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Measuring the Impact of the EU Deforestation Regulation
(EUDR) on Indonesia's Palm Oil Sector

By

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Acknowledgements

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Abstract

The European Union Deforestation Regulation (EUDR) introduces strict sustainability and traceability requirements for commodities linked to deforestation, including palm oil. This thesis examines the trade, economic, and maritime transport implications of the EUDR, with a focus on how impacts differ between large firms and SMEs.

The research applies the Global Simulation Model (GSIM) to simulate bilateral trade flows, welfare effects, and price adjustments under two scenarios: one where only large firms comply with the regulation, and another where both large firms and SMEs comply at different cost levels. To complement the model, a targeted questionnaire survey was conducted among Indonesian palm oil exporters to capture firm-level perspectives on compliance challenges.

The findings indicate that the EUDR, as a non-tariff measure, results in trade diversion away from the EU and imposing compliance costs. Welfare results show losses for major exporters such as Indonesia (-€44Million) and Malaysia (-€22Million), as well as EU as an importer(-€319Million), while EU (aggregate of industrials and households) consumers face higher prices (+4,8%), a sign of “greenflation”. On the other hand, including the SMEs in compliance reduces overall disruption, softening welfare losses and mitigating price shocks. However, SMEs remain disadvantaged due to higher per-unit compliance costs and weaker institutional support. Maritime trade analysis further indicates declines in bulk and containerized shipments to the EU, with reallocation of flows to alternative markets.

These results underline the uneven effects of sustainability-driven trade measures. For policymakers, they suggest that tailored support for SMEs is important to avoid market concentration among large firms and to ensure inclusive participation in sustainable supply chains. For the EU, the findings emphasize the importance of regulatory design adjustments that achieve environmental objectives without reinforcing global trade inequalities.

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List of Abbreviations

Abbreviations	Meaning
AHS	Effectively Applied tariffs
BPDPKS	Indonesian Palm Oil Plantation Fund Management Agency
CGE	Computable General Equilibrium
CIF	Cost Insurance Freight
CN	China
CPO	Crude Palm Oil
EGD	European Green Deal
EU	European Union
EUDR	European Union Deforestation Regulation
F2F	Farm to Fork
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GSIM	Global Simulation Model
GT	Guatemala
HCS	High Carbon Stock
HCV	High Conservation Value
HS	Harmonized System
ID	Indonesia
IN	India
ISPO	Indonesian Sustainable Palm Oil
MSPO	Malaysian Sustainable Palm Oil
MT	metric ton
MY	Malaysian Sustainable Palm Oil
NTM	non-tariff measure
PE	Partial Equilibrium
PK	Pakistan
PKO	Palm Kernel Oil
RED	Renewable Energy Directive
RoW	Rest of the World
RSPO	Roundtable on Sustainable Palm Oil
SDGs	Sustainable Development Goals
SMEs	Small and medium-sized enterprises
TCE	Trade Cost Equivalents
TEU	Twenty-Foot Equivalent Units
UNCTAD	UN Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change

USD

WITS

WTO

US Dollar

World Integrated Trade Solution

World Trade Organization

CHAPTER I: INTRODUCTION

1.1 Background

For Indonesia, palm oil is more than just a crop; it is also a key source of income for millions of workers and smallholder farmers across the archipelago. It is one of the country's biggest export commodities and contributes to national income through export duties, taxes, and other levies. In addition to its fiscal importance, the palm oil sector supports employment, especially in rural areas, where many smallholders depend on palm oil cultivation as their primary source of income. Indonesia is the world's largest producer and exporter of palm oil, and its products are used in many industries, such as food, cosmetics, and biofuel. One of Indonesia's primary market is European Union (EU), along with China, India, and Pakistan.

In 2023, in the EU, the EU Deforestation Regulation (EUDR) came into force. The Regulation will be fully enforced by the end of 2025. The objective of this regulation is to mitigate the environmental harm and deforestation that are a consequence of the production of various commodities, such as palm oil. The law mandates that companies that wish to sell these products in the EU must demonstrate that their products are not associated with deforestation. Along with completing a due diligence procedure that includes geolocation data of the producing sites, they must also present evidence of traceability (European Union, 2023).

The EUDR, while intended to preserve the environment, presents new challenges for Indonesia. For large-scale palm oil companies, many of whom are vertically integrated and RSPO-certified, the EUDR presents costly operational challenges. Small and medium-sized enterprises (SMEs) in Indonesia's palm oil sector that rely on fragmented sourcing, will face far greater difficulties. Many SMEs do not operate within certified schemes and lack the resources to implement traceability systems. As a result, SMEs are more likely to be excluded from EUDR-compliant supply chains,

This regulatory asymmetry raises critical questions about fairness, inclusion, and transition support. If uniform, and one-fit-for-all rules result in unequal outcomes, there is a need to explore how the EUDR may widen existing gaps between large companies and smaller players in the palm oil sector. This situation might affect rural incomes, employment, national budgeting, trade diversion, and the competitiveness of Indonesian palm oil. If not addressed through the proper policy response, the regulation could weaken the country's position in the global palm oil market, reduce fiscal revenues, and create further inequality between large and small producers.

Given these developments, a precise analysis is needed to assess how this regulation may affect trade flows, government income, the broader palm oil sector and sustainability. Including to conduct a side-by-side examination of how large companies and SMEs in Indonesia's palm oil sector are likely to be affected by the regulation in terms of trade flows, compliance costs, and access to EU markets.

The urgency of this research cannot be overstated. With the EUDR set to take full effect by December 2025, both exporters and policymakers are racing against time to adapt. For Indonesia, the risk is not only losing access to a key export market, but also widening the gap between large firms and SMEs in global value chains, increasing inequality. If left unaddressed, the regulation may unintentionally sideline smaller exporters who lack the institutional and technical capacity to comply, undermining inclusive growth and sustainable trade goals.

1.2 Research Question

According to GlobalData (2025), in addition to the uneven impact on different level of exporters, compliance with the EUDR could add premium US\$50-100 per ton for palm oil consumers. And combination over US\$1,5 billion in costs to global supply chains for just two commodities, palm oil and rubber. To explore these issues, this research aims to assess the trade and economic impact of the European Union Deforestation Regulation (EUDR), focusing on Indonesia's palm oil export performance. The regulation introduces new requirements for sustainability and traceability that could influence Indonesia's market access, export revenue, and policy response. Following these issues, the main

research question is: **What is the trade, economic and transport impact of the EU Deforestation Regulation on Indonesian palm oil exports, and how could policies be adjusted to mitigate any negative and enhance any positive effect?**

In order to answer this main Research Question, we will look at the following sub-questions in this thesis:

1. What aspects of trade, economic and transport impact does this thesis look at?
2. How does the global trade pattern for palm oil look like before the introduction of the EUDR, especially for Indonesia?
3. What are the key characteristics of palm oil production in Indonesia for large and SME palm oil producers and in what way do their cost structures and challenges differ?
4. What economic model could best be used to analyse the research question in terms of economic, trade and transport impact?
5. What policy options can the Indonesian government consider to reduce the compliance gap between large firms and SMEs and protect trade and fiscal outcomes?
6. How can the design of the EUDR be improved to reduce compliance burdens while still meeting its environmental goals?

1.3 Research Objective

The main objective of this research is to assess the trade, economic, and transport impact of the EUDR on Indonesia's palm oil exports. The study focuses on understanding how the regulation could affect Indonesia's export performance, trade patterns, and government revenue, particularly through market access, compliance costs, and trade redirection changes. The study pays particular attention to how the regulation affects different types of exporters, especially the contrast between large palm oil companies and SMEs. As the EUDR applies the same legal requirements to all exporters, this research seeks to understand how differences in operational capacity, supply chain structure, and access to resources influence the ability of firms to comply.

The study aims to simulate several policy scenarios and quantify their impact by utilizing a quantitative modeling method employing the Global Simulation Model (GSIM),

combined with conversion method to quantify the maritime effects. In addition, this study will also incorporate primary data collection through a structured questionnaire targeted at palm oil traders in Indonesia. The aim is to gather insights on compliance readiness, traceability practices, and perceived challenges related to the EUDR, particularly across different firm sizes.

