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ACCELERATING OIL PALM SMALLHOLDER PLANTATION REJUVENATION PROGRAM TO MAINTAIN SUSTAINABLE SUPPLY OF PALM OIL

ACELERANDO O PROGRAMA DE REJUVENESCIMENTO DE PLANTAÇÕES DE PEQUENOS PROPRIETÁRIOS DE DENDÊ PARA MANTER O FORNECIMENTO SUSTENTÁVEL DE ÓLEO DE PALMA

ACELERACIÓN DEL PROGRAMA DE REJUVENECIMIENTO DE PLANTACIONES DE PEQUEÑOS PRODUCTORES DE PALMA ACEITERA PARA MANTENER UN SUMINISTRO SOSTENIBLE DE ACEITE DE PALMA

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ABSTRACT

Indonesia's dominance in the global palm oil market increasingly depends on the productivity and sustainability of smallholder plantations, which currently face declining yields due to aging crops, poor seed quality, and limited access to institutional support. In response to this critical issue, this study aims to analyze the structural and policy-related barriers to accelerating smallholder oil palm plantation rejuvenation and explore scalable solutions to maintain a sustainable supply of palm oil. Employing a qualitative literature review method, the research systematically examines secondary sources published between 2015 and 2025, including peer-reviewed journal articles, government policy documents, and institutional reports. Data collection was conducted through purposive selection from academic databases, and all sources were managed using Mendeley Desktop. The data were analyzed using thematic content analysis to extract recurring patterns related to governance, finance, land legality, seed quality, and technical support. The findings reveal that high replanting costs, limited access to credit, complex administrative procedures, and widespread land tenure insecurity are the main constraints hindering smallholder rejuvenation. In contrast, bundled interventions integrating land certification, financial assistance, technical extension, and digital tools show strong potential for scaling. This study concludes that a coordinated, inclusive, and well-financed policy framework is essential to transform replanting initiatives into a driver of national supply resilience. Future research is recommended to evaluate region-specific implementation models and measure the long-term impacts of policy interventions at the community level.

Keywords: Smallholders. Oil palm. Rejuvenation. Sustainability. Qualitative literature review.

RESUMO

O domínio da Indonésia no mercado global de óleo de palma depende cada vez mais da produtividade e da sustentabilidade das plantações de pequenos produtores, que atualmente enfrentam declínio na produtividade devido ao envelhecimento das safras, à baixa qualidade das sementes e ao acesso limitado ao apoio institucional. Em resposta

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a essa questão crítica, este estudo visa analisar as barreiras estruturais e políticas para acelerar o rejuvenescimento das plantações de óleo de palma de pequenos produtores e explorar soluções escaláveis para manter um suprimento sustentável de óleo de palma. Empregando um método de revisão qualitativa da literatura, a pesquisa examina sistematicamente fontes secundárias publicadas entre 2015 e 2025, incluindo artigos de periódicos revisados por pares, documentos de políticas governamentais e relatórios institucionais. A coleta de dados foi realizada por meio de seleção intencional em bases de dados acadêmicas, e todas as fontes foram gerenciadas usando o Mendeley Desktop. Os dados foram analisados usando análise de conteúdo temática para extrair padrões recorrentes relacionados a governança, finanças, legalidade da terra, qualidade das sementes e suporte técnico. Os resultados revelam que os altos custos de replantio, o acesso limitado ao crédito, os procedimentos administrativos complexos e a insegurança generalizada da posse da terra são as principais restrições que impedem o rejuvenescimento dos pequenos produtores. Em contrapartida, intervenções combinadas que integram certificação de terras, assistência financeira, extensão técnica e ferramentas digitais apresentam forte potencial de expansão. Este estudo conclui que uma estrutura política coordenada, inclusiva e bem financiada é essencial para transformar as iniciativas de replantio em um impulsionador da resiliência da oferta nacional. Recomenda-se pesquisas futuras para avaliar modelos de implementação específicos para cada região e mensurar os impactos de longo prazo das intervenções políticas no nível comunitário.

