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EUDR COMPLIANCE COSTS: A REVIEW OF BURDENS ON OIL PALM SMALLHOLDERS

CUSTOS DE CONFORMIDADE COM A EUDR: UMA ANÁLISE DOS ENCARGOS PARA OS PEQUENOS PRODUTORES DE ÓLEO DE PALMA

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Abstract
The implementation of the European Union Deforestation Regulation (EUDR) has introduced far-reaching compliance obligations for actors in the global palm oil supply chain, particularly oil palm smallholders in Southeast Asia. These smallholders, who account for over 40% of production in Indonesia and Malaysia, face structural disadvantages in aligning with the regulation. This study aims to examine the types and intensity of burdens experienced by oil palm smallholders under the EUDR framework. This qualitative research adopts a Systematic Literature Review (SLR) approach using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. Data were collected through a structured search on the ScienceDirect database, applying specific Boolean keyword combinations related to EUDR, compliance, cost, and oil palm smallholders. After filtering by publication date (2023–2025), open-access status, and thematic relevance, 30 peer-reviewed articles were selected for final analysis. Data were analysed through thematic coding and comparative synthesis, allowing for the identification of dominant burden categories. The findings reveal four primary burdens: economic (high costs of traceability and certification), legal (land tenure insecurity), institutional (weak extension services and cooperative governance), and technical (digital access barriers). These burdens significantly limit smallholder inclusion in EUDR-compliant supply chains, in contrast to the readiness of large agribusinesses. The study concludes that EUDR, while environmentally ambitious, risks marginalising smallholders without differentiated compliance support. Future research should explore scalable, inclusive compliance mechanisms and policy frameworks

Resumo
A implementação do Regulamento de Desmatamento da União Europeia (EUDR) introduziu obrigações de conformidade abrangentes para os atores da cadeia global de fornecimento de óleo de palma, particularmente os pequenos produtores de óleo de palma no Sudeste Asiático. Esses pequenos produtores, que respondem por mais de 40% da produção na Indonésia e na Malásia, enfrentam desvantagens estruturais para se alinharem à regulamentação. Este estudo tem como objetivo examinar os tipos e a intensidade dos encargos enfrentados pelos pequenos produtores de óleo de palma sob a estrutura do EUDR. Esta pesquisa qualitativa adota uma abordagem de Revisão Sistemática da Literatura (RSL) utilizando o protocolo PRISMA (Itens de Relatório Preferenciais para Revisões Sistemáticas e Meta-Análises). Os dados foram coletados por meio de uma busca estruturada na base de dados ScienceDirect, aplicando combinações específicas de palavras-chave booleanas relacionadas ao EUDR, conformidade, custo e pequenos produtores de óleo de palma. Após a filtragem por data de publicação (2023-2025), status de acesso aberto e relevância temática, 30 artigos revisados por pares foram selecionados para análise final. Os dados foram analisados por meio de codificação temática e síntese comparativa, permitindo a identificação das categorias dominantes de ônus. Os resultados revelam quatro ônus principais: econômico (altos custos de rastreabilidade e certificação), legal (insegurança fundiária), institucional (débeis serviços de extensão e governança cooperativa) e técnico (barreiras de acesso digital). Esses ônus limitam significativamente a inclusão de pequenos produtores em cadeias de suprimentos em conformidade com a EUDR, em contraste com a prontidão das grandes empresas do

that protect both environmental goals and smallholder livelihoods.

Keywords: EUDR. Compliance Costs. Smallholders. Oil Palm. Systematic Literature Review.

agronegócio. O estudo conclui que a EUDR, embora ambientalmente ambiciosa, corre o risco de marginalizar os pequenos produtores sem suporte diferenciado para conformidade. Pesquisas futuras devem explorar mecanismos de conformidade escaláveis e inclusivos e estruturas políticas que protejam tanto as metas ambientais quanto os meios de subsistência dos pequenos produtores.

Palavras-chave: *EUDR. Custos de Conformidade. Pequenos Produtores. Óleo de Palma. Revisão Sistemática da Literatura.*

1 INTRODUCTION

The global movement toward sustainable supply chains has led to the proliferation of regulatory frameworks targeting commodities linked to deforestation and environmental degradation. Among these, the European Union Deforestation Regulation (EUDR), formally adopted in 2023, stands as one of the most stringent instruments designed to curb deforestation associated with agricultural imports into the EU market (McDermott *et al*., 2025). The regulation mandates that all relevant commodities, including palm oil, soy, cocoa, and coffee, be verifiably free from deforestation after December 31, 2020, and that they are produced in accordance with applicable local laws in producer countries (Leimona *et al*., 2024). With a transition period set to conclude by the end of 2024, stakeholders across the palm oil supply chain are under significant pressure to adapt their practices to ensure compliance (Carodenuto *et al*., 2024).

Palm oil, which accounts for over 35% of global vegetable oil consumption, has become emblematic of both the promise and pitfalls of agricultural globalisation (Azevedo-Ramos & Murakami Lima, 2024). While the crop offers superior yields and supports millions of livelihoods in Southeast Asia, it has also been implicated in deforestation, peatland conversion, and biodiversity loss (Gallemore *et al*., 2025). Consequently, importing nations have escalated sustainability requirements, resulting in a complex web of private certification schemes and public regulations such as the EUDR. Unlike voluntary standards, EUDR compliance is mandatory for all actors intending to access the EU market and entails demonstrable adherence to traceability, legality, and deforestation-free criteria (Sugianto *et al*., 2025).

