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SMALLHOLDERS AT THE CROSSROADS: BARRIERS TO EUDR COMPLIANCE AND EQUITY IN PALM OIL SUPPLY CHAINS

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ABSTRACT

The European Union Deforestation Regulation (EUDR) introduces a new layer of environmental accountability in global commodity markets, with major implications for smallholder farmers in palm oil-producing countries. Despite their crucial role in the palm oil sector, smallholders remain structurally disadvantaged in complying with EUDR standards due to complex regulatory, technical, and socioeconomic barriers. This study aims to critically explore the multifaceted obstacles faced by smallholders in achieving EUDR compliance while assessing the equity risks embedded in current supply chain frameworks. A qualitative literature review method was employed, drawing on 80 peer-reviewed articles, policy briefs, and technical reports published between 2015 and 2025. Data were collected using purposive sampling of scholarly sources from Scopus, ScienceDirect, JSTOR, and policy think tanks, focusing on regions such as Indonesia, Malaysia, and Thailand. Thematic analysis was used to extract recurring patterns, bottlenecks, and structural inequities. The results reveal that only 24–38% of smallholders possess the technical and legal infrastructure to meet EUDR traceability and documentation requirements. Institutional limitations, including low access to finance, weak land tenure security, and poor digital infrastructure, further marginalize their position. Compliance costs consume up to 40% of smallholder incomes, threatening widespread exclusion. The study concludes that unless proactive, equity-oriented reforms are implemented, EUDR risks entrenching a dual-tier system that favors large-scale producers. Future research should explore scalable, low-cost compliance technologies and policy innovations that center justice and inclusivity for smallholders.

Keywords: smallholders, European Union Deforestation Regulation (EUDR), palm oil supply chains, compliance barriers, equity and sustainability

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PEQUENOS PROPRIETÁRIOS NA ENCRUZILHADA: BARREIRAS À CONFORMIDADE COM A EUDR E À EQUIDADE NAS CADEIAS DE SUPRIMENTO DE ÓLEO DE PALMA

RESUMO

O Regulamento de Desmatamento da União Europeia (EUDR) introduz um novo nível de responsabilidade ambiental nos mercados globais de commodities, com grandes implicações para os pequenos agricultores em países produtores de óleo de palma. Apesar de seu papel crucial no setor de óleo de palma, os pequenos agricultores permanecem estruturalmente desfavorecidos no cumprimento dos padrões do EUDR devido a complexas barreiras regulatórias, técnicas e socioeconômicas. Este estudo visa explorar criticamente os obstáculos multifacetados enfrentados pelos pequenos agricultores para alcançar a conformidade com o EUDR, ao mesmo tempo em que avalia os riscos de equidade incorporados nas atuais estruturas da cadeia de suprimentos. Foi utilizado um método de revisão qualitativa da literatura, com base em 80 artigos revisados por pares, resumos de políticas e relatórios técnicos publicados entre 2015 e 2025. Os dados foram coletados por meio de amostragem intencional de fontes acadêmicas da Scopus, ScienceDirect, JSTOR e think tanks de políticas, com foco em regiões como Indonésia, Malásia e Tailândia. A análise temática foi utilizada para extrair padrões recorrentes, gargalos e desigualdades estruturais. Os resultados revelam que apenas 24% a 38% dos pequenos produtores possuem a infraestrutura técnica e jurídica para atender aos requisitos de rastreabilidade e documentação da EUDR. Limitações institucionais, incluindo baixo acesso a financiamento, fraca segurança fundiária e infraestrutura digital precária, marginalizam ainda mais sua posição. Os custos de conformidade consomem até 40% da renda dos pequenos produtores, ameaçando uma exclusão generalizada. O estudo conclui que, a menos que reformas proativas e voltadas para a equidade sejam implementadas, a EUDR corre o risco de consolidar um sistema dualista que favorece os grandes produtores. Pesquisas futuras devem explorar tecnologias de conformidade escaláveis e de baixo custo, bem como inovações políticas que priorizem a justiça e a inclusão para os pequenos produtores.

Palavras-chave: pequenos produtores, Regulamento de Desmatamento da União Europeia (EUDR), cadeias de suprimentos de óleo de palma, barreiras à conformidade, equidade e sustentabilidade.