This combination of quantitative modelling and stakeholder-based data will strengthen the analysis by linking scenario results with real-world business responses on the ground. These projections will be helpful in the identification of possible shifts in market destinations, especially in the direction of exports to non-EU markets, and how it is relevant for the business, especially palm oil sector. And since it is influence Indonesia's trade balance, it is also relevance for the government, because the research aims to identify policy responses by the government that could help reduce the compliance gap between large firms and SMEs.

Finally, in academic perspective, the research contributes to a more detailed understanding of how environmental trade regulations affect exporting countries not only at the national level, but also across different segments of the private sector. It also evaluates possible changes to the current regulation that can make it easier for exporters, especially SMEs, to comply, while still maintaining the main goal of preventing deforestation. It contributes to ongoing research on how sustainability rules in trade impact developing countries, and how a country's ability to prepare and respond can influence the results of those rules.

1.4 Research Design and Methodology

This research adopts a quantitative approach to assess the trade and fiscal impacts of the EUDR on Indonesia's palm oil exports. The analysis will be conducted using the Global Simulation Model (GSIM), a partial equilibrium model developed to evaluate the effects of trade policy changes across multiple countries and products. GSIM is particularly suitable for this topic as it allows for the estimation of changes in trade flows, prices, production, and welfare in response to external trade shocks, such as the introduction of non-tariff measures or sustainability regulations.

The core of the methodology involves building baseline trade data between Indonesia, the EU, and other major palm oil trading partners. Trade values will be derived from the UN COMTRADE database, focusing on the relevant Harmonized System (HS) codes for crude and refined palm oil products. Tariff and non-tariff measure (NTM) data will be sourced from the WITS and TRAINS databases. Elasticity values, including substitution, supply, and demand elasticities, and will be based on existing academic literature and adapted for palm oil-specific products where available.

Two main policy scenarios are developed to represent different levels of compliance capacity among exporters and the resulting trade, economic and transport implications. The first scenario focuses on large companies complying with the EUDR, but small Indonesian SMEs not being able to do so. The second scenario focuses on both large and small Indonesia palm oil producers being able to comply (albeit at higher relative costs for SMEs in Indonesia compared to large companies).

The use of GSIM allows the model to isolate the impact of the EUDR by simulating counterfactual outcomes. This means the model compares the post-policy scenario against a baseline situation where the regulation is not applied. In other words, the model creates a “what-if” situation to measure the changes caused by the policy. The results will help estimate the magnitude of trade shifts, potential loss or gain in fiscal revenue, and the distributional impact across different countries and actors. Additional analysis include sensitivity testing to check the uncertainty in elasticity estimates and compliance cost assumptions.

To complement the quantitative modelling, this research will also use a mini questionnaire distributed to number of Indonesian palm oil exporters. The purpose is to gather practical insights on how firms, both large and small, perceive and respond to EUDR requirements, particularly on traceability, geolocation, and additional compliance costs. The questionnaire includes both structured and scaled-response questions, allowing the study to compare SME and large exporter readiness. This field input will help validate and enrich the simulation results by grounding them in real business perspectives from actors directly affected by the regulation.

In addition, the study will attempt to quantify the maritime transport effect of EUDR-driven trade shifts using a conversion method. By estimating volume changes from trade diversion scenarios in the GSIM model, the research will convert lost or redirected trade flows into approximate shipping metrics, Tonnes or TEU. This step allows the study to capture broader logistical impacts, particularly in terms of activity between EU and non-EU markets.

1.5 Thesis Structure

This thesis is structured into six main chapters, each designed to guide the reader through the research process, from context setting to policy recommendations. The structure describes the logical flow of the study, starting with background and problem identification, followed by data analysis using the GSIM model, and concluding with practical implications.

In the Introduction, the research topic is introduced, the background of the study explained, and the main problem that is being investigated is presented. It also presents the research question, objectives, methodology, and the overall structure of the thesis.

The second chapter is Literature Review, which provides an overview of existing research on palm oil trade, sustainability regulations, and the impact of non-tariff measures (NTMs) on global trade. It also covers relevant policy frameworks such as the EU Deforestation Regulation, Indonesia's position in the global palm oil market, and previous applications of the GSIM model.

The third chapter, Methodology and Data, describes the research design, including the rationale for using the GSIM model. It outlines the data sources, the structure of the model, elasticity values, and trade parameters. It also explains the different policy scenarios used in the simulations.

The fourth chapter, Results and Analysis, presents the findings of the model simulations. It includes results on trade flows, export values, price changes, and fiscal impacts. It compares the outcomes across the different policy scenarios and discusses the potential implications for Indonesia's economy and palm oil sector.

The final chapter, Conclusion and Policy Recommendations, summarizes the key findings and presents practical recommendations for policymakers. It suggests possible strategies to minimize negative impacts from the EUDR, improve compliance capacity, and strengthen Indonesia's trade position. The chapter also outlines areas for future research.

CHAPTER II: Literature Review

The study of palm oil trade and sustainability has gained growing attention in recent years, especially with the introduction of new trade regulations such as the EU Deforestation Regulation (EUDR). A range of literature has explored the link between palm oil production, trade flows, and environmental outcomes. Several studies focus on trade dynamics, supply chain governance, non-tariff measures, and the environmental impact of commodity exports. The literature review will be divided into several subtopics, each section explains the main arguments, and findings of previous studies while identifying knowledge gaps that this research aims to address.

2.1 Overview of the palm oil sector in Indonesia

Palm oil (HS 1511) is one of Indonesia's most important agricultural commodities and fundamental in the national economy. As the world's largest producer and exporter of palm oil, Indonesia accounted for around 54% of global palm oil trade in recent years. Indonesia remains the world's top producer and exporter of palm oil, with 2023 production reaching 47 million tonnes. The sector is deeply tied to the country's economy, contributing around 4,5% to GDP and supporting over 16 million jobs. (Benedict & Heilmayr, 2024). In 2019, palm oil exports generated approximately USD 25,38 billion, or IDR 359,14 trillion, representing over 14% of the country's non-oil and gas export revenues (Nurfatriani et al., 2022). These figures depict the strategic importance of palm oil not only as a trade commodity but also as a key fiscal asset. In 2022, over 56% of palm oil and its derivatives produced and processed in Indonesia were exported to 138 different importing countries, showing how vital these commodities for global demand (Trase, 2024).

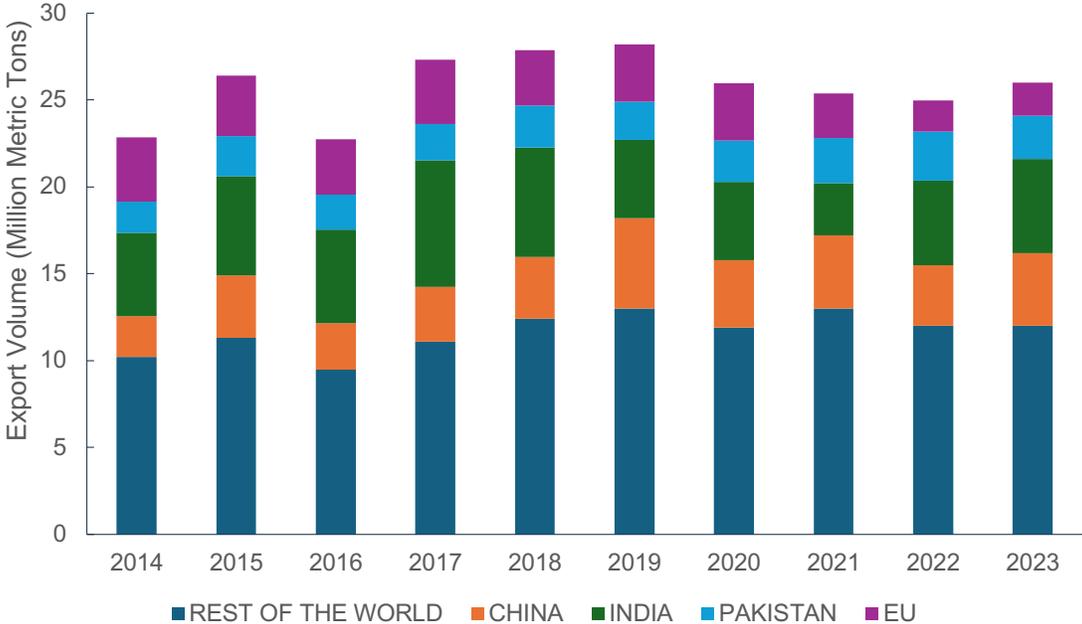
The fiscal role of the palm oil industry is evident through various government revenue streams, including export duties, levies, and non-tax state revenues. Between 2015 and 2021, the Indonesian Palm Oil Plantation Fund Management Agency (BPDPKS) collected IDR 67,53 trillion in export levies. These funds have been used to support national programs such as smallholder replanting, biodiesel subsidies, and logistics infrastructure.