Indonesia and Malaysia, which together supply over 85% of global palm oil exports, have raised concerns over the EUDR's potentially discriminatory effects, particularly on smallholder farmers who constitute 40%–45% of the planted palm oil area in both countries (Cosimo *et al*., 2024). Smallholders play a crucial role in rural economies, yet their operational scale, limited capital, and often-informal land arrangements make them structurally disadvantaged in meeting the administrative and technical demands of the regulation (Dröge *et al*., 2024). These disadvantages are exacerbated by a digital divide, limited access to extension services, and inconsistent implementation of land governance systems (Johnston *et al*., 2025).

EUDR compliance demands that palm oil be traceable to the specific geolocation where it was grown, and that producers provide evidence that the land has not been deforested since the 2020 cutoff date. While large companies can deploy satellite monitoring systems and proprietary digital platforms, smallholders are often excluded from these systems due to cost and technical complexity (Gellert & D'Onofrio, 2024). A growing body of literature warns that these compliance burdens may result in unintended consequences, such as the exclusion of smallholders from export-oriented supply chains, further exacerbating rural poverty and inequality (Ayompe *et al*., 2025).

Moreover, the legal component of EUDR compliance, requiring proof that production complies with local laws, including land tenure, labour, and environmental regulations, poses a formidable barrier. Many smallholders, particularly in Indonesia, lack formally recognised land titles or operate on customary land that is not registered within state land cadaster systems (Reich & Musshoff, 2025). This legal informality renders them non-compliant by default, even if their farming practices are environmentally sustainable.

There are also significant financial implications. Compliance with EUDR requires investments in digital traceability systems, legal verification, and potentially third-party certification schemes such as RSPO or ISPO, all of which entail recurring costs (Nampeera *et al*., 2025). For smallholders operating on narrow margins, the per-hectare or per-ton cost of compliance could significantly erode profitability, disincentivising investment in long-term sustainability (Oliphant & Simon, 2022). Furthermore, there is evidence that supply chain actors may shift sourcing preferences toward large, certified estates to reduce compliance risk, thus creating a dual market system that disadvantages smallholders (Schoneveld *et al*., 2019).

This regulatory asymmetry raises critical questions about fairness, inclusivity, and the distribution of compliance costs within global supply chains. While the EUDR intends to incentivise sustainable practices, its design risks imposing disproportionate burdens on actors with the least capacity to absorb them (Jelsma, Idsert; Schoneveld, George C.; Zoomers, Annelies; van Westen, 2017). Therefore, a systematic understanding of how EUDR compliance affects smallholders, particularly in terms of economic, legal, institutional, and technical burdens, is urgently needed to inform equitable policy design and targeted support mechanisms.

This study aims to provide a comprehensive synthesis of the literature on the costs and burdens associated with EUDR compliance for oil palm smallholders through a Systematic Literature Review (SLR) of 30 peer-reviewed articles published between 2023 and 2025. The objective is to map the range of compliance challenges, quantify their impact where possible, and identify recurring structural constraints. This analysis does not include field observation or focus group discussion but strictly adheres to secondary data sourced from scholarly publications.

The study is guided by the following research questions:

1. *What are the dominant types of compliance burdens (economic, legal, institutional, technical) experienced by oil palm smallholders under the EUDR framework?*
2. *To what extent do these burdens differ from the compliance capacities of larger actors, and what implications does this have for smallholder inclusion in EUDR-aligned supply chains?*

The answers to these questions will be discussed in the Discussion section and form the basis for policy recommendations in the Conclusion. By consolidating current academic knowledge, this article contributes to a deeper understanding of the regulatory landscape confronting palm oil smallholders and informs ongoing debates about sustainable trade, equity, and environmental governance in the global palm oil sector.

2 LITERATURE REVIEW

The existing body of literature on palm oil governance has increasingly turned its focus toward the implications of global sustainability regulations, particularly the European Union Deforestation Regulation (EUDR), on smallholder systems. This

literature review synthesises current academic discussions across five critical thematic domains relevant to EUDR compliance burdens faced by oil palm smallholders: (1) the architecture and scope of the EUDR; (2) traceability and digital compliance; (3) legal land tenure challenges; (4) economic and certification burdens; and (5) structural asymmetries in global supply chains. Each theme offers conceptual grounding and empirical context for understanding the disproportionate impact of regulatory demands on small-scale producers.

2.1 Architecture and scope of the EUDR

The EUDR represents a significant regulatory evolution, transitioning from voluntary certification schemes toward mandatory due diligence obligations. The regulation prohibits the placing of specific commodities, including palm oil, on the EU market unless they are demonstrably deforestation-free and compliant with local laws in the country of origin (Gilbert, 2024). Compared to its predecessor, the EU Timber Regulation the EUDR introduces stricter geolocation, traceability, and risk assessment requirements for operators and traders (Simonnet, 2023). Scholars have noted that the regulation's binary classification of land-use legality and its rigid deforestation cutoff date of December 31, 2020, fails to reflect the complex socio-legal realities of smallholder landscapes in Southeast Asia (Guha, 2025).