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RESUMEN

El Regulamento de Desmatamento da União Europeia (EUDR) introduce un nuevo nivel de responsabilidad ambiental en los mercados globales de productos básicos, con grandes implicaciones para los pequeños agricultores en los países productores de petróleo de palma. Apesar de su papel crucial no setor de aceite de palma, os pequeños agricultores permanecen estructuralmente desfavorecidos no cumprimento dos padrões do EUDR devido a complexas barreiras regulatórias, técnicas e socioeconômicas. Este estudo visa explorar críticamente los obstáculos multifacéticos enfrentados por los pequeños agricultores para alcançar a conformidade com o EUDR, ao mesmo tempo em que avalia os riscos de equidade incorporados nas atuais estruturas da cadeia de suprimentos. Foi utilizado un método de revisión cualitativa de la literatura, con base en 80 artículos revisados

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Palavras-chave: pequeños productores, Regulamento de Desmatamento da União Europeia (EUDR), cadeias de suprimentos de oleo de palma, barreiras à conformidade, equidade e sustentabilidade.

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1 INTRODUCTION

The global palm oil industry stands at a critical juncture, shaped by mounting environmental, social, and governance (ESG) concerns that demand more sustainable and transparent production practices (Obidzinski et al., 2012). As palm oil continues to dominate the global vegetable oil market, accounting for over 35% of total consumption, its far-reaching socio-environmental footprint has triggered intense scrutiny from policymakers, civil society, and consumers alike (Brandi, 2021). The European Union (EU), as one of the largest importers of palm oil, has emerged as a key actor in pushing for systemic transformation within palm oil supply chains (Carlson et al., 2018).

In this context, the European Union Deforestation Regulation (EUDR), adopted in 2023, seeks to curb deforestation and forest degradation by requiring companies to ensure that commodities placed on the EU market are deforestation-free, legally produced, and traceable (de Oliveira et al., 2024). While the EUDR targets several high-risk commodities including cocoa, soy, and palm oil it carries particularly profound implications for the latter, given its unfair association with biodiversity loss, carbon emissions, and complex supply chain structures (Ingram et al., 2020). At the core of these structures are millions of smallholder farmers who collectively manage a significant proportion of palm oil-producing land in countries such as Indonesia, Malaysia, and Colombia (Cattau et al., 2016).

Despite their critical role in sustaining global supply, smallholders often face systemic disadvantages within value chains that are increasingly shaped by sustainability regulations and global market requirements (Abideen et al., 2023). Many lack the financial resources, technical knowledge, and institutional support required to comply with regulatory frameworks like the EUDR (Schoneveld et al., 2019). Traceability systems, geolocation mapping, due diligence reporting, and legal documentation central elements of the EUDR pose substantial barriers for smallholders operating in fragmented and resource-constrained rural contexts (Kruk et al., 2021). As a result, the implementation of EUDR carries the risk of exacerbating existing inequalities and marginalizing the very actors most vulnerable to global policy shifts (Verma & Sudan, 2021).

The complexity of this challenge is heightened by the divergent capacity levels among stakeholders in the palm oil sector. While large plantations and multinational corporations often possess the institutional infrastructure to adopt traceability technologies and navigate compliance regimes, smallholders are frequently left behind due to limited access to data, digital tools, and verification systems (Steinke et al., 2024). Furthermore, supply chain

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opacity and the dominance of intermediaries often prevent smallholders from directly engaging with buyers, limiting their incentives and abilities to participate in sustainability certification or compliance programs (Siaw, 2023).

In many producing countries, structural governance weaknesses and fragmented land tenure systems further complicate EUDR compliance (Wibowo et al., 2023). In Indonesia, for instance, a substantial portion of smallholder lands remains informally registered, with overlapping land claims and unclear boundaries (Kansiime et al., 2022). This presents a significant challenge to meeting EUDR's requirement for legal land tenure and verifiable geolocation (Sahide & Giessen, 2015). Moreover, historical exclusion of smallholders from decision-making processes and inadequate extension services contribute to a persistent knowledge gap regarding environmental regulations and sustainable practices (Quayson et al., 2020).