This revenue helps reduce fiscal dependence on oil and gas and reinforces the sector’s importance in supporting Indonesia’s budgetary priorities (Nurfatriani et al., 2022).

2.2 Indonesia and EU relationship on palm oil

Figure 1 depicts Indonesia’s palm oil exports from 2014 to 2023, divided by destination countries. It includes five primary markets: the EU, China, India, Pakistan, and the rest of the world. From the chart, we can see that India received the largest share of Indonesia’s palm oil exports during this period. However, the EU consistently remained one of the main export destinations, even though its share was smaller compared to India and China. This shows that the EU has been an important and stable market for Indonesian palm oil over the last decade.

Figure 1 Indonesia’s export destinations of palm oil and its fractions, in metric ton (MT)

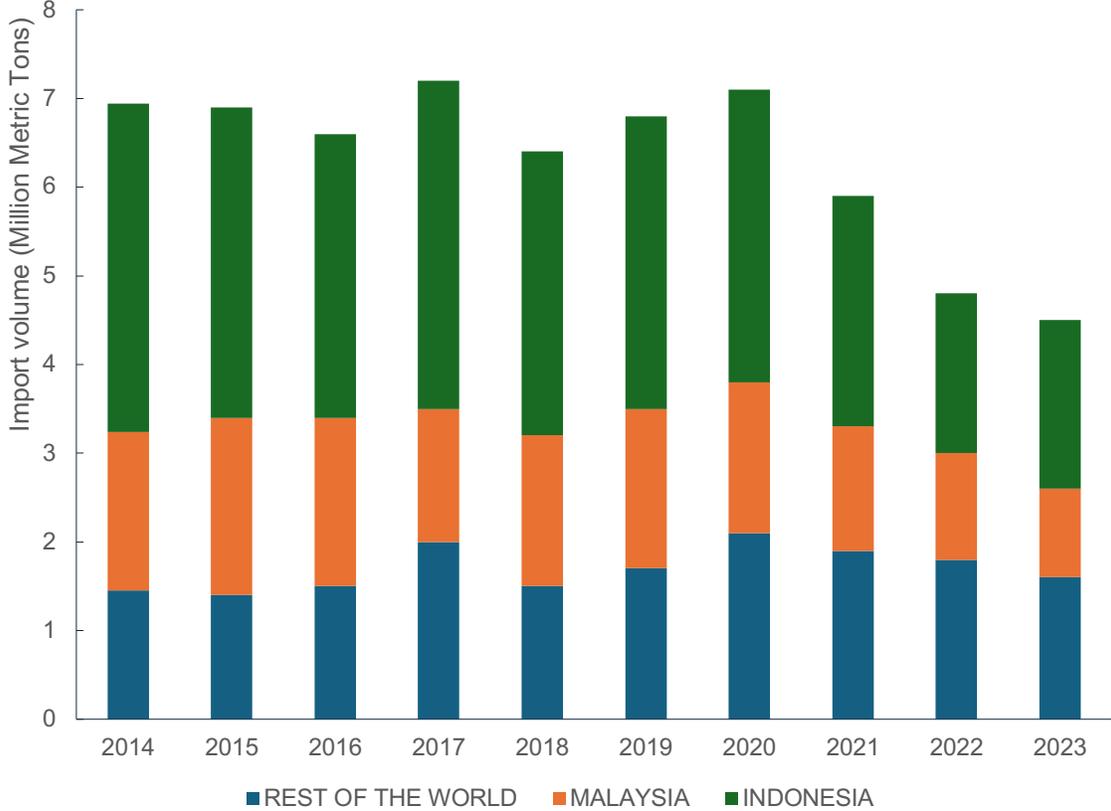


Source: Adapted by author, based on WITS (n.d.)

Between 2014 and 2020, exports to the EU stayed quite stable, yet from 2021 onwards, there has been a decline in the EU’s share. This drop happened while exports to other countries, like India and China, stayed more or less the same. A decrease in exports to

the EU could have a strong impact on Indonesia, especially because the EU is one of the markets that demand higher sustainability standards.

Figure 2 EU imports sources on palm oil and its fractions in metric tons (MT)



Source: Adapted by author, based on WITS (n.d.)

On the other hand, figure 2 shows how the EU imported palm oil and related products from 2014 to 2023. The data is divided into three sources: Indonesia, Malaysia, and the rest of the world. It is clear that Indonesia was the largest palm oil supplier to the EU for most of the period. Indonesia's proportion was consistently the highest among the other sources, and the total volume of imports remained consistent from 2014 to 2020. Moreover, EU palm oil imports dropped starting in 2021. This decline continued in 2022 and 2023. Although Malaysia and the rest of the world also experienced a decrease in imports, Indonesia experienced the most decline. Indonesia's exports to the EU declined severely from past levels by 2023.

The relationship between Indonesia and the EU on palm oil has evolved over the last decades, shaped by changing environmental priorities, trade interests, and policy instruments.

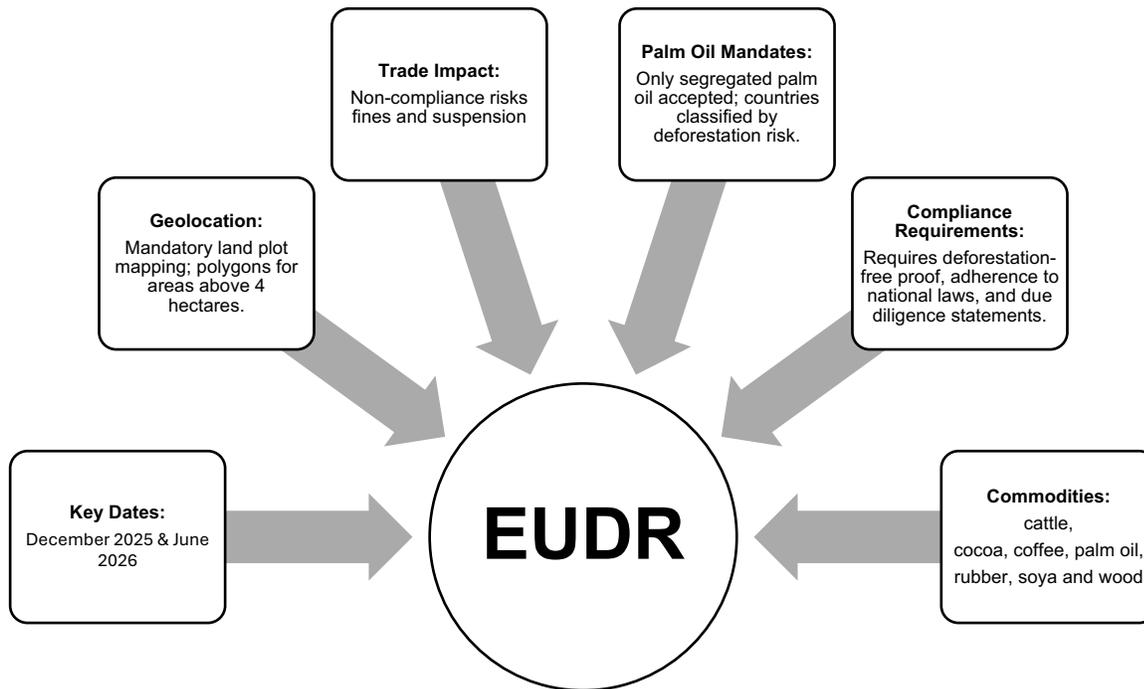
2.3 EU sustainability policies and the deforestation regulation

The EU has positioned itself as a global frontrunner in sustainability and climate action through a series of regulatory initiatives aimed at reducing environmental impacts associated with international trade. One of the central frameworks is the European Green Deal (EGD), which outlines the EU's commitment to becoming climate-neutral by 2050. Key initiatives under this framework include the Farm to Fork (F2F) Strategy, the EU Biodiversity Strategy, and the Renewable Energy Directive II (RED II), each with direct implications for imported agricultural commodities such as palm oil (PASPI, 2021a).