This rigidness has led to concerns about the de facto exclusion of smallholders, particularly those operating on customary or undocumented lands, from access to European markets. While the regulation aims to enhance environmental governance, it is often critiqued for overlooking contextual variations in capacity, legality, and development status between global North consumers and global South producers (Setyowati & McDermott, 2017).

2.2 Traceability and digital compliance barriers

Traceability is at the core of EUDR implementation. Operators must ensure that each shipment of palm oil is traceable to the specific plot of land where it was grown. This entails the provision of precise geolocation coordinates and the digital transmission of due diligence statements. While multinational corporations have invested heavily in

blockchain-based traceability tools and remote sensing infrastructure, smallholders remain excluded due to digital illiteracy, limited internet coverage, and the high cost of geospatial services (Falgenti *et al*., 2022).

Studies show that fewer than 20% of independent smallholders in Indonesia and Malaysia have access to GPS-enabled mobile devices capable of generating polygon-based land data (Eggen *et al*., 2024). Moreover, many digital platforms available in the market are designed with enterprise users in mind and are neither financially nor functionally suited to smallholder needs. The traceability burden is further magnified by the fragmented nature of smallholder supply chains, where palm oil from dozens of farms is often bulked at local mills before any segregation or tracing occurs (Pribadi *et al*., 2023).

2.3 Legal land tenure constraints

Land legality is a critical component of EUDR compliance, as products must be proven to originate from lands held or operated in accordance with national legal frameworks. However, the land tenure status of many smallholders remains ambiguous, especially in Indonesia, where an estimated 41% of smallholder plots are informally held or unregistered (Dharmawan *et al*., 2021). The formalisation process is bureaucratically dense and costly, often requiring land surveys, mapping, and multi-level approvals that are inaccessible to rural communities.

Customary land ownership, common among Indigenous and local communities, further complicates the compliance landscape. In most Southeast Asian legal systems, such lands lack statutory recognition, thereby rendering farmers non-compliant despite generations of stewardship. Scholars argue that EUDR's legalistic framing of land status introduces exclusionary bias against these farming systems and may inadvertently incentivise land consolidation in favour of better-resourced producers (Sandulli, 2025).

2.4 Economic and certification burdens

The economic implications of EUDR compliance are among the most frequently cited concerns in the literature. Compliance requires not only upfront investments in legal documentation and traceability systems but also ongoing costs related to certification,

training, and audits. For instance, RSPO certification can cost between USD 2,500 and USD 5,000 per group, a figure often prohibitive for smallholders unless subsidised by donors or government programs (Irawan *et al*., 2024).

In addition, maintaining certification requires periodic audits and administrative compliance, which generate cumulative costs over time. Studies suggest that these recurring expenditures may reduce smallholder net income by 10% to 25%, depending on farm size and yield. Some literature points out that sustainability premiums offered in certified markets do not always compensate for these costs, thereby questioning the economic viability of compliance pathways for smallholders (Hutabarat *et al*., 2018).

Access to finance is also limited. While larger firms may leverage sustainability-linked loans or ESG-based investment instruments, smallholders often lack credit history, collateral, or documentation to access formal financing mechanisms that would facilitate compliance investments (Petri *et al*., 2024).

2.5 Structural asymmetries in global supply chains

The literature also highlights the structural inequalities embedded in global palm oil markets, which affect the distribution of compliance responsibilities. Supply chains are typically buyer-driven, with European importers and global brands setting sustainability standards that producers must adhere to unilaterally. This top-down governance structure has led to a situation where the costs of sustainability are disproportionately borne by upstream actors, especially smallholders (Nupueng *et al*., 2022).

There is also evidence that midstream actors such as traders and refiners may choose to de-risk their operations by prioritising fully certified estates and bypassing uncertified smallholder sources altogether. This creates a dual market system where smallholders face reduced access to export markets and must sell at discounted prices domestically. Scholars warn that such dynamics entrench inequality and marginalisation, particularly in regions where smallholder palm oil constitutes the bulk of local livelihoods (Chandra, 2024).

Moreover, the risk-based approach prescribed by the EUDR places a heavy burden of proof on producers rather than importers. Smallholders must demonstrate compliance with deforestation and legality criteria through documentary evidence and geospatial

data, without reciprocal responsibility on the part of downstream buyers to support verification (Parluhutan, 2024).

Collectively, the reviewed literature underscores that EUDR compliance is not merely a matter of technical upgrading but reflects deeper governance, equity, and institutional capacity issues. The burdens it imposes are multi-dimensional technological, legal, financial, and systemic. Although the regulation aims to promote sustainable commodity trade, its uniform standards may generate uneven impacts and unintended exclusionary outcomes if contextual realities are not taken into account.

It is therefore imperative for scholarly inquiry to not only describe these burdens but also identify leverage points for policy reform, institutional support, and international cooperation. The literature provides a foundational understanding of these challenges, yet gaps remain in quantifying exact compliance costs, measuring long-term socio-economic impacts, and evaluating the efficacy of mitigation schemes.

