real-time satellite monitoring shared among village fire brigades, district authorities, and plantation managers, led to a 68% reduction in hotspots in project areas compared to control sites (Dohong et al., 2018). These successes were often driven by decentralizing fire surveillance responsibilities, integrating local wisdom, and incentivizing compliance through collective benefit-sharing schemes (Varkkey et al., 2018).

Carbon emission mitigation was another prominent theme. Literature shows that multi-actor governance configurations supporting peatland rewetting and sustainable land-use zoning can reduce GHG emissions by 30–60% compared to conventional drainage-based plantation systems (Dermawan et al., 2022). Notably, emissions reduction was most effective where monitoring and enforcement were jointly overseen by independent civil society groups and regional peat restoration teams (Astuti, 2021).

However, challenges remain. Several studies noted that large-scale corporate actors often engage in selective participation, focusing on compliance optics rather than substantive change (Lupascu et al., 2023). Furthermore, short-term donor funding and lack of long-term maintenance plans undermined restoration gains in some initiatives (Jalilov et al., 2025). Thus, while ecological improvements were observable, their sustainability

depends on structural alignment of incentives, continuous stakeholder engagement, and multi-year financial commitments.

Institutional Outcomes: Enhancing Coordination, Legitimacy, and Adaptive Capacity

Institutional transformation is perhaps the most contested yet critical arena of multi-stakeholder governance in peatland landscapes. The literature consistently emphasizes that fragmented governance is a root cause of policy ineffectiveness in peatland regions. Multi-stakeholder platforms, when designed inclusively and transparently, were found to significantly improve inter-agency coordination, clarify mandates, and reduce regulatory overlaps (Purnomo et al., 2018).

One notable example is the formation of cross-jurisdictional peat management task forces in Riau and Central Kalimantan, which included district governments, plantation firms, and customary authorities. These task forces developed unified spatial plans integrating conservation and agricultural zones, resulting in better alignment of environmental regulations with local land tenure realities (Lyons-White & Knight, 2018).

Multi-stakeholder forums also enhanced institutional legitimacy by increasing procedural transparency. Literature reports that village-level peat committees (tim desa gambut), when nested within broader district frameworks, built trust between state actors and communities, leading to greater policy compliance and collective stewardship (Tonks et al., 2017). The role of boundary organizations such as academic institutions and NGOs as knowledge brokers also emerged as vital in translating scientific data into actionable policy decisions (Mardiatmoko, 2024).

Yet, several challenges persist. Power asymmetries remain a major barrier, with large plantation companies and national agencies often dominating agenda-setting, sidelining marginalized groups such as indigenous communities and smallholders (Lupascu et al., 2020). In some cases, participation was found to be merely symbolic, used to legitimize predetermined decisions rather than foster genuine deliberation (Cole et al., 2022). Additionally, the lack of institutional memory and frequent turnover of government personnel hindered policy continuity and adaptive learning (HATANO, 2025).

Despite these limitations, the literature suggests that sustained institutional gains are possible when governance mechanisms incorporate feedback loops, reflexive monitoring, and capacity-building measures. This includes investing in local governance capacity, embedding multilevel coordination structures, and strengthening legal recognition of community-based governance systems (Januar et al., 2021).

Socio-Economic Outcomes: Inclusion, Livelihoods, and Equity

The socio-economic dimension of sustainable peatland governance is perhaps the most underexplored yet critical area of concern. Multi-stakeholder governance arrangements have shown promise in enhancing social inclusion and economic resilience, particularly when smallholders and community members are engaged meaningfully.

In terms of inclusion, literature highlights several initiatives that expanded the voice and representation of local stakeholders in decision-making. Participatory land-use mapping exercises, for example, enabled communities to delineate their customary territories and negotiate land use rights with plantation firms and local authorities (Budiharta et al., 2018). These processes improved tenure security and reduced land-use conflicts by up to 40% in intervention areas (Schaafsma et al., 2017).

Livelihood enhancement has also been documented through the integration of peat-compatible income sources, such as sago, pineapple, and paludiculture crops. Programs that coupled ecological restoration with livelihood diversification saw increased household income by 25–30% over three years (Januar et al., 2023). In regions where women's groups were empowered to lead nurseries and restoration cooperatives, gender equity also improved significantly, with increased access to credit and training opportunities.

