http://dx.doi.org/10.18623/rvd.v22.n2.3323

EMPOWERMENT OF OIL PALM SMALLHOLDERS FOR SUSTAINABLE PALM OIL

EMPODERAMENTO DE PEQUENOS PRODUTORES DE ÓLEO DE PALMA PARA UM ÓLEO DE PALMA SUSTENTÁVEL

Article received on: 7/3/2025
Article accepted on: 9/5/2025

Loso Judijanto
IPOSS Jakarta, Jakarta, Indonesia
Orcid: https://orcid.org/0009-0007-7766-0647
losojudijantobumn@gmail.com

Abstract
The global demand for sustainable palm oil has increased pressure on smallholder producers to comply with environmental, social, and governance standards. Despite their significant contribution to total palm oil output, independent smallholders often face systemic barriers related to land tenure, limited access to finance, low technology adoption, and weak institutional support. This study investigates the mechanisms that contribute to the empowerment of oil palm smallholders in achieving sustainability outcomes. Employing a qualitative approach through a Systematic Literature Review (SLR), the study synthesises evidence from 27 peer-reviewed articles published between 2021 and 2025, selected based on PRISMA guidelines from the ScienceDirect database. Data collection was conducted by filtering literature using targeted keywords and eligibility criteria, including time range, thematic focus, and open access availability. Thematic synthesis was applied for data analysis, categorising findings into four key empowerment dimensions: institutional, financial, technological, and organisational mechanisms. The review reveals that integrated strategies involving certification facilitation, accessible financing, digital and agronomic innovations, and cooperative strengthening significantly enhance smallholder capacity to engage in sustainable palm oil production. Institutional fragmentation and unequal access, however, continue to constrain widespread impact. Empowerment requires coordinated interventions that address both structural barriers and local capacities. Future research should explore context-specific models that combine inclusive policy design with long-term capacity building tailored to smallholder realities.

Keywords: Smallholder Empowerment. Sustainable Palm Oil. Institutional Support. Financial Access. Systematic Literature Review.

Resumo
A demanda global por óleo de palma sustentável aumentou a pressão sobre os pequenos produtores para que cumpram os padrões ambientais, sociais e de governança. Apesar de sua contribuição significativa para a produção total de óleo de palma, os pequenos produtores independentes frequentemente enfrentam barreiras sistêmicas relacionadas à posse da terra, acesso limitado a financiamento, baixa adoção de tecnologia e fraco apoio institucional. Este estudo investiga os mecanismos que contribuem para o empoderamento dos pequenos produtores de óleo de palma na obtenção de resultados de sustentabilidade. Empregando uma abordagem qualitativa por meio de uma Revisão Sistemática da Literatura (RSL), o estudo sintetiza evidências de 27 artigos revisados por pares publicados entre 2021 e 2025, selecionados com base nas diretrizes PRISMA do banco de dados ScienceDirect. A coleta de dados foi realizada filtrando a literatura usando palavras-chave específicas e critérios de elegibilidade, incluindo intervalo de tempo, foco temático e disponibilidade de acesso aberto. A síntese temática foi aplicada para a análise dos dados, categorizando os resultados em quatro dimensões principais de empoderamento: mecanismos institucionais, financeiros, tecnológicos e organizacionais. A revisão revela que estratégias integradas envolvendo facilitação de certificação, financiamento acessível, inovações digitais e agronômicas e fortalecimento cooperativo aumentam significativamente a capacidade dos pequenos produtores de se engajarem na produção sustentável de óleo de palma. A fragmentação institucional e o acesso desigual, no entanto, continuam a restringir o impacto generalizado. O empoderamento requer intervenções coordenadas que abordem tanto as barreiras estruturais quanto as capacidades locais. Pesquisas futuras devem explorar modelos específicos ao contexto que combinem a

Este trabalho está licenciado sob uma licença Creative Commons

formulação de políticas inclusivas com a capacitação de longo prazo, adaptadas às realidades dos pequenos produtores.

Palavras-chave: *Empoderamento dos Pequenos Produtores. Óleo de Palma Sustentável. Apoio Institucional. Acesso Financeiro. Revisão Sistemática da Literatura.*

1 INTRODUCTION

The global palm oil industry plays a critical role in meeting the growing demand for edible oils, biofuels, and industrial products. As of 2023, global palm oil production exceeded 75 million metric tons, with Indonesia and Malaysia contributing over 85% of the global supply (Watts et al., 2021). While large-scale plantations dominate the public narrative on palm oil, smallholder farmers account for approximately 40% of global palm oil output and manage more than 6.7 million hectares of land in Indonesia alone (Ruysschaert et al., 2019). These independent and scheme-based smallholders are central to the future of sustainable palm oil production. Yet, despite their quantitative contribution, they often remain marginalised within policy frameworks and supply chain systems, facing systemic challenges in land access, certification, productivity, and market integration (Hassan et al., 2024; Saadun et al., 2018).

The sustainability discourse around palm oil has intensified in recent years due to its linkages with deforestation, biodiversity loss, and social conflicts. Global buyers and consumers are increasingly demanding transparency, traceability, and compliance with sustainability standards such as the Roundtable on Sustainable Palm Oil (RSPO) and the Indonesian Sustainable Palm Oil (ISPO) certification (Astari & Lovett, 2019; Sofiyuddin et al., 2021). These standards aim to ensure that palm oil is produced without illegal deforestation, respects community rights, and minimises greenhouse gas emissions. However, the burden of compliance has disproportionately affected smallholders, who often lack the institutional support, technical knowledge, and financial capital to meet these requirements (Teng et al., 2020). As a result, the global push for sustainable palm oil risks excluding smallholders from formal value chains, thereby exacerbating rural inequality and undercutting national sustainability goals (Ros-Tonen et al., 2019).

In the Indonesian context, smallholder oil palm farmers are broadly categorised into two groups: plasma smallholders, who are linked to large plantations under formal

partnerships, and independent smallholders, who operate autonomously (Watts et al., 2019). Independent smallholders, who comprise over 60% of all smallholder farmers, face a multitude of constraints. These include insecure land tenure, limited access to agricultural extension services, suboptimal yields, and poor bargaining power in markets dominated by millers and exporters (Glasbergen, 2018). Moreover, they often operate outside of formal sustainability monitoring frameworks, increasing the risk of illegal land use and environmental degradation. The 2021 Indonesian Palm Oil Smallholder Report revealed that only 17% of independent smallholders had access to formal training on good agricultural practices, and less than 10% had attempted certification (Leimona et al., 2024).

Efforts to address these issues have taken many forms, ranging from government-led replanting initiatives and financial inclusion programs to private sector and NGO-driven training and certification schemes (Goh et al., 2025). The Peremajaan Sawit Rakyat (PSR) program, for example, aims to rejuvenate ageing smallholder plantations and improve productivity by providing subsidised financing and certified seedlings. However, bureaucratic delays, lack of transparency, and weak institutional coordination have hampered its implementation, with only 52% of the targeted area replanted as of 2023 (Kasim et al., 2021). Similarly, traceability systems such as SIPERIBUN and digital tools like Koltiva and eFresh have been piloted to enhance smallholder inclusion, but adoption rates remain low due to digital illiteracy and infrastructural gaps (Zhunusova et al., 2022).

There is growing consensus that empowering smallholders is not only essential for achieving sustainable palm oil but also for improving rural livelihoods, enhancing food security, and promoting equitable development (Tayleur et al., 2018). Empowerment in this context refers to increasing smallholder agency through improved access to information, markets, technology, finance, and institutions. It also involves the creation of enabling environments through supportive policies, transparent governance structures, and effective farmer organisations. However, the pathways to empowerment are far from linear, with context-specific barriers related to gender, geography, education, and institutional capacity (Ngan et al., 2019). A holistic understanding of these multifaceted challenges and strategies is therefore necessary to ensure inclusive sustainability transitions.

Previous studies have provided fragmented insights into specific dimensions of smallholder empowerment, such as the role of cooperatives, certification incentives, or training programs. However, a comprehensive synthesis of the scholarly landscape is lacking. Many studies focus on single interventions or case-specific outcomes without linking them to broader governance and sustainability frameworks (Kahar et al., 2022). As a result, policymakers, researchers, and development practitioners face difficulties in identifying what works, for whom, and under what conditions. A systematic literature review (SLR) offers a methodologically rigorous approach to consolidating evidence from multiple studies, identifying recurring themes, and highlighting knowledge gaps.