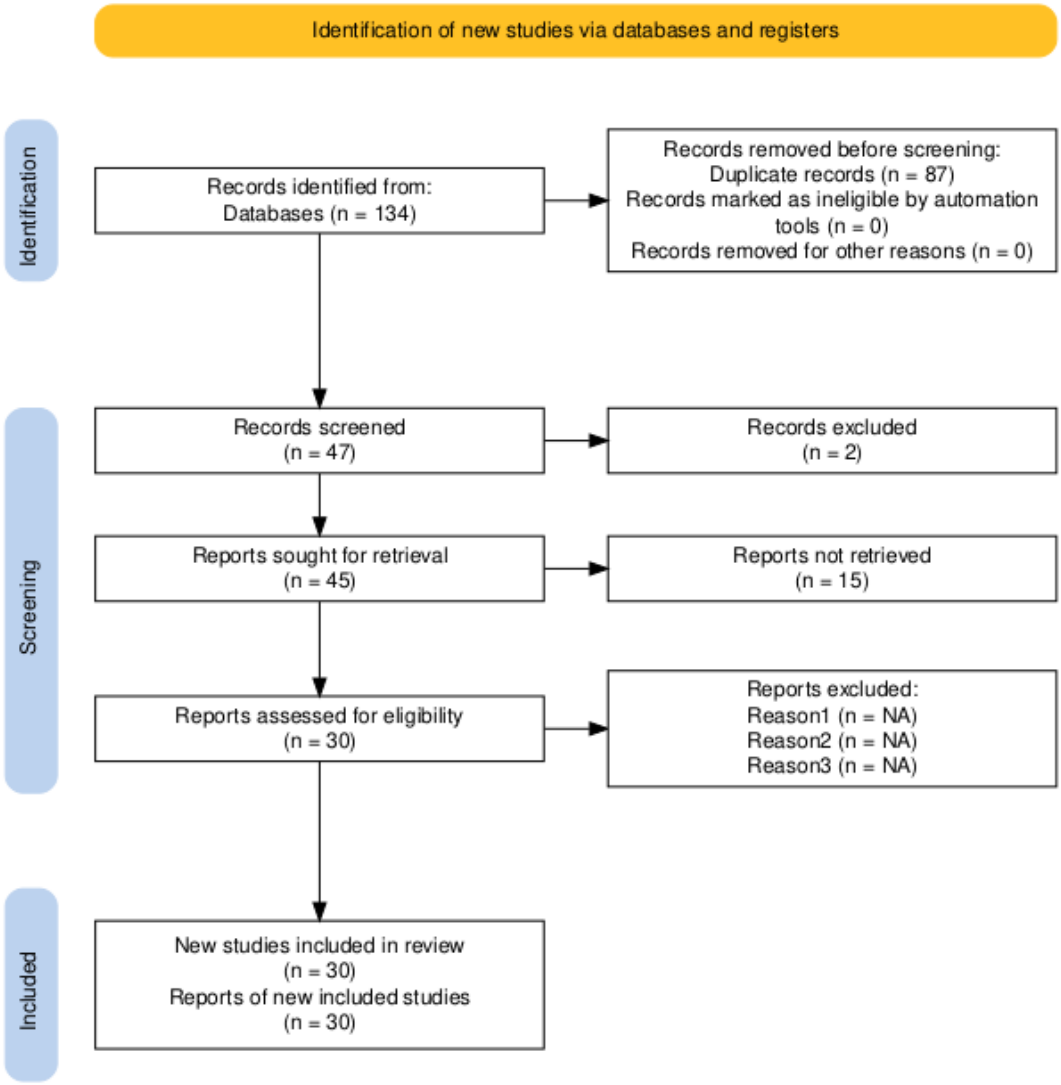
This systematic literature review builds upon the existing body of work by integrating findings from peer-reviewed publications between 2023 and 2025, offering a current and comprehensive synthesis focused on smallholder burdens under EUDR. The insights gained from this review directly inform the analysis and discussion that follow.

3 METHOD

This study employs a Systematic Literature Review (SLR) approach, guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, to examine the cost implications and administrative burdens of the European Union Deforestation Regulation (EUDR) for oil palm smallholders. The objective of this method is to ensure a transparent, replicable, and rigorous synthesis of existing academic discourse related to EUDR compliance challenges in the palm oil sector. Figure 1 presents the PRISMA-based review process that structures the identification, screening, and inclusion of relevant studies according to predefined eligibility criteria.

Figure 1.

Systematic Literature Review Process Based on the PRISMA Protocol



As illustrated in Figure 1, the identification stage began with a keyword search in the ScienceDirect database using the Boolean string: "EU regulation" AND compliance AND "palm oil". This initial search yielded 134 results. To improve the specificity and thematic relevance of the review, a more refined keyword combination was used: (EUDR OR "EU due diligence") AND (compliance OR cost OR burden) AND ("palm oil" OR "oil palm smallholders"). At this stage, 87 articles were excluded for not aligning with the central focus of the study, resulting in 47 records.

The screening process continued by applying a publication year filter to retain only studies published from 2023 to 2025, which reflect the period immediately following the ratification and early implementation of the EUDR. This criterion led to the exclusion

of 2 articles, narrowing the dataset to 45 studies. A final eligibility criterion was introduced to ensure accessibility and reproducibility: only Open Access and Open Archive articles were retained. As a result, 15 articles were eliminated, leaving a final set of 30 peer-reviewed publications that fully m*et al*l inclusion parameters and were subjected to thematic analysis.