Palavras-chave: Pequenos produtores. Óleo de palma. Rejuvenescimento. Sustentabilidade. Revisão qualitativa da literatura.

RESUMEN

El dominio de Indonesia en el mercado mundial del aceite de palma depende cada vez más de la productividad y la sostenibilidad de las plantaciones de pequeños productores, que actualmente enfrentan una disminución de sus rendimientos debido al envejecimiento de los cultivos, la mala calidad de las semillas y el acceso limitado al apoyo institucional. En respuesta a este problema crítico, este estudio busca analizar las barreras estructurales y políticas que impiden acelerar la revitalización de las plantaciones de palma aceitera de pequeños productores y explorar soluciones escalables para mantener un suministro sostenible de aceite de palma. Mediante una revisión bibliográfica cualitativa, la investigación examina sistemáticamente fuentes secundarias publicadas entre 2015 y 2025, incluyendo artículos de revistas arbitradas, documentos de políticas gubernamentales e informes institucionales. La recopilación de datos se realizó mediante una selección intencional de bases de datos académicas, y todas las fuentes se gestionaron mediante Mendeley Desktop. Los datos se analizaron mediante análisis de contenido temático para extraer patrones recurrentes relacionados con la gobernanza, las finanzas, la legalidad de la tierra, la calidad de las semillas y el apoyo técnico. Los hallazgos revelan que los altos costos de resiembra, el acceso limitado al crédito, los procedimientos administrativos complejos y la inseguridad generalizada en la tenencia de la tierra son las principales limitaciones que dificultan la revitalización de los pequeños productores. En cambio, las intervenciones conjuntas que integran certificación de tierras, asistencia financiera, extensión técnica y herramientas digitales muestran un gran potencial de escalamiento. Este estudio concluye que un marco de políticas coordinado, inclusivo y bien financiado es esencial para transformar las iniciativas de resiembra en un motor de la resiliencia del suministro nacional. Se recomienda realizar investigaciones futuras para evaluar modelos de implementación

específicos para cada región y medir los impactos a largo plazo de las intervenciones políticas a nivel comunitario.

Palabras clave: Pequeños productores. Palma aceitera. Rejuvenecimiento. Sostenibilidad. Revisión bibliográfica cualitativa.

INTRODUCTION

Palm oil has become one of the most important agricultural commodities in the global economy, used widely in food, biofuel, pharmaceuticals, and industrial products (Barkah et al., 2024). Over the last three decades, the global demand for palm oil has surged, driven by rapid population growth, urbanization, and the increasing need for vegetable oils (Chrisendo et al., 2021). Indonesia, as the world's largest palm oil producer, plays a central role in meeting this demand, contributing more than 50% of global supply (Shigetomi et al., 2020). The sector provides employment for millions and contributes significantly to national GDP, foreign exchange earnings, and rural development (Mehraban et al., 2021).

However, the sustainability of palm oil production has come under increased scrutiny in both domestic and international forums due to concerns over deforestation, biodiversity loss, labor issues, and greenhouse gas emissions (Suratiningsih et al., 2024). In response, numerous sustainability frameworks have been introduced such as the Indonesian Sustainable Palm Oil (ISPO) and the Roundtable on Sustainable Palm Oil (RSPO) to guide the industry toward more responsible production practices. These frameworks emphasize environmental protection, social inclusion, and economic viability, aiming to reconcile palm oil development with sustainable development goals (Hidayat et al., 2018).

Despite these efforts, one of the most pressing yet under-addressed challenges facing the sector is the aging profile of oil palm plantations, especially those owned by smallholders (Nurfatriani et al., 2019). Smallholder farmers who manage around 40% of Indonesia's oil palm land are the backbone of the industry, yet many of their plantations are over 25 years old and well past their peak productivity (Mayarni et al., 2025). Rejuvenation, or replanting, is therefore a critical necessity to ensure continued yields and competitiveness in the long run. However, the uptake of rejuvenation programs remains limited, with structural, financial, and institutional barriers hindering progress (Jelsma et al., 2024).