In 2008, the EU introduced the Renewable Energy Directive (RED I), which aimed to increase the share of renewable energy in the energy mix. Palm oil was initially included as a feedstock for biodiesel (European Commission, 2009). Later in 2018, the EU adopted RED II, which set a target of 32% renewable energy by 2030 but introduced stricter sustainability criteria (European Parliament, 2018). Notably, palm oil-based biofuels were classified as “high risk” for deforestation (European Commission, 2019), and subjected to a phase-out schedule starting in 2023 until 2030, effectively disqualifying them from EU renewable energy targets.

Indonesia responded with complaint, arguing that the measure unfairly targeted a single commodity and overlooked national sustainability efforts. In December 2019, Indonesia initiated a formal complaint at the World Trade Organization (WTO), alleging that RED II violated non-discrimination principles under WTO rules (WTO, 2021). And the latest, the EUDR which has become the centre of ongoing debate between the EU and palm oil-producing countries, including Indonesia, as discussions continue over its implementation, fairness, and long-term trade implications.

Figure 3 Key elements of EUDR



Source: Adapted by author, based on Nadras, et.al., (2024)

Beyond legal measures, consumer campaigns and labelling also influenced trade flows. European retailers increasingly promoted “palm-oil free” products, responding to public concern over deforestation and orangutan habitat loss. Though these labels were not legally required, they shaped market sentiment and reduced palm oil demand in certain consumer segments (PASPI, 2021b). From PASPI (2022), argues that anti-palm oil campaigns often ignore the environmental costs of alternative vegetable oils, such as soybean or rapeseed, which require more land and water to produce the same yield. Such campaigns, can create reputational risks and lead to trade discrimination, especially when sustainability efforts in palm oil-producing countries are not equally recognized or supported.

2.4 The polemic of deforestation and the variability of forest definitions

The concept of deforestation is still debated in international discussions on palm oil and sustainability, with regulations such as the EUDR relying on definitions that often do not match national legal frameworks. PASPI (2021c) explains that many assessments overlook Indonesia's land-use context, leading to misunderstandings with governments and trading partners. The core issue lies in the gap between biophysical definitions (based on canopy cover, tree height, or ecological function) and legal-administrative ones, which classify land according to zoning and spatial planning.

Lund (2002) identified 624 forest definitions worldwide, varying by purpose and institution. For instance, FAO (2020) defines forests by minimum canopy and tree height thresholds, while EU RED II sets stricter ecological criteria. In contrast, Indonesia's Law No. 41/1999 defines forest broadly as land designated in spatial plans, regardless of actual tree cover. This means that land reclassified from "forest" to "non-forest estate" can legally be converted without being recorded as deforestation, even if satellite imagery suggests otherwise.

This divergence creates compliance risks. Under the EUDR, palm oil from land legally converted in Indonesia but retaining canopy cover above 30% may still be flagged as non-compliant. PASPI (2021c) further argues that much of Indonesia's oil palm expansion occurred on land already degraded by transmigration, logging, or fires during the 1970s–1990s. However, remote-sensing analyses without legal or historical context often categorize these areas as deforestation-driven.

To understand the context more clearly, the table below compares how forest and deforestation are defined by different institutions.

Table 1 Definition of forest and deforestation by various institutions

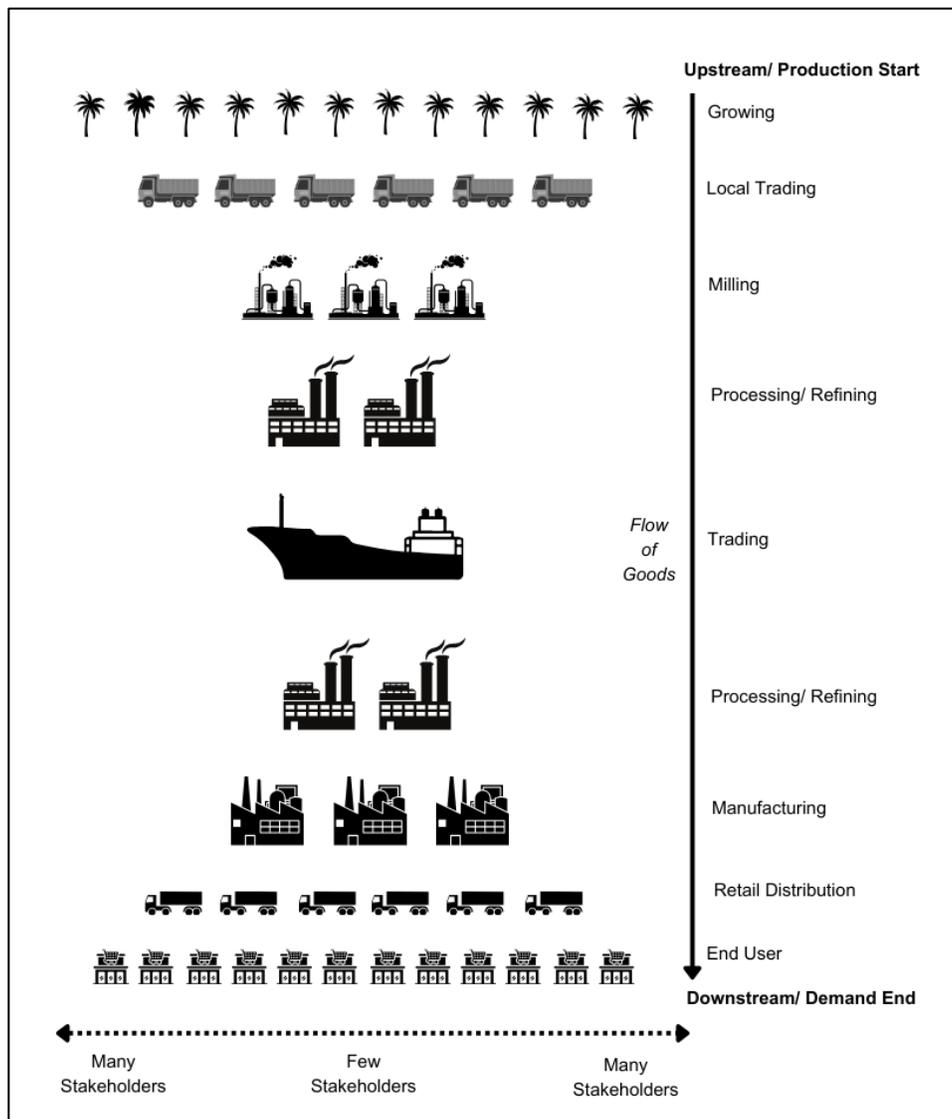
Institution/Regulation	Forest Definition	Deforestation Definition	Basis
FAO (2020)	Trees >5m, >0,5 ha, canopy >=10%	Long-term loss of tree cover below 10%	Biophysical
EU RED II (2018)	Trees >=5m, area >=1 ha, canopy >=30%, includes carbon stock potential	Conversion of forest to non-forest land after a defined cut-off date (post-2008)	Biophysical + regulatory
EU EUDR (2023)	Trees >=5m, area >=1 ha, canopy >=30%, includes carbon stock potential	Conversion of forest to agricultural use after a defined cut-off date, after 31 December 2020	Biophysical + land-use status
Indonesia (Law 41/1999)	Ecosystem dominated by trees, legally designated in spatial planning	Illegal reclassification or conversion of forest area to other land use	Legal / administrative
UNFCCC (2001)	Nationally defined: canopy >=10 - 30%, area >=0,05 - 1 ha, tree height >=2 - 5 m	Direct, human-induced conversion of forest to non-forest land	Country-defined / flexible

Source: Adapted by author, based on various sources

2.5 Understanding the supply chain of palm oil

To understand the challenges from regulations such as the EUDR, it is important to look closely at how Indonesia's palm oil supply chain works. While much of the policy focus is on production and deforestation, the actual ability of producers and exporters to comply with regulations depends heavily on how the supply chain is structured. The Indonesian palm oil supply chain is often described as the "hourglass model," which demonstrates its power imbalances, information bottlenecks, and governance challenges that exist across its stages.