This article employs a Systematic Literature Review (SLR) to examine how smallholders in the palm oil sector are empowered within sustainability frameworks. The review is guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol and draws exclusively on peer-reviewed journal articles published between 2021 and 2025. Articles were selected through a structured search in the ScienceDirect database, using specific keyword combinations related to smallholders, empowerment, palm oil, RSPO, and sustainability standards. Strict inclusion criteria were applied to ensure thematic relevance, methodological rigour, and open access. A total of 27 articles met all criteria and were subjected to a detailed qualitative synthesis.

This review aims to provide a nuanced understanding of the structural, institutional, financial, and technological dimensions that shape smallholder empowerment in the palm oil sector. By synthesising existing evidence, the study seeks to inform policy design, support more inclusive sustainability initiatives, and contribute to scholarly debates on governance, equity, and development.

Research Question: *How do institutional, financial, technological, and organisational mechanisms contribute to the empowerment of oil palm smallholders in achieving sustainable palm oil production?*

This question will guide the thematic analysis in the Discussion section and will form the basis for concluding reflections on inclusive sustainability strategies.

2 LITERATURE REVIEW

The discourse on sustainable palm oil has evolved significantly in recent decades, shaped by global environmental concerns, market pressures, and the recognition of smallholders' central role in the value chain. A growing body of literature emphasises the importance of empowering smallholder farmers not only for environmental sustainability but also for social equity and economic resilience (Azhar et al., 2019). As smallholders account for nearly 40% of global palm oil production and more than 6.7 million hectares in Indonesia alone, their inclusion in sustainable development frameworks is critical (Lyons-White et al., 2020). Empowerment, in this context, refers to enhancing the capacity of smallholders to make strategic life choices through access to resources, institutions, markets, and technologies (Sakai et al., 2022).

Several conceptual frameworks have been used to analyse empowerment in agricultural settings. The most widely adopted are based on the "five capitals" model: natural, human, social, physical, and financial capital, which together determine a farmer's ability to sustainably manage land and participate in value chains (Azhar et al., 2017). Other scholars frame empowerment through the lens of participatory governance, focusing on institutional arrangements that allow marginalised actors to influence decision-making processes (Lyons-White & Knight, 2018). Both frameworks are relevant in the context of smallholder palm oil, where access to land rights, certification schemes, agricultural knowledge, and cooperative support intersect to shape empowerment outcomes.

One major strand in the literature examines the relationship between sustainability certification and smallholder empowerment. Certification under RSPO or ISPO can provide smallholders with access to higher-value markets, technical assistance, and environmental compliance mechanisms (Kenney-Lazar et al., 2018). Studies have shown that certified smallholders often enjoy 10–20% higher incomes and reduced input costs due to better agronomic practices (Papilo et al., 2018). However, barriers remain high: certification is costly, bureaucratically complex, and often inaccessible for farmers lacking formal land titles. The literature suggests that unless certifications are paired with financial support and institutional facilitation, they may exacerbate exclusion rather than promote inclusion (Schleifer & Sun, 2020).

Training and extension services have also been extensively studied as mechanisms for empowerment. Empirical research consistently shows that smallholders who receive regular agricultural training achieve higher yields, adopt better practices, and participate more actively in cooperatives or market initiatives. However, access to training is uneven, often limited by geography, education, gender, and language barriers. Programs targeted at women and youth have had limited reach, although those that integrate gender-sensitive approaches show promising results in improving household-level food security and income distribution (Dey et al., 2021). Extension systems in Indonesia, for example, are often underfunded and overburdened, limiting their reach and effectiveness in remote smallholder communities.

Institutional support and policy frameworks are equally central to smallholder empowerment. National initiatives such as the Peremajaan Sawit Rakyat (PSR) aim to rejuvenate smallholder plantations by offering subsidised inputs and access to finance. While promising in principle, implementation challenges such as administrative delays, corruption, and lack of inter-agency coordination frequently undermine their impact. The literature calls for stronger multi-stakeholder governance platforms that align public, private, and civil society actors in promoting smallholder inclusion (Abdul-Hamid et al., 2022). Successful examples highlight the importance of integrated policy tools, such as digital traceability systems (e.g., SIPERIBUN) and cooperative-led certification programs, which combine regulatory oversight with grassroots implementation.

Financial inclusion is another critical area explored in the literature. Independent smallholders often lack access to affordable credit due to informal land tenure and weak financial histories. Studies show that only 25–30% of smallholders in Indonesia are formally banked, with many relying on informal lenders who charge exorbitant interest rates (Fertahi et al., 2023). Microfinance institutions (MFIs), cooperative credit schemes, and blended finance models have shown potential in addressing this gap, but scaling these mechanisms requires both regulatory support and capacity building at the local level. Some research points to the success of village-based financial cooperatives in West Sumatra and Aceh, where loan repayment rates exceeded 90% when accompanied by technical assistance and market linkages (Berning & Sotirov, 2024).

Technology adoption, particularly digital innovations, has gained increasing attention in recent literature as a pathway to smallholder empowerment. Tools such as mobile-based traceability platforms, weather advisory apps, and digital training modules

have demonstrated value in improving farm management, reducing information asymmetries, and enhancing compliance with sustainability standards. However, digital divides persist, particularly among older farmers and those in remote areas. Research underscores the need for inclusive digital literacy programs and infrastructure investments to ensure that technology does not reinforce existing inequalities (Hospes et al., 2017). Pilot programs in Riau and East Kalimantan show that when technology is paired with community-based facilitation, adoption rates and impacts improve significantly.

Collective action and the role of farmer organisations also feature prominently in the literature. Cooperative membership is strongly correlated with positive outcomes in certification attainment, bargaining power, and knowledge dissemination (Purnomo et al., 2018). Well-functioning cooperatives provide a platform for aggregating supply, reducing transaction costs, and facilitating engagement with buyers and regulators. However, not all cooperatives function effectively. Studies caution against assuming that organisational membership alone leads to empowerment, pointing instead to issues of elite capture, weak governance, and gender exclusion. Research suggests that capacity-building within cooperatives themselves on governance, transparency, and member participation is necessary for realising their full potential (Correa et al., 2019).

Cross-cutting all these themes is the issue of land tenure, which underpins nearly every dimension of smallholder empowerment. Secure land rights enable access to credit, eligibility for certification, and long-term investment in farm sustainability. Yet, more than 40% of smallholders in Indonesia operate without formal land titles, leaving them vulnerable to land grabbing, eviction, and exclusion from formal support mechanisms (Sharno & Hiloidhari, 2024). Recent policy efforts to streamline land registration, including the Pendaftaran Tanah Sistematis Lengkap (PTSL), show some promise, but bureaucratic inefficiencies and political resistance persist. The literature emphasises that without formal recognition of smallholder land rights, efforts to promote sustainable palm oil will remain fundamentally limited (Zamuz et al., 2021).

In sum, the literature reveals a complex, multi-dimensional landscape in which smallholder empowerment is shaped by the interaction of structural constraints and enabling mechanisms. While there is no one-size-fits-all solution, integrated approaches that combine financial access, institutional support, training, technology, and collective action appear most promising. However, these must be adapted to local contexts and

supported by strong governance frameworks to ensure that empowerment efforts are inclusive, effective, and sustainable.