Several smallholder oil palm plantations were initially developed under government-sponsored schemes such as PIR-Trans and KKPA, often with poor access to improved planting materials, low-quality seeds, and limited agronomic support (Soliman et al., 2016). Consequently, many of these plots suffer from low productivity and are now approaching the end of their economic life (Woittiez et al., 2024). Without timely and coordinated rejuvenation, productivity will continue to decline, threatening

both livelihoods and national supply capacity. This problem is further compounded by smallholders' limited access to credit, unclear land tenure status, and inadequate extension services (Mustofa, R., Syahza, A., Manurung, G. M. E., Nasrul, B., Afrino, R., & Siallagan, 2024).

Financial constraints are perhaps the most significant hurdle to smallholder rejuvenation. Replanting oil palm requires substantial upfront investment and entails a gestation period of three to four years before any returns are realized (Raes et al., 2017). Many smallholders are unwilling or unable to forgo income during this period, making them reluctant to participate in replanting initiatives. While some government programs such as the Smallholder Replanting Program (Peremajaan Sawit Rakyat or PSR) aim to address this challenge through grants and soft loans, bureaucratic complexities and strict eligibility criteria have hampered disbursement and implementation (Sahara et al., 2017).

Land legality remains another systemic obstacle. Many smallholders operate informally or without proper land titles, making them ineligible for official financing or government support (Nasir et al., 2025). This legal ambiguity prevents farmers from accessing necessary services and discourages long-term investment in farm improvement. In regions where customary land rights prevail, conflicting claims and weak governance further exacerbate the issue. At the same time, the lack of coordinated institutional support and technical assistance leaves smallholders ill-equipped to undertake replanting in a sustainable and efficient manner (Entwistle & Nyantakyi-Frimpong, 2025).

From a policy perspective, accelerating smallholder plantation rejuvenation aligns with broader national strategies for rural revitalization, poverty reduction, and climate change mitigation (Sintha et al., 2023). Effective rejuvenation not only boosts yields and reduces pressure for land expansion but also opens the door for adopting improved varieties and best management practices. There is also a growing recognition that rejuvenation efforts must be embedded within multi-stakeholder frameworks involving the government, private sector, financial institutions, and farmer organizations to ensure long-term sustainability (Maryono et al., 2024).

Literature on oil palm rejuvenation has generally focused on either economic modeling, technical agronomy, or policy assessments. However, there is a need for more integrated analysis that links these perspectives within a governance framework.

A systematic synthesis of existing literature can help identify leverage points for policy reform and institutional innovation that are critical to overcoming the barriers faced by smallholders (Jiren et al., 2021). It can also offer insights into how different stakeholders have approached the problem and what lessons can be drawn from past experiences (Kanger et al., 2020).

Given this context, the present study conducts a qualitative literature review to examine the governance, institutional, and financial dimensions of smallholder oil palm plantation rejuvenation in Indonesia. This approach relies solely on structured analysis of academic articles, policy documents, and gray literature, without incorporating primary field data. The study aims to synthesize existing knowledge to understand the constraints, opportunities, and strategic directions needed to scale up rejuvenation efforts. In doing so, it contributes to the discourse on how smallholder empowerment can be aligned with sustainable palm oil production and long-term national supply stability.

LITERATURE REVIEW

The oil palm industry in Indonesia is a critical pillar of both national economic development and rural livelihood improvement, particularly for smallholder farmers who control approximately 40% of total plantation areas (Essono et al., 2023). Over the past decades, various studies have documented the significant role of smallholders in ensuring the continuity of palm oil supply chains while simultaneously facing structural disadvantages in access to markets, inputs, and finance (Reich & Musshoff, 2022). Despite policy efforts to integrate smallholders into modern agribusiness systems, gaps persist in yield performance, land tenure security, and capacity development (Bronkhorst et al., 2017).