Figure 4 The Hourglass Model of the palm oil supply chain



Source: Author's, adapted from Lyons-White & Knight (2018)

The hourglass model, as described by Lyons-White and Knight (2018), depicts the palm oil supply chain as wide at the top and bottom, and narrow in the middle that resembling an hourglass. At the top (upstream) are thousands of smallholder producers and plantation companies. At the bottom (downstream) are global buyers, retailers, and consumers in markets such as the EU. In between is the midstream segment, consisting of a smaller number of mills, refiners, and exporters, which act as processing and logistical chokepoints.

At the upstream level, smallholders contribute around 40% of national output (Jong, 2024), but many operate independently without contracts, land mapping, or certification, making traceability a major challenge. Their reliance on intermediaries further complicates product origin, as middlemen rarely keep records.

The midstream, which consist of mills, refiners, and traders, forms the “neck” of the hourglass and acts as the key governance point. Here, bulk volumes are aggregated, certifications applied, and export flows managed. However, traceability is especially difficult when mills source from third-party suppliers (Drost et al., 2022). Mixed sourcing of certified and uncertified fruit undermines compliance, since under EUDR any untraceable input can disqualify entire shipments (European Commission, 2025).

The hourglass structure has direct implications for how Indonesia can respond to the EUDR. Because the midstream controls access to export markets, it is likely that mills and traders will begin screening their suppliers more rigorously to ensure traceability. This could lead to the exclusion of smallholders who cannot comply, not because their production causes deforestation, but because they cannot prove that it does not, unless they make significant investments in infrastructure and information systems. This creates the risk of market segmentation, where only producers integrated into traceable systems can access premium markets such as the EU, while others are diverted to less-regulated destinations. Furthermore, this structure means that policy intervention at the midstream level may be the most efficient way to scale up compliance.

2.6 Trade politics and non-tariff measure of EUDR

The EUDR represents a new type of non-tariff measure (NTM) within international trade. Unlike tariffs, which directly alter price structures, NTMs shape trade flows indirectly by requiring compliance with regulatory standards (PASPI, 2024). The EUDR specifically targets commodities such as palm oil, soy, beef, coffee, cocoa, and rubber, requiring exporters to demonstrate that products placed on the EU market are deforestation-free and fully traceable to the plot of land where they were produced. These requirements include geolocation data, legality checks against local laws, and proof that production areas were not subject to deforestation after the cut-off date of December 2020 (European Union, 2023).

From the EU's perspective, the EUDR is justified on three main grounds: (i) reducing global deforestation linked to agricultural commodities, (ii) improving transparency and traceability in supply chains, and (iii) promoting sustainable consumption within the single market. These goals align with the European Green Deal and the EU's broader climate commitments (European Union, 2023).

For exporting countries, however, the regulation presents several concerns. First, the cost of compliance is expected to be significant, especially for SMEs (Rijk & Kuepper, 2024). (Shepherd & Peters (2020) emphasize that NTMs often disproportionately affect producers in developing countries, as they require new systems for data collection, certification, and monitoring. However, the report also notes that developing countries may benefit from new market opportunities in certain countries if those markets maintain lower trade barriers for them, potentially offsetting some negative effects. Similarly, Disdier and Fontagné (2010), in their meta-analysis of European trade policies, found that NTMs often act as hidden trade barriers for agricultural exporters in developing countries. Their study emphasizes that even well-intentioned measures may reduce export volumes if compliance requirements are not aligned with the capacity of producers in the exporting country.

Second, there is concern over selectivity in product coverage. While palm oil and soy are included under the EUDR, substitute oils such as rapeseed and sunflower, which are

largely produced within the EU are not (European Union, 2023). Kinseng et al. (2022) point out that the coverage of sustainability standards is selective. They argue that applying strict rules only to palm oil, while leaving out other vegetable oils such as sunflower and rapeseed, makes the regulation discriminatory. An official from Indonesia's Foreign Ministry, explained that sustainability should not be reduced to deforestation alone or targeted at just one commodity. Instead, it should apply to all vegetable oils and be linked to the broader Sustainable Development Goals (SDGs). If not, palm oil risks being unfairly singled out, while other competing products face less scrutiny. Despite the fact that palm oil is the most productive vegetable oil crop in the world, which produces around 35% of global vegetable oil output on less than 10% of the land used for oil crops (Meijaard et al., 2018)

Third, the regulation has distributional impacts within producing countries. Many smallholders in Indonesia and Malaysia lack the financial and technical capacity to comply with the strict requirements of the EUDR, such as providing precise geolocation data and demonstrating full traceability. As a result, firms may reduce or cease sourcing from them in order to minimize compliance risks, which push small farmers out of formal supply chains. This exclusion not only undermines rural livelihoods but also narrows sector participation, leaving market access concentrated in the hands of large firms and multinational corporations. Indonesian officials have described the EUDR as “anti-smallholder, pro-big grower, pro-multinational” emphasizing how the regulation risks accelerating market consolidation rather than fostering inclusiveness (Palm Oil Monitor, 2023).

Lastly, the political reception of the regulation shows what Indonesian policymakers have called a “tin ear” on the part of the EU, that shows a lack of sensitivity to the realities of developing economies (Palm Oil Monitor, 2023). By prioritizing its own political and regulatory goals without adequate consideration for smallholder capacities, the EU risks designing a policy that achieves environmental compliance only by sidelining vulnerable groups, or what Bradford (2020) calls the “Brussels Effect”, the EU's ability to export its own regulatory framework globally, often without consensus from affected countries. This

raises the concern that instead of balancing sustainability and equity, the EUDR could deepen inequalities in the global palm oil sector.

2.7 Gaps Between Existing Certification Schemes and EUDR Requirements

Voluntary certification schemes like the Roundtable on Sustainable Palm Oil (RSPO), and Indonesian Sustainable Palm Oil (ISPO, mandatory in Indonesia), have long been used as tools to demonstrate sustainability compliance in global markets. These systems were developed to improve environmental, social, and economic standards in palm oil production. However, despite their widespread adoption, especially among large producers, these schemes do not automatically ensure compliance with the EUDR. As the regulatory bar rises, especially on traceability and legality, it becomes clear that existing certifications alone are no longer sufficient.

The RSPO, one of the most recognized global certification bodies, has some distinctions with EUDR. Firstly, they have different definition of “forest”, areas that may be considered suitable for plantation under RSPO criteria (i.e. high conservation value (HCV) and high carbon stock (HCS) assessments) could still be classified as “forest” under EUDR (based on FAO). Moreover, they also have different cut-off date for deforestation, RSPO cut-off date on November 2005 and 2018, and EUDR on December 2020. Secondly, the EUDR requires geolocation data at the plot level for every supplier linked to palm oil entering the EU. While RSPO does promote traceability through different supply chain models (e.g., Segregated, Identity Preserved), it does not yet mandate full plot-level geolocation for all volumes, especially under its mass balance model. Albeit it is supplemented with thorough audit requirements and documentation at the mill and trader level, its main strength lies in supporting a risk-based due diligence approach. (RSPO, 2025).