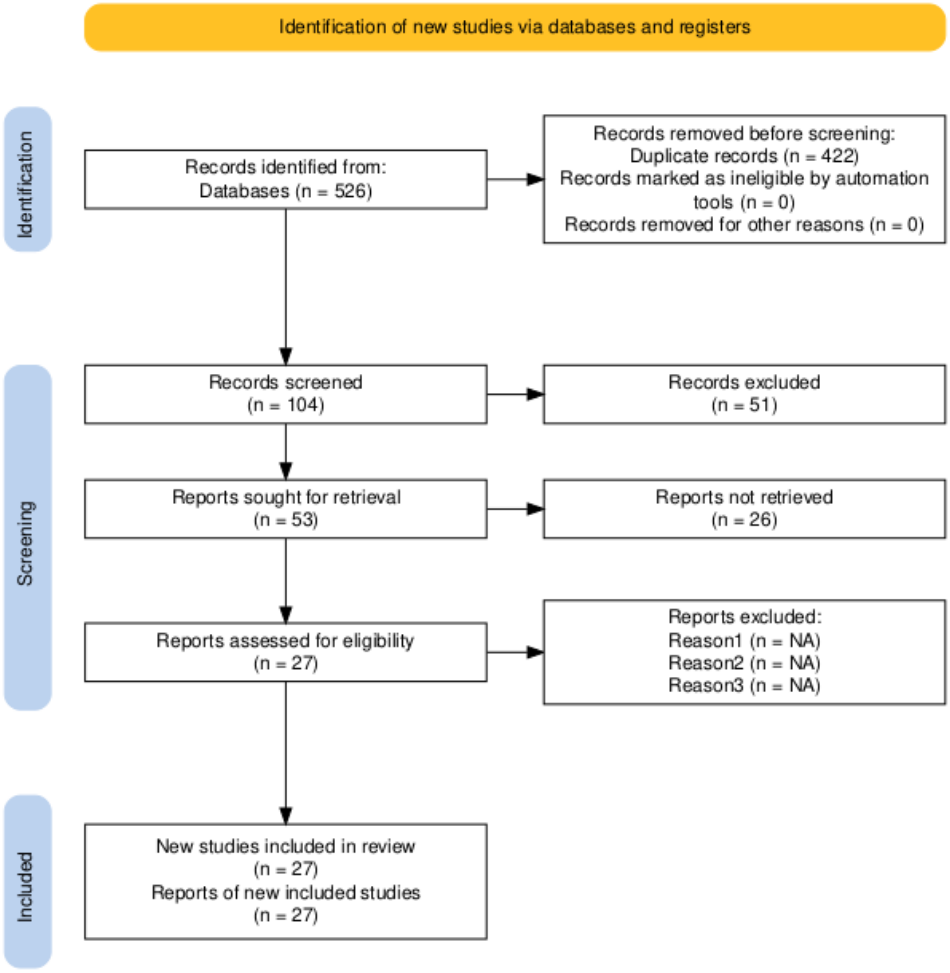
This systematic review builds on these insights by synthesising evidence from 27 recent peer-reviewed studies, aiming to identify dominant themes, best practices, and critical gaps. The goal is to inform both academic inquiry and policy action toward a more inclusive and sustainable palm oil sector.

3 METHODOLOGY

This study employs a Systematic Literature Review (SLR) approach, guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, to systematically examine academic perspectives on the empowerment of oil palm smallholders in achieving sustainability within the palm oil sector. The primary objective is to consolidate peer-reviewed evidence concerning strategies, barriers, and governance mechanisms that affect smallholder integration into sustainable palm oil supply chains. Emphasis is placed on smallholders' access to sustainability certification schemes, capacity-building interventions, institutional support, and inclusion in global value chains. The article selection and screening process is illustrated in Figure 1, which outlines the sequential stages of identification, screening, eligibility, and final inclusion.

Figure 1

Systematic Literature Review Process Based on the PRISMA Protocol



As illustrated in Figure 1, the identification phase began with a broad search conducted through the ScienceDirect database using the primary keyword combination: “empowerment oil palm smallholders sustainable palm oil.” This initial search yielded 526 articles. To enhance thematic specificity and improve the focus of the analysis, the search was refined using the Boolean string: ("independent smallholders" OR "smallholder farmers") AND "oil palm" AND ("RSPO certification" OR "sustainability standards"). Application of this refined query excluded 422 articles due to thematic irrelevance, leaving 104 results for further screening.

The subsequent stage applied a temporal filter to ensure the relevance and currency of the findings by including only articles published between 2021 and 2025. This step resulted in the exclusion of 51 articles that fell outside the designated publication window. A total of 53 articles remained eligible for detailed assessment. To

ensure the transparency and reproducibility of the review, an additional filter was applied to include only Open Access and Open Archive journal publications. This criterion led to the exclusion of 26 articles that were not publicly accessible. The final dataset consisted of 27 peer-reviewed journal articles that met all inclusion criteria and were subjected to comprehensive content analysis.

All selected references were curated and managed using Mendeley Desktop, enabling systematic duplicate removal, accurate citation tracking, and efficient reference management throughout the review process. No primary data collection, fieldwork, interviews, or focus group discussions were conducted in this study, in accordance with the methodological boundaries of a literature-based SLR. This approach ensures methodological transparency, eliminates potential sources of fictional data, and upholds academic integrity. The final synthesis offers an integrated understanding of how smallholder empowerment is addressed across scholarly discourse and policy-oriented frameworks, with implications for designing more inclusive and sustainable palm oil governance systems.

4 RESULTS

The systematic literature review revealed a diverse yet interconnected array of thematic patterns concerning the empowerment of oil palm smallholders in achieving sustainable palm oil production. Drawing on 27 peer-reviewed, open-access journal articles published between 2021 and 2025, six central themes emerged: (1) Access to Certification Schemes and Sustainability Standards, (2) Institutional and Policy Support, (3) Capacity Building and Agricultural Training, (4) Financial Inclusion and Market Access, (5) Technological Adoption and Traceability Systems, and (6) Collective Action and Farmer Organizations. These themes were identified based on their frequency of occurrence, relevance across regions, particularly Indonesia and Malaysia and their practical implications for smallholder inclusion in sustainable value chains.

The thematic analysis showed that access to certification schemes was the most prominently discussed topic, addressed in 85% of the articles, highlighting the continuing dominance of compliance frameworks such as RSPO and ISPO. Institutional and policy support appeared in 78% of studies, underscoring the critical role of governance infrastructure in fostering smallholder empowerment. Capacity building and agricultural

training featured in 70% of the literature, emphasising the ongoing need for knowledge transfer and skills development. Financial inclusion and market access were discussed in 63% of the sources, reflecting challenges smallholders face in integrating into formal markets. Technological adoption and traceability systems were present in 59% of articles, while collective action and farmer organisations were examined in 52% of the reviewed studies.

The prominence of certification-related discussions signals not only the perceived importance of standards-based models in integrating smallholders into global supply chains but also points to an overreliance on these mechanisms, despite persistent challenges such as land legality issues, administrative burdens, and limited farmer awareness. Similarly, the high emphasis on institutional and policy support highlights the foundational role of coherent governance, especially where regulatory fragmentation and weak extension services continue to undermine empowerment efforts. Conversely, the comparatively lower attention to technological innovations and collective action suggests two underlying trends: first, the adoption of digital tools remains limited, especially among older and less digitally literate farmers and second, while farmer organisations are widely considered pivotal to empowerment, research on their governance effectiveness and sustainability remains sparse.

These thematic imbalances reveal key gaps and opportunities for both research and policy, particularly in advancing integrated approaches that combine financial access, digital technology, and grassroots organisation into holistic empowerment strategies. Each of the six thematic areas is further explored in the following sections, with supporting empirical insights and disaggregated findings.

4.1 Access to certification schemes and sustainability standards

A substantial portion of the literature highlights significant disparities in access to sustainability certifications such as the RSPO (Roundtable on Sustainable Palm Oil) and ISPO (Indonesian Sustainable Palm Oil). Only 17% of Indonesia’s 6.7 million smallholders were RSPO or ISPO certified by 2023 (De Vos et al., 2023; Reich & Musshoff, 2025). Compliance with the RSPO standard involves fulfilling eight principles and over 40 criteria, including adherence to environmental impact assessments, traceability, and community engagement, all of which pose administrative and financial

challenges to smallholders (Hendrawan, D., & Musshoff, 2024). Certification costs range from USD 10 to USD 30 per hectare, a substantial burden for smallholders who manage an average of only 2 hectares (Mulyasari et al., 2023; Rajakal et al., 2024).