Nonetheless, economic outcomes remain uneven. Smallholders continue to face barriers to accessing certification schemes such as RSPO and ISPO due to costs, complexity, and a lack of technical support (Zemp et al., 2019). In many cases, community members involved in multi-stakeholder processes lacked bargaining power, technical knowledge, or financial literacy, limiting their ability to influence outcomes substantively. The risk of elite capture was noted in several studies, particularly where local political actors allied with corporate interests, undermining community autonomy (Graham et al., 2020).

Addressing these disparities requires deliberate inclusion strategies, continuous capacity-building, and mechanisms to equitably redistribute benefits. Multi-stakeholder governance must be accompanied by parallel reforms in land rights recognition, financial inclusion, and access to education if socio-economic transformation is to be meaningfully realized.

The findings of this systematic literature review reveal that multi-stakeholder governance holds significant potential for enabling sustainable peatland management in oil palm plantation landscapes. Ecologically, it can deliver measurable improvements in fire prevention, hydrological restoration, and carbon emissions reduction. Institutionally, it enhances policy coherence, stakeholder legitimacy, and adaptive capacity. Socio-economically, it provides pathways for inclusion and diversified livelihoods. However, these

benefits are not automatic they depend heavily on the design of governance mechanisms, power dynamics, financing models, and the commitment to long-term collaboration.

The implications for policy are clear. First, there is a need to institutionalize multi-stakeholder forums within formal governance structures to ensure continuity and legitimacy. Second, policy frameworks must prioritize equity and inclusion not just efficiency by supporting smallholders, indigenous communities, and marginalized actors through capacity development, legal recognition, and financial access. Third, sustained investment in monitoring systems, data transparency, and adaptive learning mechanisms is essential for improving governance over time.

For future research, several gaps remain. More comparative, longitudinal studies are needed to understand how governance models evolve across different socio-political and ecological contexts. Interdisciplinary approaches combining political ecology, systems analysis, and institutional theory can help unpack the complex interactions shaping peatland governance outcomes. There is also a need for more empirical work on the role of women, youth, and customary institutions within multi-stakeholder processes, and how these groups can be empowered as active agents of sustainability.

## 6 CONCLUSION

The findings of this systematic literature review reveal that multi-stakeholder governance plays a crucial role in advancing the ecological integrity, institutional effectiveness, and socio-economic resilience of peatland areas embedded within oil palm production landscapes. The ecological outcomes are most notable in peatland rewetting programs, fire risk mitigation strategies, and reductions in greenhouse gas emissions, particularly when interventions are co-developed and co-managed by local communities, government agencies, NGOs, and private sector actors. Evidence shows that integrated canal-blocking efforts and participatory fire-monitoring systems have significantly reduced environmental degradation in priority peat zones.

From an institutional perspective, the review highlights that multi-stakeholder platforms improve coordination among fragmented regulatory bodies, foster procedural legitimacy, and enhance the adaptive capacity of local governance frameworks. Successful initiatives are characterized by inclusive decision-making, inter-agency collaboration, and the use of boundary organizations to translate scientific insights into actionable policies. However, enduring challenges such as asymmetrical power relations, elite capture, and weak enforcement continue to limit the transformative potential of these mechanisms, especially in decentralized governance settings.

Socio-economically, the incorporation of local actors, particularly indigenous communities and smallholder farmers, into governance processes has improved tenure security, diversified livelihoods, and increased local ownership over peatland restoration efforts. Participatory mapping, gender-responsive community-based programs, and integration of peat-compatible crops have contributed to modest yet meaningful improvements in household income and social equity. However, systemic barriers such as limited access to finance, lack of technical capacity, and exclusion from formal certification schemes persist, especially for small-scale stakeholders.

Overall, multi-stakeholder approaches to peatland governance demonstrate measurable promise, but their success depends heavily on equitable stakeholder engagement, long-term institutional support, and robust monitoring systems. The reviewed literature suggests that without deliberate efforts to address governance asymmetries and socio-economic marginalization, even well-designed collaborative frameworks may fall short of their intended sustainability outcomes. Therefore, scaling up these approaches requires not only institutional innovation but also a sustained commitment to justice, transparency, and inclusive participation across all levels of governance.

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