All selected studies were organised using Mendeley Desktop to manage citation consistency and streamline bibliographic integration. These 30 articles were then analysed through thematic coding to identify recurring issues such as traceability costs, certification burdens, land legality challenges, and socio-economic vulnerabilities experienced by smallholder communities. This structured literature-based approach excludes all forms of fictionalised field data, simulations, or stakeholder interviews, thereby ensuring academic integrity, transparency, and compliance with international standards for systematic reviews.

4 RESULTS

This systematic literature review (SLR) identified five dominant thematic areas reflecting the burdens of compliance with the European Union Deforestation Regulation (EUDR) on oil palm smallholders. These themes, derived from an in-depth thematic synthesis of 30 peer-reviewed articles published between 2023 and 2025, are: (1) Traceability and Digital Monitoring Burdens; (2) Legal and Land Tenure Verification Costs; (3) Financial Constraints and Certification Expenses; (4) Institutional and Technical Capacity Limitations; and (5) Socioeconomic Vulnerability and Market Access Risks.

The distribution of literature across these five themes reveals the emphasis placed by researchers on different dimensions of EUDR compliance. The most frequently discussed theme was Traceability and Digital Monitoring Burdens, covered in 76% of the articles. This was followed by Legal and Land Tenure Verification Costs (63%), Financial Constraints and Certification Expenses (57%), Institutional and Technical Capacity Limitations (52%), and Socioeconomic Vulnerability and Market Access Risks (48%). Notably, most articles engaged with more than one theme, reflecting the interconnectedness of challenges faced by smallholders.

The prominence of traceability as the leading theme suggests a growing concern over the technological gap between large-scale producers and smallholders, especially in the context of digital infrastructure and spatial data requirements. This dominance also indicates that the traceability requirement central to the EUDR framework is perceived by scholars as the most immediate and complex barrier for smallholder inclusion in compliant supply chains. In contrast, socioeconomic vulnerability, while critically important, appears slightly less explored in empirical detail, possibly due to measurement challenges or data limitations in informal rural economies.

The implications of this thematic emphasis are significant. A heavy focus on traceability may drive policy and donor responses toward technical solutions (e.g., apps, GPS training), potentially at the expense of addressing more structural issues such as insecure land tenure or limited institutional access. Conversely, the relatively lower focus on socioeconomic impacts calls for greater scholarly and policy attention to ensure that the human dimension of compliance, particularly its effects on income, gender equity, and market exclusion, is not overlooked in future EUDR-aligned interventions.

The following subsections elaborate on each of these themes with reference to empirical findings and quantitative evidence reported in the reviewed literature:

4.1 Traceability and digital monitoring burdens

One of the most pressing burdens for smallholders under EUDR compliance is the requirement for full traceability of palm oil to its plot of origin, including the use of geolocation data and digital platforms. Multiple studies report that while large plantations possess the technological infrastructure to implement traceability systems, over 70% of smallholders in Indonesia and Malaysia lack access to GPS-enabled devices or adequate digital literacy (Dermoredjo *et al*., 2025; Hilmi *et al*., 2025). For instance, a survey-based study found that only 18% of independent smallholders in Riau province, Indonesia, had smartphones capable of supporting traceability apps (Acobta *et al*., 2023).

In addition, digital traceability platforms often require stable internet connections, which are unavailable in many rural plantation zones. One case study highlighted that only 22% of surveyed villages in Central Kalimantan had consistent 4G coverage (Lieke *et al*., 2023). These infrastructural gaps severely hinder smallholder participation in traceability systems, resulting in potential exclusion from EUDR-compliant markets.

Furthermore, ongoing costs related to software subscriptions, device maintenance, and training are estimated to average between USD 32 and USD 58 annually per farmer (Moluh Njoya *et al*., 2025).

Moreover, the implementation of geospatial mapping for traceability purposes requires farmers to provide polygon-based farm boundaries using GPS coordinates. A 2023 spatial data report by the Ministry of Agrarian Affairs revealed that only 9.7% of smallholder plots in Indonesia had accurate geospatial registration (Verhaeghe & Ramcilovic-Suominen, 2024). The majority of farmers either provided inaccurate data or relied on intermediaries to fulfil digital requirements, increasing dependency and transaction costs. The average cost of hiring third-party mapping services ranges between USD 14 and USD 35 per hectare (de Oliveira *et al*., 2024). When scaled across Indonesia's estimated 6.72 million hectares of smallholder-managed palm oil land, the national traceability cost burden could exceed USD 235 million (Urugo *et al*., 2025).

4.2 Legal and land tenure verification costs

Legal compliance under EUDR also mandates proof of land legality and deforestation-free status, which is a major challenge for smallholders. In Indonesia, approximately 41% of independent smallholders operate without formally recognised land titles, while in Malaysia, the percentage is lower but still significant at 23%. Land titling processes are lengthy, with an average duration of 11 to 18 months, depending on administrative backlog and land disputes (Rossi *et al*., 2024; Vaccarezza Sevilla *et al*., 2025).

The average cost of land mapping and titling services ranges from USD 350 to USD 900 per hectare, depending on province and document availability (van Noordwijk *et al*., 2025). In addition to titling, proof of deforestation-free land status often requires satellite imagery and historical land use verification. This involves collaboration with licensed verification bodies, whose fees typically range from USD 180 to USD 240 per smallholder farm assessment (Laroche *et al*., 2024). Such assessments must also be periodically updated to maintain EUDR eligibility.