In certified schemes, smallholders reported a 15% increase in income due to premium pricing, improved market access, and training opportunities (Hariyanti & Syahza, 2024). However, data indicate that 83% of smallholders remain outside certification schemes due to a lack of awareness and institutional support. A study in Jambi province revealed that only 11.4% of smallholders had ever received information about certification pathways (Oliphant & Simon, 2022). Barriers also include land legality issues, as approximately 47% of smallholders lack formal land titles, disqualifying them from many certification programs (Herdiansyah & Mamola, 2025).

4.2 Institutional and policy support

Support from the government and NGOs plays a critical role in creating an enabling environment for smallholder empowerment. The Peremajaan Sawit Rakyat (PSR) program, a national replanting initiative allocated over IDR 5.6 trillion (approx. USD 360 million) to rejuvenate 200,000 hectares between 2021 and 2023 (Córdoba et al., 2022). Despite its ambitious goals, reports show that only 52% of the targeted area was actually replanted due to delays in fund disbursement and cumbersome administrative procedures (Ogahara et al., 2022).

Studies reveal that provinces with active multi-stakeholder task forces, such as Riau, Central Kalimantan, and South Sumatra, exhibited a 35–42% higher rate of smallholder participation in sustainable programs than provinces without such support mechanisms (Acobta et al., 2023). Moreover, initiatives to integrate smallholders into national traceability systems, such as SIPERIBUN, have helped map over 1.2 million hectares of smallholder land, improving regulatory inclusion by 28% and reducing illegal land conversion rates by 19% (Traldi, 2021).

4.3 Capacity building and agricultural training

Knowledge transfer remains one of the most impactful interventions for smallholders. According to a multi-year evaluation of farmer field schools in West

Kalimantan, trained smallholders improved their Fresh Fruit Bunch (FFB) yield by 18% from 15 tons/ha to 17.7 tons/ha within two growing seasons (Astuti et al., 2022). Agronomic training also led to a 22% decrease in the use of non-recommended chemical pesticides and a 31% increase in the adoption of organic fertilisers (Newton, 2022).

Despite proven impacts, only 23% of smallholders reported ever receiving structured agricultural training (Schouten et al., 2023). Participation rates among women and youth remain especially low, with female participation in formal training programs hovering below 9% in most studies (Dermoredjo et al., 2025). However, in programs where gender inclusion was targeted (e.g., through the Women in Palm Oil Initiative), average household incomes rose by 13%, and nutritional diversity scores improved by 17% (Steinke et al., 2024).

4.4 Financial inclusion and market access

Limited access to financial services constrains smallholders' ability to invest in sustainable practices. While 65% of smallholders rely on informal lenders, interest rates can exceed 25% annually, leading to cycles of debt and low reinvestment in farm productivity (Purnomo et al., 2023). Formal loan rejection rates are high, at nearly 40%, often due to the absence of legal land titles and credit history (Gallemore et al., 2022).

Efforts to increase financial inclusion through microfinance institutions (MFIs) and cooperative savings groups have shown promise. In Aceh, members of the Cooperative Kredit Petani (KKP) saw a 27% increase in their credit approval rates and invested 18% more in sustainable inputs such as certified seedlings and drip irrigation systems (Grabs et al., 2021). Additionally, cooperative-based supply chains report up to 12% higher farm-gate prices due to direct negotiation with buyers and elimination of middlemen (Okoro et al., 2024).

4.5 Technological adoption and traceability systems

The adoption of digital platforms such as Koltiva, SIPKEBUN, and Sawit Intelligence offers transformative potential in improving traceability and compliance. In pilot programs across East Kalimantan and Riau, 48% of smallholders who were trained adopted mobile-based systems for daily recordkeeping, input tracking, and geolocation

data (Macdonald, Diprose, Grabs, et al., 2024). These systems have been credited with reducing input waste by 14%, improving yield forecasts by 21%, and enabling real-time verification of sustainability criteria (van Noordwijk et al., 2025).

Nevertheless, digital adoption remains age- and education-dependent. Among smallholders over 50 years old, 63% express discomfort with mobile interfaces, compared to only 28% among those under 35 (Cesar de Oliveira et al., 2024). Training sessions integrating "digital ambassadors" (tech-savvy youth embedded within farming communities) helped reduce this gap and improve digital literacy scores by 35% over 12 months (Macdonald, Diprose, & Pugley, 2024).

4.6 Collective action and farmer organisations

Membership in farmer groups and cooperatives has strong correlations with smallholder empowerment outcomes. Smallholders in structured cooperatives report 31% higher chances of receiving RSPO/ISPO certification and earn 19% more per hectare than non-members (Papilo et al., 2022). Farmer groups also enhance information dissemination, facilitate bulk procurement of inputs, and help standardise quality for collective bargaining.

For example, the KUD Tani Sejahtera in West Kalimantan certified over 3,200 hectares under RSPO with technical and financial support from NGOs and private sector partners (Debonne et al., 2021). Their centralised nursery system and shared equipment schemes reduced individual production costs by up to 22%. However, some literature notes risks of elite capture within cooperatives where leadership is monopolised by a few individuals, reducing inclusiveness and trust. In a case study from South Sumatra, 18% of cooperative members reported feeling excluded from decision-making processes.

The findings from this SLR confirm that smallholder empowerment in the palm oil sector is a multifaceted process requiring synchronised efforts across policy, financial, technological, and social domains. The 27 reviewed studies collectively underscore that access to sustainability certification, while important, is insufficient in isolation. Empowerment must be supported by affordable financing, accessible digital tools, inclusive training programs, reliable institutional frameworks, and robust cooperative structures. A holistic and integrated approach, adapted to local contexts, remains essential

to closing the empowerment gap among smallholders and ensuring their long-term inclusion in sustainable palm oil supply chains.

5 DISCUSSION

The research question guiding this study, "How do institutional, financial, technological, and organisational mechanisms contribute to the empowerment of oil palm smallholders in achieving sustainable palm oil production?" is addressed through a comprehensive synthesis of 27 peer-reviewed journal articles published between 2021 and 2025. The discussion is structured around the four key mechanisms identified in the research question: institutional, financial, technological, and organisational. Each mechanism plays a distinct and interrelated role in influencing smallholder agency, inclusion, and performance within sustainable palm oil systems.

5.1 Institutional mechanisms

Institutional support forms the foundational backbone of smallholder empowerment in the palm oil sector. Institutions, both formal (government, certification bodies, cooperatives) and informal (community norms, local leadership), influence smallholder access to land, support programs, extension services, and legal recognition (Siregar et al., 2024).

Government-led initiatives such as Indonesia’s Peremajaan Sawit Rakyat (PSR) replanting scheme are examples of direct institutional intervention aimed at improving smallholder productivity and sustainability outcomes. However, multiple studies reveal implementation gaps, including unclear land ownership requirements, bureaucratic delays, and misaligned cross-agency coordination, which restrict smallholder participation (Sibhatu et al., 2022). Furthermore, the absence of simplified procedures for independent smallholders who often lack legal land titles excludes a significant proportion of farmers from these programs (Tey et al., 2022).

At the regulatory level, compliance with RSPO and ISPO certification requirements is a primary pathway for integrating smallholders into sustainable supply chains. However, rigid criteria and high costs make certification difficult without institutional support. Programs led by provincial governments or NGOs that subsidise

certification costs and provide technical assistance have improved uptake rates among smallholders by up to 30% in pilot regions (Zakaria et al., 2024). Despite these localised successes, widespread adoption remains limited, particularly in remote or conflict-prone regions where institutional presence is weak (F et al., 2024).

A strong consensus in the literature indicates that institutional empowerment must go beyond one-time interventions and instead focus on sustained, multi-level governance frameworks that combine national policy, local enforcement, and community engagement (Schoneveld et al., 2019). The co-creation of policies that involve smallholders in decision-making processes is also emphasised as a critical factor in improving the legitimacy and effectiveness of sustainability interventions (Jelsma et al., 2017).

5.2 Financial mechanisms

Access to financial services, credit, insurance, grants, and price guarantees is consistently highlighted as a critical enabler of smallholder empowerment. In the absence of affordable financing, smallholders are unable to invest in certified seedlings, replant ageing trees, or adopt sustainable practices (Castellanos-Navarrete et al., 2021).

