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TRACEABILITY SYSTEMS FOR INDONESIAN COCOA UNDER THE EUROPEAN UNION DEFORESTATION REGULATION (EUDR): CHALLENGES AND POLICY OPTIONS

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ABSTRACT

The European Union Deforestation Regulation (EUDR) introduces new requirements for agricultural commodity supply chains by mandating traceability, legality, and deforestation-free production. As one of the world's major cocoa-producing countries, Indonesia faces increasing pressure to strengthen traceability systems to maintain access to international markets, particularly the European Union. This study aims to examine the current state of traceability systems in Indonesia's cocoa sector, identify key implementation challenges, and formulate policy options to support EUDR compliance. The study employs a desk study approach based on the review of regulatory documents, official reports, policy papers, and recent academic literature related to cocoa governance, traceability, and sustainability standards. The findings indicate that Indonesia has initiated several traceability-related programs, yet significant challenges remain, including fragmented data systems, incomplete farmer registration, limited geolocation information, weak institutional coordination, and unequal capacities among smallholder farmers. Strengthening digital traceability infrastructure, improving stakeholder coordination, enhancing farmer participation, and integrating traceability into national cocoa governance are essential for successful compliance. The study concludes that traceability should be viewed not only as a regulatory requirement but also as a strategic instrument for improving transparency, sustainability, and competitiveness in Indonesia's cocoa sector.

Keywords: *Traceability systems, EUDR, cocoa supply chain, smallholder farmers, sustainable trade, Indonesia*

INTROUCTION

The governance of global agricultural commodity trade is undergoing a profound transformation as sustainability considerations become increasingly embedded in international market regulations. Concerns regarding deforestation, biodiversity loss,

climate change, and environmental degradation have encouraged governments and international organizations to adopt stricter mechanisms for regulating commodity supply chains. As a result, market access is no longer determined solely by product quality, price competitiveness, and production volume, but also by the ability of producers and exporting countries to demonstrate environmental responsibility, legality, and supply-chain transparency (Lambin et al., 2023; OECD, 2024).

One of the most influential regulatory developments in recent years is the European Union Deforestation Regulation (EUDR), which entered into force in 2023. The regulation requires commodities placed on the European Union market to be deforestation-free, legally produced, and supported by due diligence procedures capable of verifying compliance throughout the supply chain (European Commission, 2023). Commodities covered by the regulation include cocoa, coffee, palm oil, soy, rubber, cattle products, and timber. The EUDR further requires operators to provide geolocation information for production plots and maintain traceability systems that enable products to be tracked from their origin to final markets (European Commission, 2024).

The introduction of the EUDR represents a significant shift from voluntary sustainability standards toward legally binding sustainability governance. Previous sustainability initiatives largely relied on certification schemes, corporate commitments, and market-based incentives. While these approaches contributed to raising awareness regarding environmental and social issues, their effectiveness often depended on voluntary participation and uneven implementation across producing regions. The EUDR fundamentally alters this landscape by making sustainability compliance a prerequisite for market access, thereby increasing pressure on commodity-producing countries to strengthen governance systems and traceability mechanisms (Auld et al., 2024; Garrett et al., 2023).

Indonesia is among the countries most affected by these developments. As one of the world's major cocoa-producing countries, Indonesia plays an important role in global cocoa supply chains. Cocoa contributes significantly to rural livelihoods, agricultural employment, and export earnings, with production dominated by smallholder farmers operating relatively small and geographically dispersed farms (International Cocoa Organization, 2024; Neilson, 2022). This production structure creates unique challenges for EUDR compliance because traceability systems require accurate farm-level data, geolocation information, production records, and coordinated information management across multiple actors within the supply chain.

Traceability has emerged as a central requirement of contemporary sustainability governance. Traceability systems enable stakeholders to identify commodity origins, monitor production practices, verify environmental compliance, and improve transparency throughout supply chains (Garrett et al., 2023). Within the EUDR framework, traceability is not merely a technical tool but a regulatory mechanism that underpins due diligence and risk assessment processes. Consequently, the effectiveness of traceability systems increasingly determines the ability of producers and exporters to maintain access to international markets.