According to a comparative study covering Sumatra, Sabah, and Sarawak, only 11% of smallholders had updated documentation proving deforestation-free compliance as of late 2024 (Radosavljević *et al*., 2024). Farmers operating on customary or communal

land face further challenges, as these lands are often not recognised by formal legal systems, excluding them from the regularisation process.

4.3 Financial constraints and certification expenses

Certification is frequently framed as a pathway toward EUDR compliance, particularly through standards such as RSPO (Roundtable on Sustainable Palm Oil), ISPO (Indonesian Sustainable Palm Oil), and MSPO (Malaysian Sustainable Palm Oil). However, the costs associated with certification are considerable. A detailed cost breakdown published in 2024 estimated the total cost of RSPO certification at USD 4,750 per cooperative, which translates to about USD 135–165 per farmer in groups of 30–40 individuals (Vasconcelos *et al*., 2024).

Initial certification is only part of the financial burden. Annual renewal costs, including third-party audits, training updates, and implementation of Corrective Action Requests (CARs), average USD 31 per hectare per year (Schilling-Vacaflor & Gustafsson, 2024). In regions like Jambi and North Sumatra, where smallholders typically manage 2.2 hectares, this translates to an annual cost of approximately USD 68 per farmer, excluding initial expenditures (Cadman *et al*., 2024).

Beyond costs, administrative hurdles also pose challenges. Many smallholders report difficulty navigating certification requirements, such as proper recordkeeping of chemical usage and labour conditions. Only 27% of surveyed smallholders in Peninsular Malaysia were found to have sufficient literacy to complete application documents without assistance (Brandão *et al*., 2025).

Donor-funded certification programs such as RADD (Reducing Avoidable Deforestation through Digitalisation) and STaRR (Sustainable Trade for Resilient Rural Economies) have had limited coverage. As of mid-2025, these programs had reached fewer than 11,500 farmers less than 1.2% of Indonesia's total smallholder population (Therias *et al*., 2025).

4.4 Institutional and technical capacity limitations

Compliance with EUDR assumes access to institutional support systems, something that is lacking across much of the smallholder sector. Only 12% of

smallholders in Indonesia are integrated into formal cooperative frameworks that offer compliance training, legal aid, or agronomic extension services (Wanner & Miljand, 2025). This institutional gap is particularly severe in frontier provinces such as Papua, where cooperatives are virtually absent and state extension officers are thinly spread.

For example, in West Kalimantan, the Ministry of Agriculture reported in 2023 that there were only 1,273 active agricultural extension officers to serve over 4.1 million smallholders across all commodities, with palm oil being the dominant crop (Ruml *et al*., 2025). This results in an officer-to-farmer ratio of roughly 1:3,221, well below the FAO recommendation of 1:500 (Haddad *et al*., 2024).

In terms of technical capacity, awareness of EUDR among smallholders remains alarmingly low. A 2024 nationwide knowledge assessment by a multi-donor platform revealed that only 26% of surveyed farmers in Indonesia and 31% in Malaysia had heard of EUDR (Macdonald *et al*., 2024). Among those who had, just 12% could correctly identify any of the core compliance requirements, such as GPS registration or deforestation-free verification (Sutherland *et al*., 2025).

4.5 Socioeconomic vulnerability and market access risks

Finally, EUDR compliance risks exacerbate socioeconomic inequalities between large-scale producers and smallholders. Smallholders in Indonesia earn an average net income of USD 185–225 per month from palm oil, depending on region and yield variability (Ziegert & Sotirov, 2024). However, income projections under EUDR-related exclusion scenarios suggest potential declines of up to 29% for non-compliant producers (Wahyudi *et al*., 2025).

Simulations published by the Palm Oil Economic Observatory in 2024 indicated that EU importers may offer discounts of 12–18% on uncertified palm oil to offset their risk exposure (Cesar de Oliveira *et al*., 2024). This creates a price suppression effect in local markets, where smallholders are unable to meet compliance face deteriorating terms of trade. In export-oriented provinces like Riau, over 62% of palm oil flows through intermediaries who may bypass smallholders altogether in favour of certified suppliers (Jankowski, 2025).

Further, the tightening of global sustainability standards creates indirect compliance pressure even on non-EU supply chains. A 2025 trend analysis showed that

Japanese and Korean buyers began aligning with EUDR-aligned sourcing policies, potentially expanding the market exclusion zone beyond Europe (Gustafsson *et al*., 2024).

Gender and social inequality are also interwoven with these challenges. Female-headed smallholder households are disproportionately excluded from compliance mechanisms due to lack of legal land ownership, lower digital access, and minimal representation in cooperatives. In a 2025 cross-sectional study, only 7.5% of female smallholders in Sumatra had access to compliance information through formal channels (Levy *et al*., 2024). Similar trends were observed in Sarawak, where male-dominated farmer associations control access to donor subsidies and technology.

Overall, the EUDR presents a multi-layered compliance burden that is both financial and systemic in nature. Without deliberate policy responses that target these inequities, the regulation may entrench pre-existing disparities in the global palm oil value chain (Verhaeghe, 2023).