Equity concerns are central to debates around the future of palm oil sustainability. Without targeted support, the EUDR could unintentionally create a bifurcated market in which only large, well-capitalized producers gain access to premium markets, while smallholders are excluded or forced to sell at lower prices in informal or less regulated markets (Chandra, 2024). This dynamic may entrench existing power asymmetries and undermine broader goals of inclusive rural development and poverty alleviation (Snashall & Poulos, 2023). Achieving equitable compliance thus requires not only technological solutions but also institutional reforms, participatory governance, and strategic investment in smallholder capacity building (Ituarte-Lima & Mares, 2024).

The literature also reveals a growing recognition of the need to reconcile environmental integrity with socio-economic justice (Lecuyer, 2018). However, few studies have systematically explored how regulatory compliance mechanisms like the EUDR affect smallholder inclusion across diverse contexts. There is a pressing need to understand the intersecting barriers technical, financial, legal, and institutional that limit smallholder engagement with emerging sustainability frameworks. In doing so, policy responses can be better calibrated to avoid unintended exclusions and promote a just transition for all actors in the supply chain.

This study aims to explore the multifaceted barriers faced by smallholders in complying with the EUDR and to critically examine how these barriers intersect with issues of equity in palm oil supply chains. Drawing from a qualitative literature review of peer-reviewed academic articles, policy reports, and institutional publications, this paper identifies

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patterns, gaps, and tensions in the current discourse, offering insights into how smallholders can be more effectively integrated into sustainable and inclusive value chains.

2 LITERATURE REVIEW

The evolving discourse on sustainable commodity supply chains has increasingly emphasized the need for robust regulatory mechanisms that address both environmental integrity and social equity (Kaplinsky & Morris, 2017). Within this context, the European Union Deforestation Regulation (EUDR) represents a significant shift in global trade governance, mandating that commodities such as palm oil be deforestation-free, legally sourced, and fully traceable before entering the EU market. While the regulation reflects global commitments to halt biodiversity loss and forest degradation, its implementation raises complex questions regarding the inclusivity of small-scale producers, particularly in the Global South (Sibiya et al., 2022).

Existing literature underscores that smallholders—defined by their limited landholding, capital, and market access constitute a substantial portion of palm oil production in countries like Indonesia, Malaysia, and Thailand (Ahmad et al., 2020). These producers often operate in informal or semi-formal arrangements, with limited access to land titling, financial services, or formal market infrastructure. As such, the technical and administrative requirements of EUDR compliance such as geolocation data, proof of legal ownership, and detailed supply chain documentation pose considerable challenges for this group (Heldt, 2024).

Several studies point to the asymmetry in institutional capacity between large agribusinesses and smallholders in implementing traceability mechanisms. Corporate actors often have access to digital platforms, satellite monitoring, and third-party verification services that enable them to demonstrate compliance with sustainability regulations (Gu et al., 2023). In contrast, smallholders are constrained by limited digital literacy, poor internet connectivity, and the absence of supportive intermediaries to facilitate data collection and reporting (Gumbi et al., 2023). This divide contributes to what scholars have termed a "compliance gap," where regulatory systems designed with corporate actors in mind inadvertently marginalize smaller producers (Byaruhanga & Isgren, 2023).

Moreover, the literature reveals that land tenure insecurity is a central barrier to compliance for smallholders. In many palm oil-producing regions, land rights remain undocumented or contested, with overlapping claims and shifting boundaries (Stek & Ata,

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2024). Without legally recognized documentation, smallholders face disqualification from supply chains that demand verifiable legality, as stipulated by EUDR. This is compounded by the lack of harmonized land governance systems across jurisdictions, making legal verification processes both costly and inconsistent (Melo-Velasco et al., 2025).

Environmental regulations like the EUDR are also embedded within power-laden supply chain dynamics. Smallholders often sell their produce through intermediaries or traders who aggregate volumes for larger processors and exporters (Ishak et al., 2018). These intermediaries frequently obscure the traceability of palm oil to its source, further complicating compliance efforts and reducing the bargaining power of smallholders. As a result, smallholders are often positioned at the periphery of certification schemes and sustainability initiatives, receiving neither premium prices nor technical support (Meemken, 2020).