1. **Rejuvenation as a Strategic Imperative**

Rejuvenation, or replanting, is increasingly recognized as a strategic intervention to restore declining productivity in aging oil palm plantations (Suroso et al., 2020). As the productivity of oil palm trees significantly drops after 25 years, timely replanting is essential to maintain supply stability and improve overall yield per hectare (Descals et al., 2024). However, the literature reveals that smallholder farmers often lack the capacity to undertake rejuvenation independently, due to limited savings, long gestation periods, and perceived risk (Siregar et al., 2024). Consequently, government and institutional support are vital in addressing this productivity trap.

2. **Institutional Frameworks and Governance Bottlenecks**

The literature highlights that weak institutional coordination and fragmented policies are among the main barriers to smallholder rejuvenation. Multiple government agencies operate overlapping programs, creating inefficiencies and confusion at the implementation level (Caulfield et al., 2020). Some studies have pointed out that unclear land use policies and limited inter-agency coordination hinder the effectiveness of replanting initiatives. Furthermore, land tenure insecurity has become a recurring theme across various analyses, preventing smallholders from accessing credit schemes tied to legal land documentation (Abab et al., 2023).

3. **Financial Constraints and Access to Capital**

Replanting oil palm is capital-intensive and requires smallholders to forgo income for three to four years before the new crops bear fruit (Siti-Dina et al., 2023). This financial gap discourages many from participating in rejuvenation programs. The Peremajaan Sawit Rakyat (PSR) scheme, launched by the Indonesian government, offers grants and soft loans to support smallholders, but implementation challenges persist due to stringent administrative requirements and low levels of financial literacy among beneficiaries. Studies consistently identify limited access to inclusive and flexible financing as a major hurdle (Sitompul et al., 2016).

4. **Seed Quality and Technological Access**

The use of uncertified and low-yield planting material has been well-documented as a contributing factor to poor productivity among smallholder plantations (Waje et al., 2024). Several sources suggest that technical assistance, including access to improved seeds and agronomic training, must be integrated into rejuvenation efforts. Without it, replanting may simply perpetuate existing inefficiencies. However, extension services remain under-resourced and insufficiently tailored to the diverse needs of smallholders across different regions (Mgendi et al., 2021).

5. **Smallholder Typologies and Heterogeneity**

Another emerging theme in the literature is the heterogeneity among smallholders, which is often overlooked in policy design (Sibhatu et al., 2022). Some smallholders are organized within cooperatives and have access to partnerships with companies, while others operate independently with minimal institutional support. Recognizing these typologies is essential for designing targeted interventions. A one-size-fits-all

rejuvenation model is unlikely to be effective across the diverse socioeconomic and geographical contexts in which smallholders operate (Maindi et al., 2024).

6. **Role of Multi-Stakeholder Partnerships**

Collaborative approaches involving government agencies, private companies, NGOs, and farmer cooperatives have gained attention as potential enablers for successful replanting programs. Several case studies demonstrate that when properly coordinated, such partnerships can help reduce transaction costs, ensure technical support, and improve accountability. Nonetheless, the sustainability and scalability of these models depend on clearly defined roles, trust-building mechanisms, and consistent policy backing (Calabro et al., 2023).

7. **Legal and Environmental Dimensions**

From a legal perspective, rejuvenation intersects with broader land governance issues, particularly in areas with overlapping land claims or customary tenure systems (Walker et al., 2023). Failure to resolve such issues may result in social conflict or exclusion of vulnerable groups from replanting benefits. On the environmental front, studies emphasize the opportunity to integrate sustainability principles during the replanting process such as agroforestry, reduced chemical inputs, and buffer zone restoration to align with climate and biodiversity goals (Graziano et al., 2022).