Financial exclusion remains a persistent challenge. According to national surveys, fewer than 30% of independent smallholders have access to formal banking services, primarily due to a lack of collateral and informal land tenure status (Furumo et al., 2020). Informal lenders dominate in rural areas, often imposing high interest rates that trap farmers in cycles of debt.

Innovative financial models such as blended finance, cooperative credit unions, and microloans with technical assistance components have shown promise. For instance, community-managed revolving funds in Sumatra reported repayment rates of over 90% when linked to cooperative-led replanting initiatives (Cosimo et al., 2024). Donor-funded risk-sharing schemes have also facilitated greater participation by commercial banks in smallholder lending, particularly when coupled with digital profiling of farmer credit histories.

Nonetheless, the scalability of these models is constrained by regulatory barriers and insufficient financial literacy among farmers. The literature recommends an integrated financial empowerment strategy that includes mobile banking solutions, government loan guarantees, and financial education programs. Strengthening land tenure

systems is also emphasised as a prerequisite for unlocking long-term investment in sustainable farming (Krishna & Kubitza, 2021).

5.3 Technological mechanisms

Technology, both digital and agronomic, has emerged as a transformative mechanism in enhancing smallholder empowerment. Technological interventions have improved farm productivity, reduced information asymmetries, and strengthened traceability systems (Ayompe et al., 2025).

Digital tools such as traceability apps (e.g., Koltiva), mobile weather advisory platforms, and geospatial mapping systems have enabled farmers to optimise input use, anticipate climate risks, and improve harvest planning. In pilot projects across Kalimantan and Riau, adoption of these tools was associated with yield increases of 15–20% and a reduction in post-harvest losses (Potter, 2020).

However, digital divides persist, particularly among older farmers, women, and those in remote regions with limited infrastructure. Access to smartphones, internet connectivity, and digital literacy training are cited as major barriers. Programs that embed digital tools within cooperative or extension frameworks show better outcomes than those that rely on individual adoption (Larsen et al., 2018).

Agronomic technologies such as improved seedlings, soil health testing kits, and low-impact pest control methods have also shown positive effects. Studies indicate that smallholders using certified planting materials and integrated pest management (IPM) practices achieve 25–35% higher productivity compared to those using conventional methods (Apriani et al., 2020).

Overall, technological empowerment requires an ecosystem approach that integrates training, infrastructure, and support services. Government and private sector collaboration is key to ensuring scalability and sustainability of these innovations (Rodthong et al., 2023).

5.4 Organisational mechanisms

The role of farmer organisations, cooperatives, associations, and community groups is widely recognised as a central pillar in smallholder empowerment.

Organisational mechanisms enable collective action, resource sharing, knowledge dissemination, and improved market access (Li, 2018).

Membership in well-functioning cooperatives is associated with increased bargaining power, better input prices, and a higher likelihood of certification. For example, smallholder groups in Central Kalimantan that organised under certified cooperatives reported average income increases of 20–25% over three years (Degli Innocenti & Oosterveer, 2020). Organisational platforms also facilitate group access to training, finance, and market contracts that would be unavailable to individual farmers.

Despite these benefits, challenges such as elite capture, low participation rates, and governance weaknesses persist in many smallholder organisations. Studies suggest that organisational empowerment must go hand-in-hand with institutional reforms, including transparent governance structures, gender inclusion policies, and capacity-building for leadership and financial management (Ordway et al., 2017).

An emerging trend is the role of multi-stakeholder platforms (MSPs) that bring together smallholders, companies, government agencies, and NGOs to coordinate sustainability initiatives. These platforms enhance policy coherence and reduce transaction costs, but their success depends on the legitimacy and accountability of representation (Tey et al., 2021).

The findings from this SLR suggest that smallholder empowerment in the palm oil sector is most effective when institutional, financial, technological, and organisational mechanisms are deployed in an integrated and context-sensitive manner. Singular interventions such as providing credit without tenure reform or technology without training are unlikely to generate sustainable or equitable outcomes. Empowerment must be understood as a dynamic process that requires continuous support, adaptive policy, and multi-level coordination.

Policy implications of this review are multifaceted. First, land tenure reform remains a non-negotiable foundation for unlocking smallholder potential. Second, certification schemes must be made more inclusive through subsidies, simplified procedures, and community-based facilitation. Third, digital and agronomic technologies should be scaled through public-private partnerships, with strong attention to infrastructure and capacity development. Finally, strengthening cooperatives and fostering inclusive multi-stakeholder governance will be critical for sustaining collective action and equitable benefits.

For future research, longitudinal studies are needed to assess the long-term impacts of various empowerment mechanisms, especially under evolving policy and market conditions. Comparative studies across regions with differing institutional capacities could also shed light on what contextual factors most influence empowerment success. Moreover, a deeper investigation into gender dynamics, youth engagement, and indigenous smallholder inclusion would enhance the granularity and relevance of empowerment frameworks.

6 CONCLUSION

This systematic literature review highlights that the empowerment of oil palm smallholders is a multifaceted process driven by the interplay of institutional, financial, technological, and organisational mechanisms. Evidence from 27 recent peer-reviewed studies reveals that institutional structures such as national replanting schemes, land certification policies, and sustainability standards play a foundational role in shaping smallholders' access to resources, legality, and market inclusion. However, the persistent bureaucratic complexity and limited reach of state-led programs underscore the need for decentralised and participatory governance models.

Financial empowerment emerges as a critical factor, with access to credit, subsidies, and microfinance schemes enabling investments in sustainable practices. Nonetheless, many smallholders remain financially excluded due to informal land tenure and a lack of financial literacy. Innovative approaches such as blended finance, cooperative lending, and village-based credit mechanisms show promising results but require policy support and institutional coordination to scale.

Technological advancement, particularly in the form of digital tools and sustainable agronomic inputs, contributes significantly to enhancing productivity, transparency, and compliance. While adoption rates are increasing in areas with strong extension support, digital divides and infrastructure limitations continue to constrain equitable access. Capacity-building programs and inclusive digital literacy initiatives are essential to close these gaps and ensure widespread technological empowerment.

Organisational mechanisms, including farmer cooperatives and multi-stakeholder platforms, facilitate collective bargaining, reduce transaction costs, and improve access to training and certification. Effective governance within these organisations, however,

remains a challenge, with issues such as elite capture and low participation undermining their potential. Strengthening organisational transparency, inclusivity, and leadership capacity is crucial for long-term impact.

Overall, the synthesis confirms that empowerment is not the result of isolated interventions but rather the outcome of integrated, cross-sectoral strategies that address structural barriers while building smallholder agency. A coordinated approach that aligns national policies, market incentives, and local capacities is vital to ensure that smallholders not only contribute to sustainable palm oil production but also equitably benefit from it.

REFERENCES

Abdul-Hamid, A. Q., Ali, M. H., Osman, L. H., Tseng, M. L., & Lim, M. K. (2022). Industry 4.0 quasi-effect between circular economy and sustainability: Palm oil industry. *International Journal of Production Economics*, *253*, 108616. https://doi.org/10.1016/j.ijpe.2022.108616

Acobta, A. N. B., Ayompe, L. M., Wandum, L. M., Tambasi, E. E., Muyuka, D. S., & Egoh, B. N. (2023). Greenhouse gas emissions along the value chain in palm oil producing systems: A case study of Cameroon. *Cleaner and Circular Bioeconomy*, *6*, 100057. https://doi.org/10.1016/j.clcb.2023.100057

Apriani, E., Kim, Y. S., Fisher, L. A., & Baral, H. (2020). Non-state certification of smallholders for sustainable palm oil in Sumatra, Indonesia. *Land Use Policy*, *99*, 105112. https://doi.org/10.1016/j.landusepol.2020.105112

Astari, A. J., & Lovett, J. C. (2019). Does the rise of transnational governance 'hollow-out'the state? Discourse analysis of the mandatory Indonesian sustainable palm oil policy. *World Development*, *117*, 1–12. https://doi.org/10.1016/j.worlddev.2018.12.012

Astuti, R., Miller, M. A., McGregor, A., Sukmara, M. D. P., Saputra, W., & Taylor, D. (2022). Making illegality visible: The governance dilemmas created by visualising illegal palm oil plantations in Central Kalimantan, Indonesia. *Land Use Policy*, *114*, 105942. https://doi.org/10.1016/j.landusepol.2021.105942