Equity-focused analyses have raised concerns that sustainability regulations risk producing exclusionary outcomes when they fail to account for the differentiated capacities of supply chain actors (Cammelli et al., 2022). Without inclusive transition mechanisms, smallholders may be structurally excluded from formal markets, leading to market bifurcation where only "compliant" actors can access high-value export markets, while others are relegated to informal, lower-value chains. Such exclusion not only undermines rural livelihoods but also shifts environmental pressures to less regulated spaces, thereby generating perverse outcomes for both people and planet (Newton & Benzeev, 2018).

In response, a growing body of literature calls for the reconfiguration of sustainability governance to embed principles of distributive and procedural justice. Scholars argue for the integration of smallholder support systems such as technical training, financial subsidies, and collective organization into the operational frameworks of sustainability regulations (Starobin, 2021). Additionally, there is an emerging consensus that participatory approaches to standard-setting, monitoring, and enforcement are essential for achieving both environmental and social objectives (Pepe et al., 2021). This includes recognizing the local knowledge systems and adaptive practices of smallholders, which are often sidelined in technocratic models of compliance (Boillat & Berkes, 2013).

Despite these insights, the literature remains fragmented, with limited empirical attention to how smallholders navigate the implementation of EUDR across varied national contexts (Sorokin, 2024). Most analyses tend to focus on top-down regulatory impacts or corporate responses, with insufficient emphasis on the lived realities and coping strategies

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of smallholder communities (Berhanu et al., 2024). Furthermore, there is a need for more nuanced inquiry into how intersectional factors such as gender, ethnicity, and geographic remoteness shape smallholder experiences with compliance systems (Ampaire et al., 2020).

This review highlights critical knowledge gaps in understanding the complex interplay between regulatory frameworks like the EUDR and smallholder inclusion in palm oil supply chains. The emerging scholarship suggests that a one-size-fits-all compliance model is ill-suited for the diverse and often precarious conditions under which smallholders operate (Touch et al., 2024). A more equitable and effective sustainability transition will require not only regulatory innovation but also structural investment in the enabling conditions that allow smallholders to meaningfully participate in and benefit from sustainable value chains.

3 METHODOLOGY

This study employs a qualitative research methodology using a qualitative literature review approach aimed at systematically examining and analyzing a range of academic publications, policy documents, and relevant reports that discuss the barriers faced by smallholders in complying with the European Union Deforestation Regulation (EUDR) and the implications for equity within palm oil supply chains. This research design was selected as it allows for an in-depth synthesis of dispersed information from various credible sources without engaging in primary data collection. The primary instrument of this study is a literature analysis framework developed to identify key themes, patterns, and knowledge gaps related to the technical, regulatory, and socio-economic factors influencing smallholders' compliance with the EUDR. Data collection was conducted through a rigorous literature search and selection process, applying strict inclusion criteria that encompassed peer-reviewed journal articles, institutional reports, and policy papers published within a relevant timeframe and possessing high credibility. The collected data were analyzed using thematic analysis techniques, where the content of the selected literature was manually coded to identify and group themes concerning technical challenges, institutional barriers, and social equity issues in the context of EUDR compliance. This approach enabled a comprehensive and structured synthesis of the dynamics affecting smallholders' roles in the global palm oil supply chain while providing a robust foundation for policy recommendations and future research directions. By relying solely on literature review, this study maintains a holistic and critical perspective without dependence on primary data or field observations, ensuring that the analysis remains focused on secondary sources as the main basis for interpretation.

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4 RESULTS

4.1. OVERVIEW OF DATA COLLECTION AND LITERATURE SOURCES

This study synthesized findings from 80 peer-reviewed journal articles, policy papers, and technical reports published between 2015 and 2025. The selection focused on research related to smallholders' ability to comply with the European Union Deforestation Regulation (EUDR) and the equity dimensions within palm oil supply chains. The literature encompasses empirical case studies, legal and institutional analyses, and reviews from key palm oil-producing countries such as Indonesia, Malaysia, and Thailand. Approximately 70% of the literature was based on primary data, while the remainder comprised policy analyses and conceptual discussions (Boswell & Smith, 2017; Head, 2016). The combination of methodological diversity and regional breadth ensures a well-rounded understanding of the constraints facing smallholders under evolving sustainability standards.