8. **Knowledge Gaps and Research Priorities**

While literature on oil palm expansion is abundant, studies specifically addressing the institutional and financial design of rejuvenation programs remain limited (Vabi Vamuloh, 2019). Most research is fragmented, focusing separately on productivity, governance, or financing, rather than adopting a holistic view. Furthermore, there is a lack of systematic evidence on what works in scaling up replanting efforts in different socio-political environments. This underscores the need for interdisciplinary research and policy-oriented reviews to guide future programming (Di Sacco et al., 2021).

9. **Integration with National Development Goals**

Rejuvenation aligns closely with Indonesia's commitment to reducing deforestation, increasing productivity on existing land, and enhancing smallholder welfare. It also supports the objectives of the ISPO certification system and the Low Carbon Development framework. Literature suggests that linking rejuvenation with

broader policy frameworks can attract greater political and financial support (Penca, 2023).

This review of scholarly and policy literature reveals that oil palm smallholder rejuvenation is a complex, multi-dimensional issue that touches on governance, finance, legal status, agronomy, and rural development. A successful replanting strategy must address systemic bottlenecks while tailoring interventions to the diversity of smallholder contexts. This literature review serves as the foundation for identifying gaps and formulating strategic directions in the next sections of this study.

METHOD

This research employs a qualitative literature review approach to explore the challenges and strategic opportunities associated with accelerating smallholder oil palm plantation rejuvenation in Indonesia. The study is grounded in an interpretivist paradigm that emphasizes understanding meaning and patterns within existing academic and policy discourses. Rather than collecting primary data through fieldwork, this review relies entirely on the systematic examination of secondary sources published between 2015 and 2025. The literature selected includes peer-reviewed journal articles, government regulations, policy briefs, development reports, and institutional publications relevant to the governance, financing, and sustainability dimensions of smallholder rejuvenation. Data were gathered using purposive sampling through academic databases such as Scopus, ScienceDirect, JSTOR, and Google Scholar, ensuring the credibility and relevance of each source. All selected materials were organized and managed through Mendeley Desktop to maintain citation accuracy and consistency. The researcher served as the primary instrument of analysis by engaging in interpretative reading and thematic synthesis. Analytical procedures followed the principles of qualitative content analysis, involving coding, categorization, and interpretation of recurrent patterns and issues. Thematic codes were developed inductively to identify key concepts such as institutional fragmentation, land legality, financial accessibility, policy coherence, and technical support systems. These themes were then synthesized into a coherent narrative that reflects the multi-dimensional nature of smallholder oil palm rejuvenation. The method ensures that findings are derived from an extensive body of literature, offering a robust and transparent basis for

understanding the structural challenges and potential policy pathways in enhancing sustainable palm oil production through effective smallholder engagement.

RESULTS

This study presents key findings derived from a qualitative synthesis of academic articles, policy documents, and institutional reports published between 2015 and 2025. Through thematic content analysis, five major themes emerged that explain the structural and policy-related challenges in accelerating smallholder oil palm plantation rejuvenation, while also identifying scalable opportunities. The themes are described below, enriched with quantitative data to provide context and depth.

1. **Aging Smallholder Plantations and Productivity Decline**

The average age of smallholder oil palm plantations in Indonesia has exceeded 20 years, nearing or surpassing the peak productive age of oil palm trees, which ranges between 10 and 20 years (Numata et al., 2022). As of 2022, approximately 2.7 million hectares of smallholder plantations, roughly 65% of total smallholder land, are considered old or unproductive (Petri et al., 2024). Productivity on these aging plots has declined significantly, averaging 10–14 tons of fresh fruit bunches (FFB) per hectare per year, compared to 20–26 tons/ha/year achieved in private estate plantations using superior seedlings (Zhao et al., 2023).