Despite growing recognition of the importance of traceability, significant challenges remain in many cocoa-producing countries. Existing studies indicate that traceability implementation is frequently constrained by fragmented data systems, incomplete farmer registration, weak institutional coordination, limited digital infrastructure, and varying levels of technological literacy among farmers (Klerkx et al., 2024; Trendov et al., 2021). In Indonesia, these challenges are compounded by the predominance of smallholder production systems, diverse marketing channels, and uneven institutional capacities across regions.

Recent policy discussions have increasingly emphasized the importance of strengthening farmer readiness and institutional capacity for EUDR compliance. Sustainability learning, agricultural extension services, and farmer capacity-building programs have been identified as important mechanisms for improving preparedness among cocoa producers (Obie, 2026a; Obie, 2026b). However, while previous studies have examined farmer readiness and capacity development, comparatively limited attention has been devoted to the traceability systems themselves as a distinct governance challenge requiring policy intervention. Understanding how traceability systems function, what obstacles constrain their implementation, and what policy options are available for strengthening them remains a critical research need.

This study addresses this gap by examining traceability systems within Indonesia's cocoa sector under the emerging EUDR framework. Specifically, the study aims to analyze the current state of cocoa traceability systems, identify major implementation challenges, and formulate policy options for strengthening traceability governance. Using a desk study approach, the research draws upon regulatory documents, policy reports, institutional publications, and recent academic literature to provide a comprehensive assessment of traceability readiness within Indonesia's cocoa supply chains. The findings are expected to contribute to ongoing policy discussions regarding sustainable commodity governance and support Indonesia's efforts to strengthen compliance with emerging international sustainability standards.

METHOD

This study employed a qualitative desk study approach to examine traceability systems within Indonesia's cocoa sector under the European Union Deforestation Regulation (EUDR). Desk studies are widely used in policy and governance research to analyze emerging issues through the systematic review and synthesis of documentary evidence, including policy documents, institutional reports, regulatory frameworks, and academic publications (Bowen, 2009; Johnston, 2017). Given the relatively recent implementation of the EUDR and the evolving nature of compliance mechanisms across commodity-producing countries, a desk study approach was considered appropriate for assessing traceability readiness and identifying policy options relevant to Indonesia's cocoa sector.

The study relied exclusively on secondary data obtained from multiple sources. The first category consisted of regulatory and policy documents related to the EUDR, including

official regulations, implementation guidelines, due diligence requirements, and technical guidance issued by the European Commission (European Commission, 2023, 2024). These documents provided the regulatory framework underpinning traceability requirements for commodities entering the European Union market. The second category included official reports and statistical publications from international organizations such as the International Cocoa Organization (ICCO), Food and Agriculture Organization (FAO), World Bank, Organisation for Economic Co-operation and Development (OECD), and United Nations Development Programme (UNDP). These sources were used to understand broader developments in cocoa governance, sustainability standards, and traceability systems.

The third category consisted of academic literature published in peer-reviewed journals between 2020 and 2026. Particular attention was given to studies addressing traceability systems, sustainability governance, digital agriculture, commodity supply chains, agricultural extension, cocoa production, and EUDR implementation. Relevant publications were identified through searches using keywords including “traceability,” “cocoa supply chain,” “EUDR,” “deforestation-free commodities,” “digital agriculture,” “sustainability governance,” and “Indonesia.” Priority was given to recent publications that reflected current developments in sustainability regulations and traceability governance.

Document selection followed three principal criteria. First, sources had to be directly relevant to traceability systems, cocoa governance, or EUDR compliance. Second, documents were required to originate from credible institutions, peer-reviewed journals, or recognized policy organizations. Third, preference was given to publications that provided empirical evidence, policy analysis, or conceptual insights relevant to smallholder-dominated commodity supply chains. Documents lacking clear relevance to traceability governance or sustainability compliance were excluded from the review.

Data were analyzed using thematic content analysis, which enables researchers to identify recurring themes, patterns, and relationships across documentary sources (Braun & Clarke, 2022). The analytical process involved several stages. First, selected documents were reviewed comprehensively to identify key concepts and findings related to cocoa traceability systems. Second, information was coded according to recurring themes. Third, codes were grouped into broader analytical categories representing major dimensions of traceability governance. Finally, these themes were synthesized to develop an integrated understanding of the current state of traceability systems, implementation challenges, and policy responses within Indonesia’s cocoa sector.