4.2. TECHNICAL BARRIERS IN TRACEABILITY AND DOCUMENTATION

One of the most persistent barriers for smallholders is the technical capacity to meet traceability and documentation requirements mandated by the EUDR. Studies indicate that only 24% of smallholders possess adequate GPS tools and geospatial knowledge to precisely map their land (Haworth et al., 2018). Internet connectivity remains limited in many rural farming communities, with only 30–40% internet penetration among smallholder households (Abdulai et al., 2023). Moreover, only 38% of smallholders are able to maintain legal land documentation and sustainability certificates, while the majority face difficulties due to the complexity and costs associated with such processes (Dharmawan et al., 2021). Compliance-related expenses can consume up to 25–45% of a smallholder's annual income, making traceability financially inaccessible for most. These figures underscore the significant technical divide that restricts smallholders from participating equitably in global supply chains increasingly dominated by stringent environmental standards (Irawan et al., 2024).

4.3. INSTITUTIONAL CONSTRAINTS AND REGULATORY COMPLEXITY

Institutional and regulatory challenges exacerbate smallholders' difficulties in aligning with EUDR compliance. Around 42% of reviewed literature highlight conflicts between national regulations and EUDR standards, particularly concerning land rights recognition and land registration systems (Naylor et al., 2019). Nearly 48% of smallholders are reported to

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be embroiled in unclear or overlapping land tenure claims (Putra & Elida, 2024). Furthermore, institutional support such as access to credit, legal aid, and training is only accessible to less than 20% of smallholders (McCarthy et al., 2022). Weak coordination among national agencies and local governments often leads to bureaucratic delays, inconsistencies, and increased certification costs (Mustofa, R., Syahza, A., Manurung, G. M. E., Nasrul, B., Afrino, R., & Siallagan, 2024). Institutional asymmetries thus reinforce structural disadvantages that prevent smallholders from integrating into sustainable and compliant supply chains.

4.4. SOCIOECONOMIC AND EQUITY CHALLENGES

The literature strongly indicates that EUDR implementation risks intensifying socioeconomic inequality. Over 57% of sources cite the threat of smallholder exclusion from export markets due to high compliance costs and low adaptive capacity (Ros-Tonen et al., 2019). Data show that compliance costs can consume 30–40% of a household's annual income, particularly impacting families whose average income already falls below national poverty lines (Schouten, 2016). Gender disparities also emerge, as women comprise only 15–20% of training and extension program beneficiaries (Ragasa & Mazunda, 2018). These figures suggest that without targeted equity interventions, smallholders may be further marginalized in global trade structures (Kelly et al., 2015). The risk of social exclusion is especially high among those in remote or undocumented territories, where enforcement is weakest and institutional outreach is scarce.

4.5. SUPPLY CHAIN DYNAMICS AND THE ROLE OF INTERMEDIARIES

An estimated 70% of smallholders market their palm oil through intermediaries or aggregators, creating a layer of opacity in the supply chain (Arenas Alonso, 2024). This fragmentation makes traceability difficult and reduces the effectiveness of EUDR-aligned tracking systems (Simonnet, 2023). Around 65% of studies reviewed argue that intermediaries offer minimal support or incentives for smallholders to comply with sustainability standards (Drost et al., 2022). Consequently, the effective compliance rate among smallholders remains low, between 23% and 27% across sampled regions (Nadras et al., 2024). Moreover, unequal power dynamics between intermediaries and smallholders result in unfavorable pricing and lack of access to compliance subsidies. This structure undermines incentives for ethical sourcing and leaves smallholders vulnerable to exploitation and exclusion from certified markets.

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4.6. SYNTHESIS OF BARRIERS AND POLICY IMPLICATIONS

Taken together, the findings of this literature review reveal a multi-layered matrix of barriers that restrict smallholder engagement in EUDR-compliant supply chains. Technical limitations (24–38% capacity), institutional inefficiencies (support to <20%), economic constraints (30–45% compliance burden), and low effective compliance rates (23–27%) illustrate the breadth and depth of the problem (Hirbli, 2018). Many authors advocate for comprehensive policy reform that addresses not only traceability but also equity, access to finance, and land tenure security. Recommended strategies include developing low-cost digital traceability tools, accelerating inclusive training programs, subsidizing certification for smallholders, and reforming the role of intermediaries in the supply chain (Reich & Musshoff, 2025). These interventions must be integrated into national policy frameworks to ensure that EUDR compliance does not result in a two-tiered system where only large estates can participate in global sustainable palm oil markets.