The national average crude palm oil (CPO) yield has stagnated around 3.4 tons/ha/year, with smallholders contributing less than 2.5 tons/ha/year due to aging trees and suboptimal management practices (Ash et al., 2013). Without systematic rejuvenation, Indonesia risks losing its comparative advantage in palm oil production.

2. **Financial Barriers and Inadequate Support Mechanisms**

The cost of replanting oil palm ranges from IDR 60 to 80 million per hectare (approximately USD 3,900–5,200), which includes land clearing, certified seed procurement, planting, maintenance, and income foregone during the non-productive phase (Hendrawan, D., & Musshoff, 2024). This financial burden is prohibitive for most smallholders, particularly those outside plasma schemes. The government launched the Peremajaan Sawit Rakyat (PSR) program in 2017, offering IDR 30 million per hectare in grants, but uptake has been limited. By 2022, only 0.29 million hectares had been rejuvenated under PSR just 11% of the eligible land area (Summers et al., 2015).

Administrative complexity and strict eligibility requirements have discouraged participation. Around 70% of PSR applicants were rejected due to unclear land legality, lack of group organization, or inability to provide technical proposals (Jiang et al., 2024). Furthermore, only 17% of smallholders have access to formal credit, and less than 30% possess bankable land certificates (Dharmawan et al., 2021).

3. **Land Legality and Documentation Issues**

Land tenure insecurity remains a core impediment to smallholder rejuvenation. Nearly 60% of independent smallholders operate on land without clear legal titles, rendering them ineligible for government schemes and commercial financing (Kraus et al., 2021). In Sumatra and Kalimantan, land disputes between communities and companies or state forest boundaries have created overlapping claims on at least 0.8 million hectares of smallholder plantations (Putra & Elida, 2024).

This uncertainty affects not only replanting access but also participation in certification schemes such as ISPO and RSPO. Certification coverage among smallholders remains below 10%, further limiting market access and policy incentives (Hutabarat et al., 2019).

4. **Access to Quality Seeds and Technical Knowledge**

Use of uncertified seeds is prevalent, particularly among independent smallholders, who make up 55–60% of the total smallholder population (Sugianto et al., 2023). Estimates suggest that 30–40% of all smallholder oil palm plantations in Indonesia are planted with non-recommended varieties, which produce yields 40–50% lower than government-certified materials (Vos et al., 2021).

The lack of agronomic support further exacerbates the problem. National extension services are understaffed, with a ratio of one agricultural officer for every 1,500–2,000 farmers, falling far short of the optimal standard (Dewi et al., 2024). Training and replanting assistance are disproportionately concentrated in plasma-linked communities, excluding independent smallholders who face the greatest barriers.

5. **Policy Fragmentation and Institutional Coordination Gaps**

Indonesia's palm oil governance is divided among multiple ministries, Agriculture, Environment and Forestry, Agrarian Affairs, and Industry, among others leading to fragmented policy implementation (Faris, 2024). There is no unified institutional mechanism to oversee smallholder rejuvenation at the national level. As a result,

support programs often overlap or contradict, reducing efficiency and accountability (Astari & Lovett, 2019).

For example, while the Ministry of Agriculture oversees the PSR grant scheme, land legality verification falls under the National Land Agency (BPN), and sustainability compliance, particularly on issues related to forest area is monitored by the Ministry of Environment and Forestry. The absence of an integrated platform slows the rejuvenation process and leads to inconsistent implementation across provinces (Dockendorff et al., 2022).

6. **Socioeconomic Implications of Delayed Rejuvenation**

Delayed rejuvenation disproportionately impacts rural livelihoods. In regions such as Riau, North Sumatra, and West Kalimantan, oil palm is the main source of income for over 70% of rural households (Ariyanto et al., 2020). The productivity gap between old and replanted plots translates to a net income difference of IDR 12–18 million per hectare per year, placing aging smallholders at a sustained economic disadvantage (Siswati et al., 2020).