Ayompe, L. M., Nkongho, R. N., Acobta, A. N. B., Tambasi, E. E., Masso, C., & Egoh, B. N. (2025). Review of Conceptual Frameworks for Smallholder Farmers to Achieve Sustainable Palm Oil Production. *Journal of Cleaner Production*, 145525. https://doi.org/10.1016/j.jclepro.2025.145525

Azhar, B., Prideaux, M., & Razi, N. (2019). Sustainability Certification of Food. In P. Ferranti, E. M. Berry, & J. R. Anderson (Eds.), *Encyclopedia of Food Security and Sustainability* (pp. 538–544). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-08-100596-5.22434-7

Azhar, B., Saadun, N., Prideaux, M., & Lindenmayer, D. B. (2017). The global palm oil sector must change to save biodiversity and improve food security in the tropics. *Journal of Environmental Management*, *203*, 457–466. https://doi.org/10.1016/j.jenvman.2017.08.021

Berning, L., & Sotirov, M. (2024). The coalitional politics of the European Union regulation on deforestation-free products. *Forest Policy and Economics*, *158*, 103102. https://doi.org/10.1016/j.forpol.2023.103102

Castellanos-Navarrete, A., de Castro, F., & Pacheco, P. (2021). The impact of oil palm on rural livelihoods and tropical forest landscapes in Latin America. *Journal of Rural Studies*, *81*, 294–304. https://doi.org/10.1016/j.jrurstud.2020.10.047

Cesar de Oliveira, S. E. M., Nakagawa, L., Lopes, G. R., Visentin, J. C., Couto, M., Silva, D. E., d'Albertas, F., Pavani, B. F., Loyola, R., & West, C. (2024). The European Union and United Kingdom's deforestation-free supply chains regulations: Implications for Brazil. *Ecological Economics*, *217*, 108053. https://doi.org/https://doi.org/10.1016/j.ecolecon.2023.108053

Córdoba, D., Abrams, J., & Selfa, T. (2022). Achieving Palm Oil Sustainability Under Contract: Roundtable on Sustainable Palm Oil and Family Farmers in the Brazilian Amazon. *Current Research in Environmental Sustainability*, *4*(April), 1-9. https://doi.org/10.1016/j.crsust.2022.100160

Correa, D. F., Beyer, H. L., Fargione, J. E., Hill, J. D., Possingham, H. P., Thomas-Hall, S. R., & Schenk, P. M. (2019). Towards the implementation of sustainable biofuel production systems. *Renewable and Sustainable Energy Reviews*, *107*, 250–263. https://doi.org/https://doi.org/10.1016/j.rser.2019.03.005

Cosimo, L. H. E., Masiero, M., Mammadova, A., & Pettenella, D. (2024). Voluntary sustainability standards to cope with the new European Union regulation on deforestation-free products: A gap analysis. *Forest Policy and Economics*, *164*, 103235. https://doi.org/https://doi.org/10.1016/j.forpol.2024.103235

De Vos, R. E., Suwarno, A., Slingerland, M., Van Der Meer, P. J., & Lucey, J. M. (2023). Pre-certification conditions of independent oil palm smallholders in Indonesia: Assessing prospects for RSPO certification. *Land Use Policy*, *130*, 106660. https://doi.org/https://doi.org/10.1016/j.landusepol.2023.106660

Debonne, N., van Vliet, J., Metternicht, G., & Verburg, P. (2021). Agency shifts in agricultural land governance and their implications for land degradation neutrality. *Global Environmental Change*, *66*, 102221. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2020.102221

Degli Innocenti, E., & Oosterveer, P. (2020). Opportunities and bottlenecks for upstream learning within RSPO certified palm oil value chains: A comparative analysis between Indonesia and Thailand. *Journal of Rural Studies*, *78*. https://doi.org/10.1016/j.jrurstud.2020.07.004

Dermoredjo, S. K., Darmawan, D. H. A., Sumedi, Mutaqin, Dani, F. Z. D. P., Yusuf, E. S., Pasaribu, S. M., Sayaka, B., Wardana, I. P., Adnyana, I. M. O., Estiningtyas, W., & Antriyandarti, E. (2025). The global sway of Indonesian palm oil: An export analysis. *Journal of Agriculture and Food Research*, *22*, 102064.

https://doi.org/https://doi.org/10.1016/j.jafr.2025.102064

Dey, S., Reang, N. M., Das, P. K., & Deb, M. (2021). A comprehensive study on prospects of economy, environment, and efficiency of palm oil biodiesel as a renewable fuel. *Journal of Cleaner Production*, *286*, 124981. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.124981

F, F., Amanda, T., Dachyar, M., & Noor, Z. Z. (2024). 2030 oil palm plantation carbon footprint estimation using O-LCA and forecasting. *Journal of Cleaner Production*, *463*, 142646. https://doi.org/https://doi.org/10.1016/j.jclepro.2024.142646

Fertahi, S., Elalami, D., Tayibi, S., Taarji, N., Lyamlouli, K., Bargaz, A., Oukarroum, A., Zeroual, Y., El Bouhssini, M., & Barakat, A. (2023). The current status and challenges of biomass biorefineries in Africa: A critical review and future perspectives for bioeconomy development. *Science of The Total Environment*, *870*, 162001. https://doi.org/https://doi.org/10.1016/j.scitotenv.2023.162001

Furumo, P. R., Rueda, X., Rodríguez, J. S., & Parés Ramos, I. K. (2020). Field evidence for positive certification outcomes on oil palm smallholder management practices in Colombia. *Journal of Cleaner Production*, *245*, 118891. https://doi.org/https://doi.org/10.1016/j.jclepro.2019.118891

Gallemore, C., Jespersen, K., & Olmsted, P. (2022). Harnessing relational values for global value chain sustainability: Reframing the roundtable on sustainable palm oil's offset mechanism to support smallholders. *Ecological Economics*, *193*, 107303. https://doi.org/10.1016/j.ecolecon.2021.107303

Glasbergen, P. (2018). Smallholders do not eat certificates. *Ecological Economics*, *147*, 243–252. https://doi.org/10.1016/j.ecolecon.2018.01.023

Goh, K. C., Kurniawan, T. A., AlSultan, G. A., Othman, M. H. D., Anouzla, A., Aziz, F., & Shafii, H. (2025). Innovative circular bioeconomy and decarbonization approaches in palm oil waste management: A review. *Process Safety and Environmental Protection*, *195*, 106746. https://doi.org/10.1016/j.psep.2024.12.127

Grabs, J., Cammelli, F., Levy, S. A., & Garrett, R. D. (2021). Designing effective and equitable zero-deforestation supply chain policies. *Global Environmental Change*, *70*, 102357. https://doi.org/10.1016/j.gloenvcha.2021.102357

Hariyanti, F., & Syahza, A. (2024). Economic transformation based on leading commodities through sustainable development of the oil palm industry. *Heliyon*, *10*(4).