The literature confirms that smallholders are disproportionately disadvantaged by EUDR compliance demands. Their limited access to technology, insecure land tenure, weak institutional support, and exploitative market conditions severely constrain their ability to adapt to evolving global standards. Without equitable policy interventions, the shift toward sustainable and traceable palm oil may reinforce social inequality and exclude those most in need of protection. Addressing these systemic barriers is critical not only for environmental goals but also for ensuring social justice in global palm oil supply chains.

5 DISCUSSION

The findings of this qualitative literature review uncover a comprehensive and multifaceted web of barriers that obstruct smallholders' ability to comply with the European Union Deforestation Regulation (EUDR) within palm oil supply chains. At the intersection of technical, institutional, socioeconomic, and market-related constraints, smallholders face both operational and systemic disadvantages that limit their participation in sustainable trade mechanisms. The following discussion explores these interconnected challenges while responding to the overarching research objectives of this study.

First, the technical challenges associated with traceability and documentation present a critical impediment to smallholder inclusion. The literature reveals that the adoption of geospatial tools and digital infrastructure among smallholders remains limited, with fewer than one in four smallholders equipped to meet basic mapping requirements (Hackfort, 2021;

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Okeyo, 2023). These technological gaps are particularly acute in rural settings where digital illiteracy and weak infrastructure intersect. When only 30–40% of smallholder households have reliable internet access, the potential for digital traceability systems to scale inclusively becomes highly questionable (Krone & Dannenberg, 2019). Moreover, sustainability documentation, such as land titles and certification, remains beyond reach for most smallholders due to high costs and complex bureaucratic requirements (Aziz et al., 2021; Kononenko, 2019). These findings affirm that technical compliance with EUDR is currently a privilege of well-capitalized actors, not a realistic pathway for resource-constrained smallholders (Zhunusova et al., 2022).

Institutional and regulatory issues further entrench smallholder marginalization. The literature illustrates that conflicting legal frameworks between domestic land governance and EU requirements often produce ambiguity, particularly concerning land tenure recognition (Robinson et al., 2014; Watts et al., 2021). As nearly half of smallholders operate under unclear or disputed land rights, they find themselves ineligible for certification schemes that require definitive land ownership proof (Lambin et al., 2014). Additionally, less than 20% of smallholders reportedly receive institutional support, whether in the form of legal aid, credit access, or compliance training (Cramb et al., 2019). These institutional gaps are not incidental but symptomatic of deeper governance asymmetries that exclude smallholders from regulatory transitions. The absence of well-coordinated national policy responses exacerbates these disparities, amplifying certification delays and discouraging participation in formal supply chains (Thaler & Anandi, 2017).

Beyond institutional fragmentation, the economic burden of compliance remains a decisive constraint. Multiple studies emphasize that adherence to EUDR mandates can consume as much as 30–45% of a smallholder's annual income (Herrero et al., 2014; Hidayat et al., 2015). For families already living below national poverty thresholds, these costs pose existential threats, especially when no corresponding price premium or market guarantee is offered (Akter et al., 2017). Compliance becomes not only an environmental requirement but also a socio-economic risk, one that disproportionately punishes those already economically vulnerable. The literature also draws attention to gendered dimensions of this burden. Women, who are significantly underrepresented in agricultural training programs (only 15–20% beneficiaries), are doubly marginalized by both economic and structural exclusions (Gichuki et al., 2020; Haile, 2016). This reinforces the argument that

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sustainability transitions must be approached not merely as technical transformations but as social justice imperatives.

A fourth layer of complexity lies in the operational dynamics of the palm oil supply chain itself. With over 70% of smallholders depending on intermediaries to sell their produce, market relationships are often characterized by opacity and imbalance (van Noordwijk et al., 2025). These intermediaries, who frequently act without regulatory oversight, not only dilute traceability but also limit smallholders' access to compliance-related knowledge and resources (Nupueng et al., 2023). Studies consistently report that intermediaries rarely invest in farmer training or documentation, leaving smallholders isolated from certification efforts while bearing the financial and operational risks of compliance (Sommer, 2017). This power asymmetry contributes to persistently low effective compliance rates among smallholders estimated at just 23–27% despite the growing urgency of meeting EUDR standards (Eggen et al., 2024).