For ISPO, it's still far from the requirements, although made mandatory for all growers since Presidential Regulation No. 44/2020. The definition of forest is based on the Indonesian national definitions, and no cut-off date for deforestation, which is also differs from the EUDR. Unlike the RSPO, ISPO's current system lacks digital compatibility and real-time transparency. Consequently, traceability under ISPO remains largely unverifiable and unsuitable for EUDR compliance, particularly for independent

smallholders who rely on intermediaries not mandated to capture or transmit origin data. ISPO permits the use of a mass balance supply chain model, where certified and uncertified fresh fruit bunches of palm oil can be blended, provided that at least 30% of the input volume is ISPO-certified. While practical from a market perspective, this model does not meet EUDR requirements, which prohibit mixing of commodities from unknown or potentially deforested origins. This is especially problematic in ISPO, where no mechanism currently ensures that uncertified components are deforestation-free or legally sourced according to EUDR standards (KAMI & EFI, 2024).

EUDR as a mandatory, product-based regulation, is legally binding across EU member states. Unlike voluntary schemes, which offer a set of standards verified through audits and documentation, the EUDR requires operators and traders to submit a due diligence statement confirming that products are free from deforestation and are legally produced. This statement must be backed by exact geolocation coordinates, land-use history verification, and country risk assessments. Certification may be used as supporting evidence, but it does not replace the obligation for due diligence based on EU Regulation 2023/1115, (52), European Union (2023).

In practice, this leaves palm oil exporters in a difficult position. While many have invested in certification to meet earlier market demands, they now face new requirements that may render those certifications insufficient. For SMEs, this shift presents a major barrier, as they have limited capacity to comply with both voluntary certification and mandatory EU due diligence requirements at the same time. Without meaningful integration or recognition mechanisms, certification loses much of its strategic value in the EU market. While sustainability certification systems like RSPO and ISPO remain important tools, they are not enough on their own to ensure compliance with the EUDR. Bridging this gap will require alignment of standards, and better traceability infrastructure. Otherwise, producers may face double compliance burdens, risking exclusion from the market despite having already adopted sustainability practices.

2.8 SMEs under the EUDR

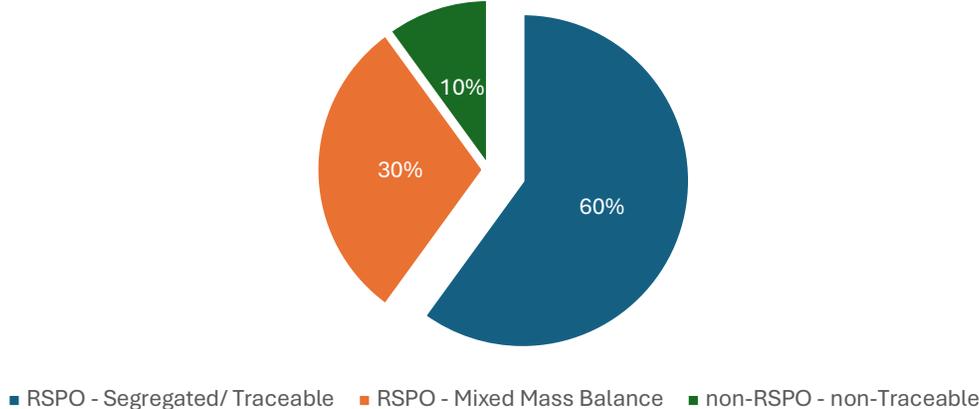
Small and medium enterprises (SMEs) are vital actors in Indonesia's palm oil supply chain, yet they face significant barriers in adapting to the EUDR. While the regulation makes a partial effort to acknowledge the position of smaller producers, which offers a six-month grace period and some reference to capacity building, it falls short of addressing the practical realities they face in meeting the stringent requirements of traceability, legality, and zero-deforestation commitments.

In Indonesia, smallholders manage over 41% of total oil palm plantation area (Solidaridad, 2023), in Malaysia, they hold about 38% (Kusumaningtyas, et. al., 2019). Among them, independent smallholders, who are not tied to any mill or plantation company, make up a large portion. These farmers often work on small plots, with minimal access to financial resources, digital tools, or agronomic assistance. In reality, smallholders contribute significantly to the global palm oil supply, about 35-40% (Solidaridad, 2023).

For EU market only, 90% are RSPO certified sourcing. So it can be assumed that 10% of them are SMEs without RSPO-certified production. But if the mass balance is considered, only 2/3 of RSPO-certified palm oil imported by the EU falls under the "Segregated" category, meaning it is kept separate from non-certified palm oil throughout the supply chain. Most of this certified volume is sourced from large-scale industrial plantations. Only a small number of independent smallholders are involved, as the cost and complexity of obtaining certification remain a major barrier for them. Thus it can be suggested that for the rest 1/3 are still mixed, and most likely sourced from SMEs.

Since there is no exact number of the SMEs, from figure 5, it can be assumed that 40% of palm oil imported to the EU still involving SMEs, which is roughly around the proportion of smallholders operating in both Indonesia and Malaysia.

Figure 5 RSPO proportion on palm oil imported to EU



Source: Author’s, adapted from Solidaridad (2023)

While large companies with vertically integrated operations and compliance systems may be better prepared to adapt, SMEs lack the infrastructure and financial capacity to meet such standards. Collecting geolocation data, maintaining documentation, and implementing full due diligence mechanisms are difficult for farmers working on informal land or without formal titles, a common situation in rural Indonesia (Fern, 2025).

The major issue is traceability. Unlike large plantations, many smallholders sell their produce to middlemen who consolidate and resell palm fruits to mills. This fragmented and opaque system breaks the traceability chain, especially when mixed-sourcing models are used. As outlined by Trase (2024), refineries and exporters often source from diverse and loosely linked supply networks, making it harder to trace the origin of palm oil to individual farms.

What the regulation does not fully account for, as Veenstra (2024) points out, is that mixing is a common and necessary practice in agricultural supply chains that rely on smallholders. This consolidation is often the only way to meet the volume demands of larger export markets. The EUDR, however, does not make room for mass-balance or

mixed-certification models that were previously used to accommodate supply chain complexities. This decision, while strengthening the policy's environmental goal, risks excluding smallholders altogether from the EU market (Veenstra, 2024).

In terms of SMEs, most operate at the mid-level of the supply chain, including independent mills and small-scale exporters. These companies often do not have the resources to build traceability systems, invest in digital infrastructure, or meet administrative requirements under EUDR. Although the regulation mentions support for smallholders, it places no binding obligation on European importers to ensure inclusive practices. The responsibility falls mostly on upstream actors, who may prefer to switch to larger, more compliant suppliers rather than invest in building capacity among SMEs and smallholders (Fern, 2025).

A key distinction between large companies and SMEs in the palm oil sector lies in their cost structures and capacity to invest in compliance. Large firms typically benefit from economies of scale, which allow them to spread compliance costs, such as digital traceability systems, geolocation mapping, or third-party audits, over a much larger export volume. This makes the per-unit cost of compliance relatively lower for large firms. In contrast, SMEs operate with smaller export volumes, with the same or even higher fixed costs, represent a much higher share of their overall operations, both from set-up cost and ongoing operational cost (Rijk & Kuepper, 2024).