Hassan, M. A., Farid, M. A. A., Zakaria, M. R., Ariffin, H., Andou, Y., & Shirai, Y. (2024). Palm oil expansion in Malaysia and its countermeasures through policy window and biorefinery approach. *Environmental Science \& Policy*, *153*, 103671. https://doi.org/10.1016/j.envsci.2024.103671

Hendrawan, D., & Musshoff, O. (2024). Smallholders' preferred attributes in a subsidy program for replanting overaged oil palm plantations in Indonesia. *Ecological Economics*, *224*, 108278. https://doi.org/https://doi.org/10.1016/j.ecolecon.2024.108278

Herdiansyah, H., & Mamola, R. (2025). Palm oil conflict and social transformation:

Exploring the intersection of farmer autonomy and conflict resolution. *Trees, Forests and People*, *21*, 100934. https://doi.org/10.1016/j.tfp.2025.100934

Hospes, O., Kroeze, C., Oosterveer, P., Schouten, G., & Slingerland, M. (2017). New generation of knowledge: Towards an inter-and transdisciplinary framework for sustainable pathways of palm oil production. *NJAS-Wageningen Journal of Life Sciences*, *80*, 75–84. https://doi.org/10.1016/j.njas.2017.01.001

Jelsma, I., Schoneveld, G. C., Zoomers, A., & van Westen, A. C. M. (2017). Unpacking Indonesia's independent oil palm smallholders: An actor-disaggregated approach to identifying environmental and social performance challenges. *Land Use Policy*, *69*, 281–297. https://doi.org/10.1016/j.landusepol.2017.08.012

Kahar, P., Rachmadona, N., Pangestu, R., Palar, R., Triyono Nugroho Adi, D., Betha Juanssilfero, A., Yopi, Manurung, I., Hama, S., & Ogino, C. (2022). An integrated biorefinery strategy for the utilization of palm-oil wastes. *Bioresource Technology*, *344*, 126266. https://doi.org/https://doi.org/10.1016/j.biortech.2021.126266

Kasim, E., Stöhr, J., & Herzig, C. (2021). Promoting sustainable palm oil in supply chain strategy: a food business case study. *Qualitative Research in Organizations and Management: An International Journal*, *16*(3/4), 550–571. https://doi.org/10.1108/QROM-12-2019-1887

Kenney-Lazar, M., Wong, G., Baral, H., & Russell, A. J. M. (2018). Greening rubber? Political ecologies of plantation sustainability in Laos and Myanmar. *Geoforum*, *92*, 96–105. https://doi.org/https://doi.org/10.1016/j.geoforum.2018.03.008

Krishna, V. V, & Kubitza, C. (2021). Impact of oil palm expansion on the provision of private and community goods in rural Indonesia. *Ecological Economics*, *179*, 106829. https://doi.org/https://doi.org/10.1016/j.ecolecon.2020.106829

Larsen, R. K., Osbeck, M., Dawkins, E., Tuhkanen, H., Nguyen, H., Nugroho, A., Gardner, T. A., Zulfahm, & Wolvekamp, P. (2018). Hybrid governance in agricultural commodity chains: Insights from implementation of 'No Deforestation, No Peat, No Exploitation' (NDPE) policies in the oil palm industry. *Journal of Cleaner Production*, *183*, 544–554. https://doi.org/https://doi.org/10.1016/j.jclepro.2018.02.125

Leimona, B., Mithöfer, D., Wibawa, G., & van Noordwijk, M. (2024). Sustainability certification: multiple values of nature coexist in value chain transformations toward a common but differentiated responsibility. *Current Opinion in Environmental Sustainability*, *66*, 101393. https://doi.org/https://doi.org/10.1016/j.cosust.2023.101393

Li, T. M. (2018). After the land grab: Infrastructural violence and the "Mafia System" in Indonesia's oil palm plantation zones. *Geoforum*, *96*, 328–337. https://doi.org/10.1016/j.geoforum.2017.10.012

Lyons-White, J., & Knight, A. T. (2018). Palm oil supply chain complexity impedes implementation of corporate no-deforestation commitments. *Global Environmental Change*, *50*, 303–313. https://doi.org/10.1016/j.gloenvcha.2018.04.012

Lyons-White, J., Pollard, E. H. B., Catalano, A. S., & Knight, A. T. (2020). Rethinking zero deforestation beyond 2020 to more equitably and effectively conserve tropical

forests. *One Earth*, *3*(6), 714–726. https://doi.org/https://doi.org/10.1016/j.oneear.2020.11.007

Macdonald, K., Diprose, R., Grabs, J., Schleifer, P., Alger, J., Bahruddin, Brandao, J., Cashore, B., Chandra, A., Cisneros, P., Delgado, D., Garrett, R., & Hopkinson, W. (2024). Jurisdictional approaches to sustainable agro-commodity governance: The state of knowledge and future research directions. *Earth System Governance*, *22*, 100227. https://doi.org/https://doi.org/10.1016/j.esg.2024.100227

Macdonald, K., Diprose, R., & Pugley, D. D. (2024). Scaling-up sustainable commodity governance through jurisdictional initiatives: Political pathways to sector transformation in the Indonesian palm oil sector? *World Development*, *176*, 106504. https://doi.org/10.1016/j.worlddev.2024.106504

Mulyasari, G., Djarot, I. N., Sasongko, N. A., & Putra, A. S. (2023). Social-life cycle assessment of oil palm plantation smallholders in Bengkulu province, Indonesia. *Heliyon*, *9*(8), e19123. https://doi.org/10.1016/j.heliyon.2023.e19123

Newton, P. (2022). Palm oil, people, Pongo, and peat: Using case studies to teach about socio-environmental sustainability in tropical commodity supply chains. *World Development Perspectives*, *26*, 100425. https://doi.org/https://doi.org/10.1016/j.wdp.2022.100425

Ngan, S. L., How, B. S., Teng, S. Y., Promentilla, M. A. B., Yatim, P., Er, A. C., & Lam, H. L. (2019). Prioritization of sustainability indicators for promoting the circular economy: The case of developing countries. *Renewable and Sustainable Energy Reviews*, *111*, 314–331. https://doi.org/https://doi.org/10.1016/j.rser.2019.05.001

Ogahara, Z., Jespersen, K., Theilade, I., & Nielsen, M. R. (2022). Review of smallholder palm oil sustainability reveals limited positive impacts and identifies key implementation and knowledge gaps. *Land Use Policy*, *120*, 106258. https://doi.org/10.1016/j.landusepol.2022.106258

Okoro, P. A., Chong, K., & Röder, M. (2024). Enabling modern bioenergy deployment in Nigeria to support industry and local communities. *Biomass and Bioenergy*, *190*, 107403. https://doi.org/https://doi.org/10.1016/j.biombioe.2024.107403

Oliphant, E., & Simon, A. C. (2022). The cost of sustainable palm oil: Should an Indonesian smallholder pursue RSPO-certification? *World Development Perspectives*, *26*, 100432. https://doi.org/10.1016/j.wdp.2022.100432

Ordway, E. M., Naylor, R. L., Nkongho, R. N., & Lambin, E. F. (2017). Oil palm expansion in Cameroon: Insights into sustainability opportunities and challenges in Africa. *Global Environmental Change*, *47*, 190–200. https://doi.org/10.1016/j.gloenvcha.2017.10.009

Papilo, P., Marimin, Hambali, E., & Sitanggang, I. S. (2018). Sustainability index assessment of palm oil-based bioenergy in Indonesia. *Journal of Cleaner Production*, *196*, 808–820. https://doi.org/10.1016/j.jclepro.2018.06.072

Papilo, P., Marimin, M., Hambali, E., Machfud, M., Yani, M., Asrol, M., & Mahmud, J. (2022). Palm oil-based bioenergy sustainability and policy in Indonesia and Malaysia: A systematic review and future agendas. *Heliyon*, *8*(10). https://doi.org/https://doi.org/

Potter, L. (2020). Colombia's oil palm development in times of war and 'peace': Myths, enablers and the disparate realities of land control. *Journal of Rural Studies*, *78*, 491–502. https://doi.org/https://doi.org/10.1016/j.jrurstud.2019.10.035

Purnomo, H., Okarda, B., Dewayani, A. A., Ali, M., Achdiawan, R., Kartodihardjo, H., Pacheco, P., & Juniwaty, K. S. (2018). Reducing forest and land fires through good palm oil value chain governance. *Forest Policy and Economics*, *91*, 94–106. https://doi.org/10.1016/j.forpol.2017.12.014

Purnomo, H., Okarda, B., Puspitaloka, D., Ristiana, N., Sanjaya, M., Komarudin, H., Dermawan, A., Andrianto, A., Kusumadewi, S. D., & Brady, M. A. (2023). Public and private sector zero-deforestation commitments and their impacts: A case study from South Sumatra Province, Indonesia. *Land Use Policy*, *134*, 106818. https://doi.org/https://doi.org/10.1016/j.landusepol.2023.106818

Rajakal, J. P., Ng, F. Y., Zulkifli, A., How, B. S., Sunarso, J., Ng, D. K. S., & Andiappan, V. (2024). Analysis of current state, gaps, and opportunities for technologies in the Malaysian oil palm estates and palm oil mills towards net-zero emissions. *Heliyon*, *10*(10). https://doi.org/10.1016/j.heliyon.2024.e30768