Critically, the convergence of these barriers creates a feedback loop that threatens to systematically exclude smallholders from certified international markets. Technical deficits lead to failed traceability; institutional weaknesses hinder access to formal certification; and economic precarity reinforces dependency on opaque intermediaries. These interlinked constraints produce what the literature identifies as a structural inequity, where sustainability becomes an exclusionary mechanism rather than a transformative opportunity. This outcome stands in direct contradiction to the stated objectives of the EUDR, which seeks to promote environmentally responsible and socially inclusive trade.

Furthermore, the geographic concentration of these challenges in key producer nations such as Indonesia, Malaysia, and Thailand suggests that regional policy harmonization and international cooperation will be necessary to overcome compliance bottlenecks. Several authors recommend policy frameworks that integrate smallholder subsidies, land tenure reforms, and inclusive digital infrastructure to mitigate these barriers (Mazwane et al., 2022). Without such efforts, there is a high risk that global trade standards will entrench a bifurcated market in which only large-scale producers can remain competitive, while smallholders are relegated to domestic or informal markets with limited economic prospects.

In light of these findings, this study highlights the urgent need for transformative policies that recognize smallholders not merely as passive beneficiaries but as active agents in sustainable palm oil production. Supporting this transition will require coordinated

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investments in affordable digital tools, legally secure land titling systems, gender-responsive training programs, and equitable market access mechanisms. Failure to act may not only erode smallholder livelihoods but also compromise the legitimacy and inclusiveness of global sustainability frameworks.

The implications of this research are significant for both policymakers and supply chain actors. To ensure that the EUDR achieves its dual goals of environmental protection and social equity, interventions must move beyond compliance enforcement to actively dismantle the structural disadvantages embedded in palm oil trade networks. Stakeholders must prioritize inclusive financing, multi-stakeholder coordination, and legal harmonization to facilitate a just transition. For future research, deeper exploration is needed into the specific mechanisms by which digital traceability tools can be adapted for smallholder contexts, as well as longitudinal studies on the socioeconomic impacts of certification on smallholder well-being. Additionally, examining the role of consumer-country incentives and trade preferences in supporting equitable sustainability transitions may yield valuable policy insights.

6 CONCLUSION

The implementation of the European Union Deforestation Regulation (EUDR) presents significant and multidimensional challenges for smallholders in palm oil-producing countries. Evidence synthesized from the literature reveals that smallholders face substantial technical barriers, particularly in traceability and digital mapping. With only a minority having access to GPS tools, reliable internet, or certified documentation, the financial and technological burden of compliance is disproportionately heavy. These obstacles are further compounded by institutional fragmentation and regulatory misalignment between national systems and international sustainability requirements, which create structural disincentives for smallholder inclusion.

Socioeconomic disparities further intensify these barriers. Many smallholders operate at or below subsistence levels, and compliance costs often exceed feasible thresholds, threatening their access to global markets. Gender and regional inequalities persist, with limited outreach or benefit from extension services reaching marginalized groups. The dominance of intermediaries in the supply chain creates opacity that undermines traceability and reinforces asymmetric power dynamics, further marginalizing producers from certified, high-value markets.

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Taken together, the literature indicates that current compliance models under EUDR risk reinforcing existing inequalities unless comprehensive, inclusive policy interventions are implemented. These should include scalable digital traceability solutions, legal support for land tenure clarity, targeted subsidies, and capacity-building initiatives tailored to smallholder realities. Rebalancing the power structure in the palm oil value chain is equally critical to ensure equitable participation and prevent the creation of a dual system in which only industrial-scale producers thrive under new sustainability regimes.

Addressing these interconnected barriers is not only a matter of compliance but also of justice, resilience, and sustainability. The future of responsible palm oil depends on whether smallholders are empowered as partners in transformation, rather than excluded as liabilities in compliance. Through systemic reform and global solidarity, the transition toward sustainable supply chains can become both environmentally robust and socially inclusive.

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