The findings of this SLR indicate that EUDR compliance requirements though normatively driven by sustainability goals generate unintended and disproportionately adverse effects on smallholder farmers. These effects manifest in high entry and maintenance costs for traceability systems, prohibitive legal titling processes, certification expenses, and weak institutional scaffolding. The combination of financial precarity and infrastructural exclusion severely constrains smallholder adaptability to regulatory change.

At the aggregate level, compliance costs for smallholders may range from USD 400 to USD 950 per farmer per year, depending on farm size, geography, and support access. When scaled to the estimated 2.5 million independent smallholders in Indonesia and Malaysia combined, this implies a potential sectoral burden exceeding USD 1.3 billion annually. These figures underscore the urgency of integrated interventions, including subsidised certification, land regularisation programs, and digital inclusion initiatives.

This review of 30 peer-reviewed studies provides a robust, evidence-based account of the multi-dimensional burdens imposed by the EUDR. It offers not only a diagnostic of structural vulnerabilities but also a foundation for future research, policy innovation, and international cooperation toward equitable palm oil governance.

5 DISCUSSION

This section addresses the two research questions posed in the introduction by synthesising the findings from the systematic literature review and critically examining the implications of EUDR compliance for oil palm smallholders. The discussion is structured to explore the dominant types of burdens experienced by smallholders and to assess the degree to which these burdens diverge from the capacities of larger actors, thereby influencing smallholder inclusion in EUDR-aligned value chains.

5.1 Dominant types of compliance burdens faced by smallholders

The literature reveals four primary categories of burdens that oil palm smallholders face under the EUDR framework: economic, legal, institutional, and technical. These burdens are interconnected and cumulatively reinforce exclusionary dynamics within the global palm oil supply chain.

Economic Burdens: Compliance with EUDR imposes significant economic costs on smallholders, most of whom operate with limited financial resources. The costs associated with traceability systems, legal documentation, land mapping, and potentially certification (e.g., RSPO or ISPO) represent a substantial proportion of annual income for small-scale farmers. For instance, the installation of GPS systems and participation in group certification schemes may cost between USD 400 and USD 950 per smallholder annually, depending on land size and cooperative efficiency (Pasaribu *et al*., 2025). Such expenditures are often unaffordable, especially for independent smallholders not supported by corporate partnerships or donor programs (VanderWilde *et al*., 2023).

Additionally, recurring compliance-related costs such as document renewals, audit fees, or platform subscriptions create a long-term financial strain. This is particularly problematic in contexts where farmgate prices are volatile and sustainability premiums (for certified oil) are either negligible or captured upstream by intermediaries (Azhar *et al*., 2021). These economic constraints disincentivise participation in regulated export supply chains and may push smallholders to divert output to informal or domestic markets with weaker standards (Verneau *et al*., 2019).

Legal Burdens: One of the most substantial barriers relates to land legality requirements embedded within EUDR. Many smallholders, particularly in Indonesia, lack

formally registered land titles or operate on ancestral land not recognised by statutory systems (Zhunusova *et al*., 2022). Compliance requires legal proof of ownership or use rights, which may involve complex and costly bureaucratic processes that smallholders find difficult to navigate (Muradian *et al*., 2025). Literature suggests that over 40% of smallholder plots in Indonesia are informally held, making legal compliance a structural barrier rather than a behavioral one (Berning & Sotirov, 2024).

The challenges are magnified in regions where overlapping land claims or inconsistencies between customary and statutory land regimes prevail. In such contexts, the binary legal requirement under EUDR effectively criminalises traditional tenure systems, despite their ecological and social legitimacy (Larsen *et al*., 2018).

Institutional Burdens: Institutional capacity, both within state agencies and farmer organisations, significantly affects smallholder readiness for compliance. Studies highlight a chronic shortage of trained extension officers, with ratios as wide as 1 officer per 3,200 farmers in parts of Sumatra and Kalimantan (Santeramo *et al*., 2021). This undermines technical support, legal literacy, and digital training efforts needed for compliance readiness. Moreover, local governance bodies often lack coordination, funding, or clarity on how to operationalise EUDR compliance, resulting in fragmented policy support (Muller *et al*., 2025).

Farmer cooperatives, which are critical intermediaries for group certification and data aggregation, also face resource and management challenges. Many are under-capacitated, lack financial autonomy, or are not formally recognised in compliance governance structures (Partzsch *et al*., 2023). These institutional weaknesses hinder smallholders' onboarding into traceable, compliant supply chains.

Technical Burdens: The technical dimension of compliance is equally significant. Smallholders must generate precise geolocation data, submit digital due diligence statements, and maintain transparent transaction records across fragmented value chains (Hosseini *et al*., 2025). While corporate actors can deploy remote sensing, blockchain platforms, and compliance software, smallholders operate with minimal access to smartphones, the internet, or digital infrastructure.

Furthermore, the need for polygon-based land maps, which require GPS-enabled devices and spatial literacy, is beyond the reach of most smallholder communities (Harnesk, 2019). The technical complexity of compliance tools and the lack of tailored interfaces for low-literacy users compound these barriers. Some initiatives have

attempted to bridge the gap, but most are in pilot stages or constrained by scale and funding (Kumareswaran *et al*., 2024).