The analysis focused on four thematic dimensions. The first dimension examined traceability requirements under the EUDR framework. The second assessed the current state of traceability systems within Indonesia’s cocoa supply chains. The third identified major challenges affecting implementation, including institutional, technological, and socio-economic constraints. The fourth explored policy options and strategic interventions that could strengthen traceability governance and support EUDR compliance.

To enhance the credibility of the findings, source triangulation was applied by comparing information obtained from academic studies, policy documents, institutional reports, and regulatory publications (Patton, 2015). This approach enabled the

identification of converging evidence across different sources and reduced potential biases associated with reliance on a single category of information. By integrating multiple forms of documentary evidence, the study provides a comprehensive assessment of traceability readiness and governance challenges facing Indonesia's cocoa sector under the emerging EUDR regime.

RESULT AND DISCUSSION

RESULT

Traceability Requirements under the EUDR

The European Union Deforestation Regulation (EUDR) establishes one of the most comprehensive traceability requirements ever applied to agricultural commodity supply chains. Unlike previous sustainability initiatives that relied primarily on voluntary certification mechanisms, the EUDR requires operators and traders placing products on the European Union market to demonstrate that commodities are both legally produced and free from deforestation. Compliance must be supported by verifiable evidence obtained through traceability and due diligence systems (European Commission, 2023).

For cocoa-producing countries, traceability has become a central compliance requirement. The regulation obliges supply-chain actors to identify the geographical origin of commodities through geolocation data and maintain records that allow products to be traced from production sites to final markets (European Commission, 2024). Consequently, traceability is no longer viewed as a voluntary sustainability tool but as a mandatory component of international trade governance.

The EUDR requires operators to collect information concerning production locations, quantities produced, supplier identities, and supply-chain transactions. This information forms the basis of risk assessment procedures intended to determine whether commodities are associated with deforestation or legal non-compliance. Operators must subsequently implement mitigation measures where risks are identified before products can enter the European market (European Commission, 2023).

The regulation also emphasizes transparency and accountability throughout supply chains. Companies must be capable of demonstrating where products originate, how they move through supply chains, and whether production activities comply with applicable regulations. As a result, traceability systems increasingly function as governance mechanisms that connect environmental objectives, market access requirements, and corporate accountability (Garrett et al., 2023).

For cocoa-producing countries such as Indonesia, these requirements imply substantial adjustments in existing governance arrangements. Traditional commodity marketing systems often involve aggregation processes in which cocoa beans from numerous farmers are combined before reaching processors and exporters. While efficient from a commercial perspective, such arrangements complicate efforts to maintain product-level traceability. The EUDR therefore encourages the development of more transparent and digitally integrated supply-chain systems capable of preserving information throughout production, collection, processing, and export stages.

Recent assessments indicate that traceability readiness is becoming a critical determinant of competitiveness in global commodity markets (World Bank, 2025). Countries capable of establishing reliable traceability systems are more likely to maintain market access and attract sustainability-oriented investments. Conversely, weak traceability systems may increase compliance costs and create barriers to participation in premium markets.

Current Traceability Systems in Indonesia's Cocoa Supply Chains

The review of policy documents and institutional reports indicates that traceability systems within Indonesia's cocoa sector remain in a developmental stage. Although various traceability-related initiatives have been introduced by government agencies, private companies, certification organizations, and development partners, implementation remains uneven across regions and supply-chain actors.

At the farm level, traceability efforts generally focus on farmer registration, farm mapping, production monitoring, and sustainability certification. Several sustainability programs have developed databases containing information on participating farmers, farm locations, production practices, and commodity transactions. These initiatives provide an important foundation for future EUDR compliance because they demonstrate that traceability mechanisms can be implemented within smallholder-dominated production systems.

Private-sector actors have also played a significant role in advancing traceability. Major cocoa exporters and processors increasingly require information regarding production origins and sustainability practices. Some companies have invested in digital monitoring systems, supplier databases, and farm-level mapping programs designed to improve supply-chain transparency. These efforts reflect growing recognition that traceability is becoming essential for maintaining access to international markets.

In addition, several international development programs have supported the adoption of digital agriculture technologies and geospatial monitoring systems. These initiatives have introduced tools capable of recording farm locations, monitoring land-use changes, and supporting data management processes. Such technologies represent important building blocks for traceability governance under the EUDR framework.