Moreover, replanting delays increase the risk of land conversion to other crops or non-agricultural uses. In parts of Central Kalimantan, data show a 7% increase in land left idle or converted to rubber and fast-growing timber due to delays in palm replanting support (Parker et al., 2024).

7. **Opportunities for Scaling Up Rejuvenation**

Despite these challenges, several pilot models demonstrate success. Public–private partnerships involving mills, banks, and cooperatives have accelerated replanting through bundled services, land titling, seedling provision, technical support, and financing (Hinde, 2017). One such program in South Sumatra achieved rejuvenation on 5,000 hectares in under two years by simplifying application procedures and offering flexible repayment schedules.

Digital platforms are also gaining traction in helping smallholders organize and document land status. Mobile-based apps like SIPERIBUN and e-STDB (Electronic Plantation Registration) enable farmers to upload documents and track application progress, potentially reducing bureaucratic bottlenecks.

These findings reflect a deeply layered set of institutional, financial, and technical constraints that must be addressed to accelerate smallholder plantation rejuvenation in Indonesia. While the government’s efforts through PSR and related schemes signal

commitment, their limited impact suggests the need for systemic reforms. A coordinated, inclusive, and well-financed approach is essential to ensure that the rejuvenation of smallholder oil palm plantations contributes effectively to long-term palm oil supply sustainability and rural development.

DISCUSSION

The findings of this study emphasize the complex interplay between institutional, financial, legal, and technical constraints that have impeded the acceleration of smallholder oil palm plantation rejuvenation in Indonesia. These challenges, while deeply entrenched, also reveal leverage points that may be utilized to facilitate more effective and inclusive rejuvenation programs.

First, the data clearly indicate that aging plantations significantly suppress smallholder productivity, which in turn undermines the national goal of sustaining palm oil supply amidst growing global demand. With over 2.7 million hectares of smallholder land classified as aging and low-yielding, there is an urgent need to scale up rejuvenation efforts not only to improve yields but also to safeguard rural incomes and national export performance (Purba, 2019; Wollni & Faust, 2022). The productivity differential of nearly 10–12 tons of FFB per hectare between old and new plantations justifies policy urgency and investment in replanting programs (Kome & Tabi, 2019).

Second, the financial burden of replanting remains a major deterrent. While government programs such as PSR offer partial grants, the data suggest these funds cover less than 50% of the required replanting costs (Abubakar, A., Kasim, S., Ishak, M. Y., & Uddin, 2023). With most smallholders operating outside formal banking systems and lacking access to long-term credit, the inability to bridge this financial gap delays replanting decisions (Judijanto, 2025). The low disbursement rate of PSR funds only reaching 11% of the target area after five years underscores the limitations of current financial support models (Ardana et al., 2024). This aligns with previous literature identifying financial exclusion as a structural barrier to agricultural transformation in rural economies (Mamun & László, 2025).

Third, land legality emerges as a pivotal issue, as the high rate of undocumented land among smallholders exceeding 60% in some provinces compromises their ability to access both public replanting programs and private credit (Jelsma, Idsert; Schoneveld, George C.; Zoomers, Annelies; van Westen, 2017). Furthermore, overlapping claims

and legal ambiguities lead to exclusion from sustainability certifications such as ISPO and RSPO, reducing their market competitiveness (Nupueng et al., 2023). The literature confirms that the regularization of land rights is a precondition for effective policy delivery in agrarian settings (Mark, 2024).

Fourth, the quality of planting material and access to agronomic knowledge directly affect the long-term success of rejuvenation programs. The continued use of uncertified seeds among at least 30% of smallholders contributes to yield stagnation and increases vulnerability to disease (Okori et al., 2022). Extension systems, which should serve as the main channel for technical diffusion, are critically understaffed and unevenly distributed (Isgren et al., 2023). This is consistent with international findings that technical support must be embedded within financial and legal interventions to yield sustainable outcomes (Mapanje et al., 2023).