2. Disparities in Compliance Capacity Between Smallholders and Large Producers

The burdens outlined above contrast sharply with the capacities of large estates and integrated agribusiness firms. Larger actors typically possess the financial capital, human resources, legal departments, and digital infrastructure necessary for seamless compliance. They often already engage in sustainability reporting, RSPO certification, and ESG disclosures, giving them a head start in aligning with EUDR requirements (Köthke *et al*., 2023).

In contrast, smallholders particularly those operating outside corporate supply chains are left to navigate compliance alone. This imbalance creates a two-speed system in which well-capitalized actors continue exporting to the EU, while smallholders risk exclusion from global markets (Conte *et al*., 2020). The regulatory burden is thus asymmetrically distributed: compliance is universal in mandate but unequal in feasibility.

Supply chain actors often respond to this asymmetry by excluding smallholders from procurement altogether. Studies have found that some European buyers, traders, and refiners prefer to source exclusively from certified, estate-based production to minimise due diligence costs and regulatory risks. This de-risking strategy, while rational from a business perspective, reinforces marginalisation and erodes the socioeconomic base of smallholder livelihoods (Triboulet & Plumecocq, 2021).

The exclusion of smallholders from EUDR-aligned supply chains could have macro-level implications. In Indonesia and Malaysia, smallholders account for more than 40% of oil palm production. If they are systematically excluded, overall supply to the EU may decline, potentially shifting market dynamics in favour of less regulated destinations or creating incentives for leakage markets (Hakme *et al*., 2018).

Furthermore, the loss of access to higher-value export markets may trigger land use change as farmers seek more profitable crops or engage in unsanctioned practices to survive. This paradox, where a regulation meant to reduce deforestation might indirectly incentivise it has been flagged in recent critical policy analyses (Koytsoumpa *et al*., 2021).

The compliance divide also creates reputational risks for producer countries. Policymakers have raised concerns that unilateral regulations like the EUDR undermine

multilateral sustainability efforts and impose extraterritorial standards that disregard national sovereignty. This tension may hinder cooperation and fuel geopolitical friction over trade and environmental governance (Kabir *et al*., 2021).

The findings of this systematic review carry several implications for policy, industry, and research. First, there is an urgent need for differentiated compliance mechanisms that account for the structural disadvantages of smallholders. This may include phased implementation, tiered standards, or technical assistance programs co-financed by importing countries or development agencies.

Second, digital traceability tools must be simplified and subsidised for smallholder use. Open-source, mobile-based platforms with offline functionality could significantly lower technical entry barriers. Public–private partnerships are key to scaling such innovations, as is inclusive data governance to protect farmer privacy and autonomy. decentralised, community-based mapping approaches that recognise customary rights. Legal pluralism must be acknowledged within regulatory frameworks to avoid the disenfranchisement of traditional landholders.

Third, tenure formalisation efforts must be accelerated, particularly through

Lastly, future research should focus on quantifying the long-term socioeconomic impacts of EUDR implementation on smallholders. Mixed-method impact assessments, longitudinal studies, and geospatial simulations could enhance our understanding of unintended outcomes and guide adaptive regulatory design.

In sum, the EUDR represents a pivotal shift in global trade governance. However, unless accompanied by inclusive implementation strategies, it risks reinforcing systemic inequalities in the palm oil sector. This review underscores the importance of aligning environmental integrity with social justice in the architecture of sustainable commodity regulation.

6 CONCLUSION

This systematic literature review reveals that the European Union Deforestation Regulation (EUDR) introduces a complex set of compliance obligations that place a disproportionate burden on oil palm smallholders. The evidence highlights four interrelated types of burdens: economic, legal, institutional, and technical, that significantly hinder smallholder capacity to participate in EUDR-aligned supply chains.

The economic burdens include both initial and recurrent costs related to land registration, traceability systems, training, and certification. These financial demands are often beyond the reach of independent smallholders who lack access to affordable credit and stable market premiums. Legal compliance is further complicated by widespread land tenure insecurity, particularly in areas governed by customary or informal land systems, which are not readily compatible with EUDR's strict legal land-use criteria.

Institutionally, limited support infrastructure, such as under-resourced cooperatives and government extension services, prevents effective dissemination of compliance knowledge and assistance. Technological burdens are equally significant: smallholders typically lack the digital tools, literacy, and connectivity needed to meet traceability and reporting requirements mandated under EUDR. The cumulative impact of these challenges risks systematically excluding smallholders from premium markets, despite their central role in national palm oil production systems.

In contrast, large-scale producers and vertically integrated firms are better positioned to comply due to their access to legal counsel, digital platforms, and investment capital. This asymmetry in compliance capacity reinforces unequal power dynamics in global supply chains and contributes to the marginalisation of smallholders from international markets. Moreover, exclusionary compliance regimes may inadvertently incentivise leakage into unregulated markets or lead to land-use shifts that undermine long-term sustainability goals.

These findings underscore the urgent need for inclusive, context-sensitive regulatory frameworks that balance environmental objectives with the realities of smallholder agriculture. Without such adjustments, the EUDR may fall short of its intended sustainability outcomes while amplifying existing socio-economic disparities. Therefore, future policy dialogues must consider adaptive pathways that enable equitable participation and accountability across all tiers of the palm oil sector.

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