Despite these developments, the overall traceability landscape remains fragmented. Information is often stored in separate databases managed by different organizations. Farmer registration systems may operate independently of certification databases, while company-level monitoring systems frequently remain disconnected from public-sector information platforms. Consequently, data interoperability remains limited and information exchange across institutions is often constrained.

The predominance of smallholder production further complicates traceability implementation. Indonesian cocoa production is characterized by thousands of geographically dispersed producers operating relatively small farms. Collecting, verifying, updating, and integrating information from such a large number of actors requires

substantial institutional and technological capacity. As a result, traceability coverage remains uneven and comprehensive end-to-end traceability has yet to be fully achieved.

Another important observation concerns regional disparities. Areas with stronger institutional support, active farmer organizations, and private-sector engagement tend to exhibit more advanced traceability practices. In contrast, regions with limited technical assistance and weaker organizational capacity often experience slower progress. These disparities suggest that traceability readiness varies considerably across Indonesia's cocoa-producing regions.

Existing initiatives demonstrate that traceability systems are gradually emerging within Indonesia's cocoa sector. However, substantial efforts remain necessary to transform these fragmented initiatives into integrated governance systems capable of meeting EUDR requirements.

Major Challenges to Traceability Implementation

The findings identify several major challenges affecting the implementation of traceability systems within Indonesia's cocoa supply chains.

The first challenge concerns fragmented data systems. Effective traceability requires integrated information regarding farmers, production plots, commodity movements, and supply-chain actors. However, existing data are frequently dispersed across multiple institutions and platforms. Government agencies, private companies, certification organizations, and development programs often maintain separate databases with limited interoperability. This fragmentation creates difficulties in establishing unified traceability systems capable of supporting EUDR compliance.

The second challenge relates to incomplete farmer registration. Traceability systems depend on accurate information regarding producer identities and farm locations. Yet many smallholder farmers remain outside formal registration systems. In some cases, producer records are incomplete, outdated, or inconsistent across institutions. The absence of comprehensive farmer databases limits the ability of stakeholders to establish reliable traceability mechanisms.

A third challenge involves geolocation data availability. The EUDR requires precise information regarding production locations, making farm mapping a critical component of compliance. While geospatial technologies are increasingly available, implementation remains uneven. Many producers have not yet been mapped, while existing spatial records may vary in quality and accuracy. Expanding geolocation coverage therefore represents a major priority for future compliance efforts.

The fourth challenge concerns institutional coordination. Traceability implementation requires cooperation among numerous actors, including agricultural agencies, environmental authorities, exporters, cooperatives, farmer organizations, and certification bodies. However, coordination mechanisms often remain weak or informal. Differences in institutional mandates, priorities, and data management practices can hinder collaborative efforts and slow implementation processes.

Technological limitations also present significant barriers. Digital traceability systems require internet connectivity, hardware infrastructure, data management capacity, and technical expertise. These resources are not distributed evenly across cocoa-producing regions. Farmers and local organizations operating in remote areas may face difficulties accessing and utilizing digital technologies, thereby reducing the effectiveness of traceability initiatives.

Financial constraints constitute another important challenge. Establishing and maintaining traceability systems requires investments in farm mapping, database development, training programs, monitoring activities, and technological infrastructure. For smallholder farmers and local organizations with limited resources, such investments may represent substantial burdens. Without external support, compliance costs could discourage participation in traceability programs.

Human capacity constraints further affect implementation. Traceability systems rely on actors who are capable of collecting data, managing information, interpreting regulatory requirements, and applying digital tools. Many stakeholders continue to possess limited knowledge regarding EUDR requirements and traceability procedures. As a result, capacity-building initiatives remain essential for strengthening implementation readiness.

Finally, concerns regarding data governance and information ownership have emerged as increasingly important issues. Traceability systems require extensive collection of farm-level information, yet questions remain regarding who controls such data, how information is used, and how benefits are distributed among stakeholders. Addressing these concerns will be critical for building trust and encouraging participation among farmers and other supply-chain actors.

Existing Initiatives and Emerging Opportunities

Despite the challenges identified above, the review also reveals several opportunities that may support the development of stronger traceability systems within Indonesia's cocoa sector.

First, growing international demand for sustainable and traceable commodities provides a strong incentive for investment in traceability infrastructure. As buyers increasingly prioritize transparency and environmental compliance, traceability systems become valuable tools for enhancing competitiveness and securing market access.