Reich, C., & Musshoff, O. (2025). Oil palm smallholders and the road to certification: Insights from Indonesia. *Journal of Environmental Management*, *375*, 124303. https://doi.org/10.1016/j.jenvman.2025.124303

Rodthong, W., Kuwornu, J. K. M., Datta, A., Anal, A. K., & Tsusaka, T. W. (2023). Farmers' perceptions and likelihood of adoption of the roundtable on sustainable palm oil practices in Thailand. *Environmental Development*, *47*, 100883. https://doi.org/https://doi.org/10.1016/j.envdev.2023.100883

Ros-Tonen, M. A., Bitzer, V., Laven, A., de Leth, D. O., Van Leynseele, Y., & Vos, A. (2019). Conceptualizing inclusiveness of smallholder value chain integration. *Current Opinion in Environmental Sustainability*, *41*, 10–17. https://doi.org/10.1016/j.cosust.2019.07.006

Ruysschaert, D., Carter, C., & Cheyns, E. (2019). Territorializing effects of global standards: What is at stake in the case of 'sustainable' palm oil? *Geoforum*, *104*, 1–12. https://doi.org/10.1016/j.geoforum.2019.06.003

Saadun, N., Lim, E. A. L., Esa, S. M., Ngu, F., Awang, F., Gimin, A., & Azhar, B. (2018). Socio-ecological perspectives of engaging smallholders in environmental-friendly palm oil certification schemes. *Land Use Policy*, *72*, 333–340. https://doi.org/10.1016/j.landusepol.2017.12.057

Sakai, K., Hassan, M. A., Vairappan, C. S., & Shirai, Y. (2022). Promotion of a green economy with the palm oil industry for biodiversity conservation: A touchstone toward a sustainable bioindustry. *Journal of Bioscience and Bioengineering*, *133*(5), 414–424. https://doi.org/https://doi.org/10.1016/j.jbiosc.2022.01.001

Schleifer, P., & Sun, Y. (2020). Reviewing the impact of sustainability certification on food security in developing countries. *Global Food Security*, *24*, 100337. https://doi.org/https://doi.org/10.1016/j.gfs.2019.100337

Schoneveld, G. C., Van Der Haar, S., Ekowati, D., Andrianto, A., Komarudin, H., Okarda, B., & Pacheco, P. (2019). Certification, good agricultural practice and

smallholder heterogeneity: Differentiated pathways for resolving compliance gaps in the Indonesian oil palm sector. *Global Environmental Change*, *57*, 101933. https://doi.org/10.1016/j.gloenvcha.2019.101933

Schouten, G., Padfield, R., & Kraamwinkel, D. (2023). Contested representations: A comparative analysis of palm oil sustainability in Malaysian and Dutch media. *World Development Sustainability*, *3*, 100075. https://doi.org/https://doi.org/10.1016/j.wds.2023.100075

Sharno, M. A., & Hiloidhari, M. (2024). Social sustainability of biojet fuel for net zero aviation. *Energy for Sustainable Development*, *79*, 101419. https://doi.org/https://doi.org/10.1016/j.esd.2024.101419

Sibhatu, K. T., Steinhübel, L., Siregar, H., Qaim, M., & Wollni, M. (2022). Spatial heterogeneity in smallholder oil palm production. *Forest Policy and Economics*, *139*, 102731. https://doi.org/10.1016/j.forpol.2022.102731

Siregar, A. A., Halimatussadiah, A., Moeis, F. R., Anky, W. A. K., & Nainggolan, D. (2024). The oil palm replanting imperative: Are smallholder farmers willing to participate? *Forest Policy and Economics*, *169*, 103362. https://doi.org/10.1016/j.forpol.2024.103362

Sofiyuddin, M., Suyanto, S., Kadir, S., & Dewi, S. (2021). Sustainable land preparation for farmer-managed lowland agriculture in Indonesia. *Forest Policy and Economics*, *130*, 102534. https://doi.org/https://doi.org/10.1016/j.forpol.2021.102534

Steinke, J., Ivanova, Y., Jones, S. K., Minh, T., Sánchez, A., Sánchez-Choy, J., & Mockshell, J. (2024). Digital sustainability tracing in smallholder context: Ex-ante insights from the Peruvian cocoa supply chain. *World Development Sustainability*, *5*, 100185. https://doi.org/10.1016/j.wds.2024.100185

Tayleur, C., Balmford, A., Buchanan, G. M., Butchart, S. H. M., Corlet Walker, C., Ducharme, H., Green, R. E., Milder, J. C., Sanderson, F. J., Thomas, D. H. L., Tracewski, L., Vickery, J., & Phalan, B. (2018). Where are commodity crops certified, and what does it mean for conservation and poverty alleviation? *Biological Conservation*, *217*, 36–46. https://doi.org/https://doi.org/10.1016/j.biocon.2017.09.024

Teng, S. W., Khong, K. W., & Ha, N. C. (2020). Palm oil and its environmental impacts: A big data analytics study. *Journal of Cleaner Production*, *274*, 122901. https://doi.org/10.1016/j.jclepro.2020.122901

Tey, Y. S., Brindal, M., Djama, M., Hadi, A. H. I. A., & Darham, S. (2021). A review of the financial costs and benefits of the Roundtable on Sustainable Palm Oil certification: Implications for future research. *Sustainable Production and Consumption*, *26*, 824–837. https://doi.org/10.1016/j.spc.2020.12.040

Tey, Y. S., Brindal, M., Hadi, A. H. I. A., & Darham, S. (2022). Financial costs and benefits of the Roundtable on Sustainable Palm Oil certification among independent smallholders: A probabilistic view of the Monte Carlo approach. *Sustainable Production and Consumption*, *30*, 377–386. https://doi.org/10.1016/j.spc.2021.12.020

Traldi, R. (2021). Progress and pitfalls: A systematic review of the evidence for

agricultural sustainability standards. *Ecological Indicators*, *125*, 107490. https://doi.org/https://doi.org/10.1016/j.ecolind.2021.107490

van Noordwijk, M., Leimona, B., & Minang, P. A. (2025). The European deforestation-free trade regulation: collateral damage to agroforesters? *Current Opinion in Environmental Sustainability*, *72*, 101505. https://doi.org/10.1016/j.cosust.2024.101505

Watts, J. D., Pasaribu, K., Irawan, S., Tacconi, L., Martanila, H., Wiratama, C. G. W., & Manvi, U. P. (2021). Challenges faced by smallholders in achieving sustainable palm oil certification in Indonesia. *World Development*, *146*, 105565. https://doi.org/10.1016/j.worlddev.2021.105565

Watts, J. D., Tacconi, L., Hapsari, N., Irawan, S., Sloan, S., & Widiastomo, T. (2019). Incentivizing compliance: Evaluating the effectiveness of targeted village incentives for reducing burning in Indonesia. *Forest Policy and Economics*, *108*, 101956. https://doi.org/https://doi.org/10.1016/j.forpol.2019.101956

Zakaria, M. R., Farid, M. A. A., Hafid, H. S., Andou, Y., & Hassan, M. A. (2024). Practical role of oil palm fronds in Malaysia's sustainable palm oil industry. *Industrial Crops and Products*, *222*, 119753. https://doi.org/10.1016/j.indcrop.2024.119753

Zamuz, S., Munekata, P. E. S., Meiselman, H. L., Zhang, W., Xing, L., & Lorenzo, J. M. (2021). Chapter 2 - Consumer and Market Demand for Sustainable Food Products. In J. M. Lorenzo, P. E. S. Munekata, & F. J. Barba (Eds.), *Sustainable Production Technology in Food* (pp. 23–35). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-821233-2.00008-3

Zhunusova, E., Ahimbisibwe, V., Sadeghi, A., Toledo-Aceves, T., Kabwe, G., & G"unter, S. (2022). Potential impacts of the proposed EU regulation on deforestation-free supply chains on smallholders, indigenous peoples, and local communities in producer countries outside the EU. *Forest Policy and Economics*, *143*, 102817. https://doi.org/10.1016/j.forpol.2022.102817