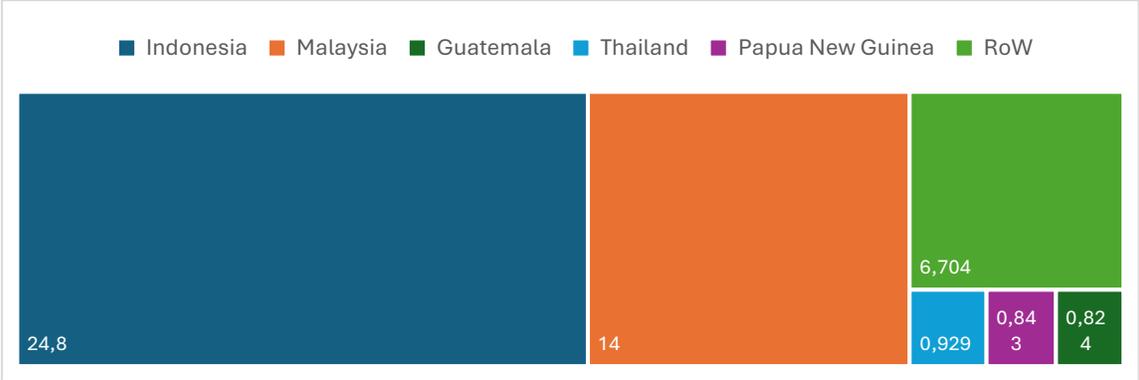
Moreover, for SMEs the adjustment to the EUDR is not limited to small operational changes. Instead, it often requires step-up investments (Drost et.al, 2022), such as establishing new data collection systems, training staff in sustainability reporting, or upgrading plantation management practices to meet traceability and due diligence requirements (Ezeofor, 2025). These are not one-time costs but ongoing obligations, making them harder to absorb in business models that already operate with thin margins. Such dynamics have the potential to concentrate market power in the hands of large companies, moving the sector towards oligopoly or near-monopoly conditions. If SMEs are forced out of the EU supply chain, buyers in Europe will rely increasingly on a few large exporters (Gilbert, 2024).

SMEs are integral to palm oil industry, but without tailored support and policy flexibility, they may be pushed out of high-standard markets like the EU. This not only threatens their income and survival, but also undermines the goal of making palm oil production more sustainable, as exclusion may result in leakage into less-regulated markets. Future revisions of the EUDR should therefore consider more inclusive mechanisms that balance environmental integrity with social equity and development goals.

2.9 Maritime transport and logistical implications of the EUDR

The global movement of palm oil relies on maritime transport. The most common transport mode is by bulk chemical tankers, and some of them by ISO-tanks on container vessels (Musim Mas, 2022). Indonesia serves as global leader of palm oil producer and exporter, followed by Malaysia (figure 5). As the EUDR is implemented, new logistical pressures may emerge across shipping networks, especially about the palm oil trade route that may differ.

Figure 6 Major palm oil exporters (in US\$ billion)



Source : Author’s, adapted from UN Comtrade

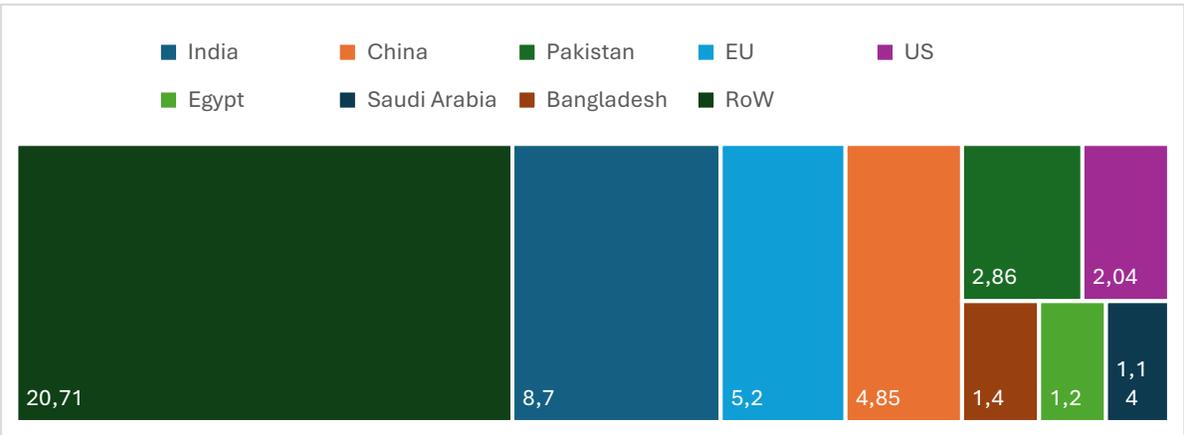
In 2023, total US\$ 48,1 Billion of palm oil was traded around the world. Figure 6 shows that Indonesia dominates the market, exporting palm oil worth around US\$ 24,8 billion, followed by Malaysia with US\$ 14 billion. Together, these two countries account for the majority of global exports, it shows their established role as the core suppliers in international palm oil trade.

Beyond these two leaders, the exports of Guatemala, Thailand, and Papua New Guinea are each under US\$ 1 billion, while the “Rest of the World” (RoW) accounts for around

US\$ 6,7 billion. This distribution underlines how concentrated the industry is, with Indonesia and Malaysia setting the pace for production, trade, and global supply chain dynamics.

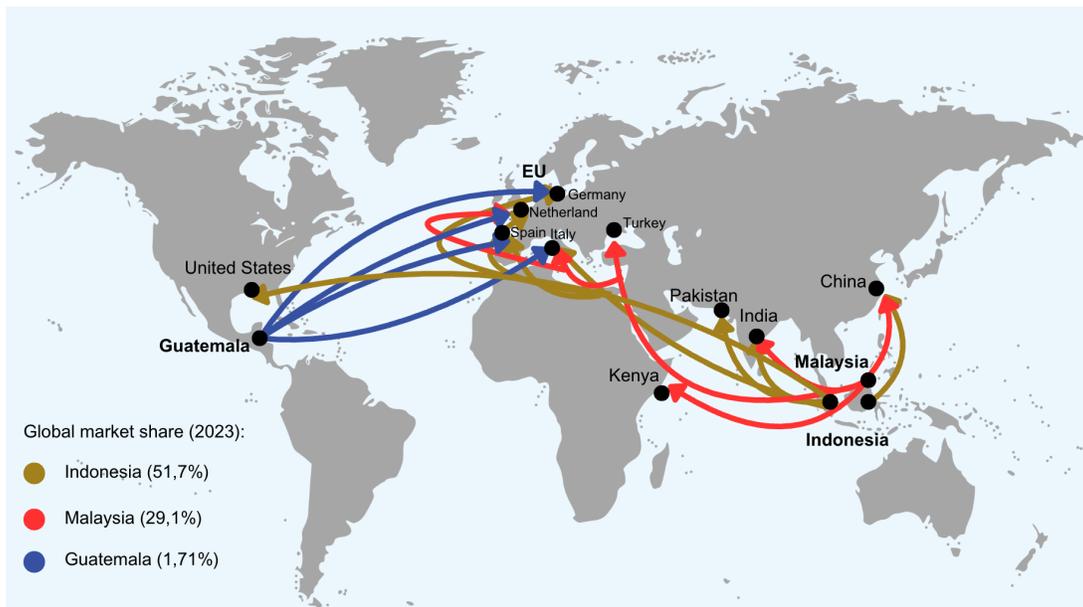
Figure 7 depicts that India stands as the largest importer by a significant margin, purchasing palm oil worth around US\$ 8,7 billion. This dominant position emphasizes India’s reliance on palm oil as a key source for food, consumer goods, and industrial uses. The EU follows with imports valued at US\$ 5,2 billion, which also makes it one of the most important regulated markets for palm oil. China (US\$ 4,85 billion) and Pakistan (US\$ 2,86 billion) also feature as substantial buyers, alongside demands from United States (US\$ 2.04 billion), Bangladesh (US\$ 1,4 billion), Egypt (US\$ 1.2 billion), and Saudi Arabia (US\$ 1.14 billion).

Figure 7 Major palm oil importers (in US\$ billion)



Source : Author’s, adapted from UN Comtrade

Figure 8 Major palm oil trade flows related to EU



Source : Author's, adapted from UN Comtrade

While trade volumes depict the scale of palm oil exchange across countries, it is important to examine maritime trade flows that show how these exports are physically routed through global shipping networks. Figure 8 illustrates the major maritime trade flows of palm oil in 2023, that signifies the role of main exporters; Indonesia, Malaysia, and Guatemala. These countries are expected to be most affected by the implementation of the EUDR. Indonesia dominates global supply with more than half of the market share (51,7%), followed by Malaysia (29,1%), while Guatemala accounts for a much smaller share (1,7%).