Second, digital technologies continue to expand opportunities for more efficient traceability management. Mobile applications, geospatial mapping tools, digital farmer registries, remote sensing technologies, and cloud-based databases offer new possibilities for collecting and managing information across dispersed production systems. These technologies can reduce transaction costs while improving data accuracy and accessibility.

Third, farmer organizations represent important institutional assets for traceability implementation. Cooperatives and producer groups can facilitate farmer registration, coordinate information collection, disseminate knowledge, and serve as intermediaries between producers and downstream actors. Strengthening these organizations may therefore significantly enhance traceability readiness.

Fourth, existing sustainability initiatives provide valuable foundations for future development. Programs related to certification, climate-smart agriculture, agroforestry, and sustainable cocoa production have already generated experience in data collection, monitoring, and stakeholder engagement. These experiences can be integrated into broader traceability strategies aligned with EUDR requirements.

Finally, the increasing policy attention devoted to EUDR compliance creates opportunities for stronger coordination among government agencies, private companies, development partners, and research institutions. Such collaboration can facilitate resource mobilization, knowledge sharing, and institutional learning, thereby accelerating progress toward more comprehensive traceability systems.

Taken together, these findings indicate that Indonesia possesses important assets for strengthening traceability governance. While substantial challenges remain, existing initiatives and emerging opportunities provide a foundation upon which more integrated and effective traceability systems can be developed in support of EUDR compliance and sustainable cocoa sector development.

DISCUSSION

Traceability as the Core of EUDR Compliance

The findings confirm that traceability has become the central pillar of EUDR compliance and a defining feature of contemporary sustainability governance. Unlike previous approaches that relied heavily on certification and voluntary sustainability commitments, the EUDR requires verifiable evidence regarding the origin of commodities and their production history (European Commission, 2023). Consequently, traceability functions not merely as a technical management tool but as a governance mechanism that links environmental accountability, market access, and regulatory compliance.

This transformation reflects broader changes in global commodity governance. Sustainability requirements increasingly depend on the ability of supply-chain actors to generate, verify, and communicate information regarding production processes and land-use conditions (Lambin et al., 2023). Within this context, traceability serves as the foundation upon which due diligence systems, risk assessments, and compliance verification procedures are built. Without reliable traceability systems, the implementation of deforestation-free regulations becomes difficult, if not impossible.

For Indonesia's cocoa sector, this shift has significant implications. Historically, cocoa supply chains have prioritized efficiency in commodity aggregation and market distribution. However, EUDR compliance requires greater transparency and information continuity across all stages of production and marketing. As a result, traceability is emerging as a strategic determinant of competitiveness in international cocoa markets.

The findings also suggest that traceability should not be viewed solely as a response to external regulatory pressure. Effective traceability systems can generate broader benefits, including improved supply-chain transparency, stronger quality control, enhanced market credibility, and better access to sustainability-oriented markets. Therefore,

investments in traceability may contribute not only to regulatory compliance but also to the long-term modernization of Indonesia's cocoa sector.

Institutional and Technological Constraints

Although various traceability initiatives have emerged within Indonesia's cocoa sector, the findings indicate that institutional and technological constraints continue to limit implementation effectiveness. Fragmented governance arrangements represent one of the most significant barriers. Multiple organizations collect and manage information relevant to traceability, yet coordination among these actors remains limited. The absence of integrated governance mechanisms often results in duplication, inefficiency, and inconsistent data management practices.

These findings are consistent with previous studies emphasizing that sustainability governance depends not only on technological solutions but also on institutional capacity and coordination (Ponte, 2019). Traceability systems require collaboration among government agencies, private companies, farmer organizations, certification bodies, and development partners. Where institutional relationships remain fragmented, the effectiveness of traceability initiatives may be significantly reduced.

Technological challenges further complicate implementation. Digital traceability systems require reliable infrastructure, geospatial technologies, database management systems, and technical expertise. While technological innovation has expanded rapidly in recent years, access to these resources remains uneven across Indonesia's cocoa-producing regions. Remote rural areas often face limitations in connectivity, equipment availability, and technical support, creating disparities in implementation capacity.

Moreover, technology alone cannot guarantee successful traceability. Digital systems depend on accurate and regularly updated information. Weak farmer registration systems, incomplete geolocation records, and inconsistent data collection practices may undermine the reliability of traceability databases regardless of the sophistication of the technologies employed. Therefore, technological investments must be accompanied by institutional reforms capable of improving data quality, interoperability, and governance effectiveness.