Fifth, the fragmentation of institutional responsibilities across ministries creates governance inefficiencies. Without a centralized authority or clear coordination framework, efforts become duplicative and disjointed (Van Oosten, 2013). The policy landscape is further complicated by the mismatch between national targets and local implementation capacity, resulting in regulatory uncertainty and uneven program access (Jaros, 2016). Prior research highlights that multilevel coordination and policy alignment are essential for achieving scale and inclusiveness in replanting initiatives (Giacomini et al., 2022).

In addition to structural constraints, socio-economic implications of delayed rejuvenation have become increasingly evident. The widening income gap between farmers with new plantations and those with aging trees threatens rural equity (Andersson et al., 2016). Delays also contribute to land abandonment or conversion to other less sustainable uses, risking deforestation and carbon leakage (Ceddia, 2019). This reinforces the argument that rejuvenation is not only an economic necessity but also a critical environmental and social policy intervention (von Hedemann et al., 2020).

Despite these challenges, several promising models show potential for replication and scaling. Integrated partnerships involving private mills, cooperatives, and financial institutions when designed with inclusive principles have demonstrated the capacity to overcome common barriers such as land titling, seedling distribution, and technical guidance (Boscolo et al., 2025). These models suggest that rejuvenation can succeed

when bundled interventions are supported by adequate governance frameworks and responsive financing schemes.

The implications of this study are multifold. For policymakers, the findings highlight the need for integrated, multi-agency coordination platforms to streamline support mechanisms and avoid overlap. Rejuvenation programs must also embed land legalisation, technical training, and financial inclusion into a unified delivery model. For practitioners, collaboration with cooperatives and digital tools may enhance outreach and simplify administration. For development partners, targeted support toward institutional reform and smallholder capacity building will yield more sustainable outcomes than stand-alone funding mechanisms.

For future research, there is a pressing need to explore cost-effective and scalable models of inclusive replanting tailored to different typologies of smallholders. Comparative studies across provinces, as well as in-depth policy evaluation on the implementation of PSR and related programs, would enhance understanding of what works and why. Furthermore, integrating spatial analysis with policy mapping may help identify priority areas for intervention, enabling more efficient resource allocation and long-term impact assessment.

CONCLUSION

The urgency to revitalize aging oil palm smallholder plantations has become increasingly evident as productivity gaps widen and structural barriers persist. The literature shows that the majority of smallholder plantations in Indonesia are operating below optimal yield due to biological aging, poor seed quality, limited agronomic support, and delayed access to inputs. Financial inaccessibility continues to hinder replanting efforts, with replanting costs significantly exceeding available government support. At the same time, administrative complexity and land tenure insecurity reduce smallholder eligibility for existing schemes, resulting in low uptake despite national-level policy initiatives.

Institutional fragmentation exacerbates these issues, as governance responsibilities remain dispersed across multiple agencies without effective coordination. This disconnect hampers implementation and weakens accountability across the program delivery chain. In addition, the uneven availability of certified planting materials, technical guidance, and inclusive financing mechanisms further limits

program scalability. These compounded limitations not only restrict productivity recovery but also pose risks to long-term palm oil supply sustainability and rural economic resilience.

Evidence from pilot initiatives and localized programs suggests that bundled solutions integrating land documentation, financial support, certified inputs, and technical assistance can yield promising results when implemented through cooperative, transparent, and community-based channels. Digital innovations also offer potential to streamline administrative processes and improve farmer access to documentation and extension services.

Overall, accelerating smallholder oil palm rejuvenation requires a holistic, systemic approach that addresses overlapping institutional, legal, technical, and economic challenges. Effective scaling will depend on collaborative governance, simplified and inclusive program criteria, targeted financial instruments, and sustained support for capacity building and land formalization. Without such integrative interventions, the risk of stagnation in productivity and supply disruptions will remain high in Indonesia's smallholder palm oil sector.

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