The discussion highlights the importance of viewing traceability as a socio-technical system rather than a purely technological intervention. Successful implementation requires the integration of technological infrastructure with organizational capacity, stakeholder engagement, and governance coordination.

Smallholder Inclusion in Traceability Systems

One of the most important findings emerging from this study concerns the position of smallholder farmers within traceability governance. Indonesia's cocoa sector is dominated by smallholder producers, making their participation essential for successful EUDR compliance. However, the findings indicate that smallholders simultaneously represent the actors most vulnerable to compliance challenges.

Traceability systems require detailed information regarding farm locations, production activities, and supply-chain transactions. Collecting and maintaining such

information may impose additional responsibilities on farmers who often possess limited financial resources, technological capacity, and administrative support. Consequently, compliance requirements may create new barriers for producers who are already operating under challenging economic conditions (Stockholm Environment Institute, 2024).

This issue has important implications for sustainability governance. If traceability systems are implemented without adequate support mechanisms, there is a risk that compliance costs will be transferred disproportionately to smallholder farmers. Such outcomes could contribute to exclusion from premium markets and exacerbate existing inequalities within commodity value chains (Trase, 2025).

At the same time, the findings suggest that traceability can generate benefits for smallholders when implemented through inclusive governance arrangements. Improved access to market information, stronger farmer organizations, enhanced transparency, and greater recognition within supply chains may strengthen the position of producers and improve market opportunities. The challenge therefore lies in ensuring that traceability systems promote inclusion rather than exclusion.

Farmer organizations play a particularly important role in this regard. Cooperatives and producer groups can facilitate registration processes, coordinate data collection, disseminate information, and provide technical assistance. Strengthening these institutions may therefore represent one of the most effective strategies for enhancing smallholder participation in traceability systems.

Policy Options for Strengthening Cocoa Traceability

The findings identify several policy options that could strengthen traceability systems and improve EUDR readiness within Indonesia's cocoa sector.

The first priority involves developing an integrated national traceability framework. Existing traceability initiatives often operate independently, resulting in fragmented information systems and inconsistent implementation practices. Establishing a nationally coordinated framework capable of integrating farmer registration, geolocation data, production records, and supply-chain information would significantly improve governance effectiveness.

The second priority concerns strengthening digital infrastructure and data management capacity. Investments in geospatial technologies, digital registries, cloud-based databases, and interoperability standards are necessary to support large-scale traceability implementation. Such investments should be accompanied by efforts to improve data quality, security, and accessibility.

Third, greater emphasis should be placed on farmer registration and farm mapping programs. Comprehensive producer databases and accurate geolocation information are essential components of EUDR compliance. Expanding registration coverage and improving spatial data quality should therefore become central objectives of traceability policy.

Fourth, stakeholder capacity-building programs should be expanded. Farmers, extension officers, local government agencies, and supply-chain actors require training regarding traceability procedures, digital technologies, data management practices, and

EUDR requirements. Capacity development will be particularly important for ensuring equitable participation among smallholder producers.

Fifth, stronger public-private partnerships should be encouraged. Private-sector actors possess valuable experience in traceability implementation, while public institutions provide regulatory authority and coordination capacity. Collaborative approaches can facilitate resource mobilization, institutional learning, and innovation in traceability governance.

Collectively, these policy options highlight the need for a comprehensive approach that combines technological innovation, institutional strengthening, and stakeholder empowerment.

Implications for Sustainable Cocoa Governance

Beyond EUDR compliance, the findings have broader implications for the future of sustainable cocoa governance in Indonesia. Traceability systems are increasingly becoming foundational components of sustainability governance frameworks worldwide. As environmental regulations continue to evolve, the ability to generate reliable information regarding commodity origins and production practices will become increasingly important.

The development of robust traceability systems may contribute to multiple policy objectives simultaneously. In addition to supporting market access, traceability can improve transparency, strengthen environmental monitoring, facilitate sustainable land management, and enhance accountability throughout supply chains. These functions align closely with broader goals related to sustainable agricultural development and responsible commodity governance.

The findings also suggest that traceability should be understood as a long-term governance investment rather than a short-term compliance exercise. Building effective traceability systems requires sustained commitment, institutional learning, and continuous adaptation to changing regulatory environments. Countries that successfully develop such systems may gain competitive advantages within increasingly sustainability-oriented global markets.

For Indonesia, the challenge is not merely to comply with the EUDR but to leverage traceability as a catalyst for broader governance transformation. By strengthening information systems, enhancing institutional coordination, promoting smallholder inclusion, and investing in digital innovation, Indonesia can position its cocoa sector to meet emerging sustainability expectations while simultaneously supporting rural development and long-term competitiveness.

Ultimately, the transition toward traceable and transparent cocoa supply chains represents an opportunity to modernize governance systems and strengthen the resilience of Indonesia's cocoa sector in an increasingly complex global regulatory environment.

CONCLUSION

The European Union Deforestation Regulation (EUDR) represents a significant transformation in global commodity governance by establishing legally binding

requirements related to traceability, legality, and deforestation-free production. For Indonesia's cocoa sector, the regulation introduces new expectations regarding transparency and accountability throughout the supply chain. Compliance is no longer determined solely by product quality and market performance but increasingly depends on the ability of producers, traders, exporters, and regulatory institutions to generate and verify reliable information regarding commodity origins and production practices. As a consequence, traceability systems have emerged as a strategic component of sustainable cocoa governance and an essential prerequisite for maintaining access to international markets.

This study demonstrates that Indonesia has made important progress in developing traceability-related initiatives within the cocoa sector. Various government programs, sustainability initiatives, certification schemes, and private-sector investments have contributed to the establishment of farmer databases, farm mapping activities, digital monitoring systems, and supply-chain transparency mechanisms. These developments provide a valuable foundation for strengthening compliance with emerging sustainability regulations. Nevertheless, the findings indicate that current traceability systems remain fragmented and unevenly implemented across regions and stakeholders. Existing databases are often disconnected, farmer registration remains incomplete, geolocation information is not universally available, and coordination among institutions continues to face significant challenges.

The analysis further reveals that the effectiveness of traceability systems depends not only on technological solutions but also on governance capacity. Traceability should be understood as a socio-technical system that requires the integration of digital infrastructure, institutional coordination, stakeholder participation, and regulatory support. Investments in technology alone are unlikely to produce effective outcomes if data management systems remain fragmented, institutional responsibilities are unclear, or stakeholders lack the capacity to participate meaningfully in implementation processes. Consequently, strengthening traceability requires a comprehensive governance approach that combines technological innovation with institutional reform and capacity development.

The study also highlights the critical role of smallholder farmers within traceability governance. Because Indonesia's cocoa sector is dominated by smallholder production, successful EUDR compliance depends heavily on farmer participation. However, many smallholders continue to face constraints related to information access, technical capacity, financial resources, and digital literacy. If traceability systems are implemented without adequate support mechanisms, there is a risk that compliance costs will disproportionately burden farmers and contribute to market exclusion. Therefore, inclusive implementation strategies are essential to ensure that traceability systems enhance rather than undermine the sustainability and resilience of rural livelihoods.

Several policy priorities emerge from the findings. First, Indonesia should accelerate the development of an integrated national cocoa traceability framework capable of linking farmer registration, geolocation data, production records, and supply-chain information.

Second, greater investment is needed in digital infrastructure, data interoperability, and information management systems to improve transparency and compliance verification. Third, farmer registration and farm mapping programs should be expanded to strengthen the foundation of traceability governance. Fourth, capacity-building initiatives targeting farmers, cooperatives, extension services, and local institutions should be intensified to improve implementation readiness. Finally, stronger collaboration among government agencies, private-sector actors, development partners, and research institutions will be necessary to support coordinated and inclusive implementation.

In conclusion, traceability should not be viewed merely as a regulatory requirement imposed by external markets. Rather, it should be regarded as a strategic opportunity to modernize cocoa governance, strengthen sustainability performance, improve supply-chain transparency, and enhance the long-term competitiveness of Indonesia's cocoa sector. By addressing existing governance and institutional challenges, Indonesia can transform EUDR compliance from a potential constraint into a catalyst for sustainable agricultural development. Future research should therefore focus on empirical assessments of traceability implementation at the local level, particularly in major cocoa-producing regions, in order to better understand how farmers, cooperatives, and supply-chain actors adapt to evolving sustainability requirements and how traceability systems influence rural development outcomes.

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