Palm oil from Indonesia is primarily exported through ports such as Dumai, Belawan, and Balikpapan (Drewry, 2022). These ports are located close to the plantation and processing areas on Sumatra and Borneo, that make them the gateways for Indonesia's palm-based products. The country's exports are directed to India, China, Pakistan, the EU, and the United States (UNComtrade, n.d.), which displays its dominant role in global palm oil trade.

In Malaysia, exports are also concentrated in Borneo, with Kunak Port in Sabah serving as one of the key outlets for palm oil shipments (WWF, 2021). Malaysian palm oil is

distributed across several major markets, including China, India, Kenya, Turkey, and the EU. Guatemala, on the other hand, relies heavily on the Port of Santo Tomás on the Atlantic coast (Mighty Earth, 2017). This location provides direct access to trans-Atlantic shipping routes, with the EU standing out as the country's primary export destination (UNComtrade, n.d.).

From the importer side, several ports serve as gateways for palm oil entering major consumer markets. In India, Kandla Port operates as one of the country's primary hubs for palm oil inbound flows (IndianExpress, 2025). Pakistan relies on Port Qasim, which is positioned to support the country's large-scale refining and processing industries (Bernama, 2025). In China, palm oil imports are mainly directed through the Port of Shanghai and the Port of Guangzhou, both of which are well-integrated into China's vast distribution networks and industrial processing clusters (Proforest & WWF, 2019). In the United States, the Port of New Orleans, Port of Savannah, and Port of New York are the main entry points for palm oil, benefiting from its refining facilities and connections to the domestic transport system (MPOC, n.d.).

In the EU, palm oil imports are channelled through several entry ports that function as distribution hubs for the bloc. Italy relies on the Port of Genoa (Tempo, 2024), which serves as a gateway to southern European markets and connects to inland processing and consumption centres. Spain primarily uses the Port of Barcelona (Gonzales-Cancelas et al., 2025), a Mediterranean hub with logistical infrastructure that facilitates both regional consumption and re-exports within the EU. The Netherlands continues to use Port of Rotterdam (Port of Rotterdam, n.d.), the largest seaport in Europe and the main entry point for bulk agricultural commodities, including palm oil, which are then redistributed across the continent. Germany, meanwhile, depends on the Port of Hamburg (Port of Hamburg, n.d.), a northern hub with hinterland connections that link maritime imports directly to industrial and consumer markets across central and eastern Europe. Together, these ports illustrate the EU's integrated import system, where palm oil entering through a few gateways. This concentration of flows also means that regulatory measures such as the EUDR will have direct implications not only at the border but also across the entire distribution network.

From the exporting side, vessels departing Indonesia and Malaysia, loaded with palm oil and its derivatives, embark on long-haul maritime routes that are connecting Southeast Asian supply with global demand. These ships typically pass through the Strait of Malacca, one of the world's busiest and most strategic chokepoints, before navigating westward across the Indian Ocean, to serve South Asia's demand, or northward to serve China mainland. To reach Europe, the vessels continue from Indian Ocean through the Suez Canal, that links Asian production centres to Mediterranean and northern European markets such as Rotterdam in the Netherlands, Hamburg in Germany, Genoa in Italy, and Barcelona in Spain (Tandra et al., 2021).

In contrast, palm oil from Guatemala follows a different path. Vessels typically depart and cross the Transatlantic route directly to European ports. This shorter trade corridor reflects Guatemala's reliance on the EU market for its palm oil exports (UNComtrade, n.d.). Unlike Indonesia and Malaysia, which diversify exports toward India, China, and other Asian destinations, Guatemala's palm oil maritime flows are concentrated to European buyers.

These routes are shaped by economies of scale and well-established shipping alliances. However, the added requirements under the EUDR can reduce the number of eligible exporters to the regulated market. This may shrink the volume consolidated for each shipment, especially from small or fragmented producers, which is making some maritime routes less commercially viable. One expected outcome is trade diversion away from the EU toward other major markets (Indrasto, et. al, 2024) such as China, India, or countries in the Middle East and Africa, which do not currently impose strict sustainability verification. This shift will not only affect export composition but also alter maritime flows. Carriers may reroute vessels to other regions, adjust their port call schedules, or reposition fleet capacity based on new trade lanes.

CHAPTER III: Research Methodology and Data

On the Literature Review Chapter, most of these studies focus on supply chain governance, sustainability certification, or qualitative assessments of regulatory compliance. What remains underexplored is the quantitative impact of the EUDR on international trade patterns, export volumes, and fiscal revenue for producing countries like Indonesia. This research aims to fill these gaps by applying a product-level, economical model simulation to quantify the trade and fiscal implications of the EUDR under multiple policy scenarios. It will contribute to the literature by providing empirical estimates of export reduction, trade diversion, and government revenue loss, with a focus on the differentiated impact across SMEs and Large supply chains.

3.1 Model Selection

Trade policy research often uses both qualitative and quantitative approaches to understand the effect of regulations on market performance. While qualitative methods can help explore stakeholder perspectives and institutional dynamics, quantitative models also important for simulating the possible impact of external shocks or policy changes on trade flows, prices, and economic outcomes. As noted by Piermartini and Teh (2005), trade models provide a structured framework for analyzing changes in international trade based on economic fundamentals, allowing governments and stakeholders to assess policy outcomes systematically.

In the case of the EUDR, which will be fully enforced by the end of 2025, there is growing concern about how exporters in countries like Indonesia will respond. The palm oil industry in Indonesia is highly integrated into global markets, but also structurally diverse, ranging from large, vertically integrated companies to SMEs that often source from smallholders. To understand the impact of this new regulation on trade volumes, welfare changes, and market access, a model is needed that can quantify these effects through scenario-based simulation.

There are several types of trade models used in policy analysis: Gravity Models, Computable General Equilibrium (CGE) Models, and Partial Equilibrium (PE) Models. Each has different assumptions and levels of complexity. These models can be used for

either ex-post or ex-ante policy analysis. Ex-post models are better suited to assess policies that have already been implemented, using historical data. In contrast, ex-ante models, such as CGE and PE, are used to simulate expected outcomes from future policies. Since EUDR is still in the implementation phase, an ex-ante simulation approach is likely the most appropriate for this study.

The Gravity Model, introduced by Tinbergen (1962), is based on the idea that trade between two countries is positively correlated with their economic size (usually GDP) and negatively correlated with geographical distance. Although gravity models are useful for identifying trade patterns and evaluating trade agreements over time as an ex-post, they are less suited for assessing the future impact of new and evolving regulations such as the EUDR. This is because gravity models rely on past trade data and assume a stable policy environment, they are not suitable for analyzing the impact of recent regulatory changes, as is the case with the EUDR. As a result, the gravity model is not adopted in this study.

Therefore, this study focuses on ex-ante modelling, which allows us to simulate forward-looking policy scenarios. Two commonly used ex-ante models are the CGE model and the PE model. CGE models account for the broader interaction between sectors in the economy, including household income, government policy, and inter-sectoral linkages. While this approach is powerful for assessing economy-wide impacts, it requires extensive data and calibration, which may not be feasible for a focused, sectoral study for this topic. Given that the main concern of this research lies in the palm oil sector, particularly the export dimension and firm-level compliance cost, a CGE model would be unnecessarily broad.

By contrast, Partial Equilibrium (PE) models are designed to focus on specific sectors or products, allowing for a more detailed and targeted simulation. PE models use inputs such as bilateral trade data, tariffs, non-tariff measures (NTMs), and elasticity estimates to simulate how changes in external policy affect supply and demand in the sector of interest (WTO & UNCTAD, 2012). Because the objective of this study is to assess the direct effects of the EUDR on Indonesian palm oil exports, especially differentiating

between large firms and SMEs, the PE model provides a more appropriate methodological fit.

Among the various PE models available, the Global Simulation Model (GSIM) developed by Francois and Hall (2002) is chosen for this research. GSIM is well-suited for modelling the effects of trade policies at the product and country level. It is also relatively data-efficient and allows the researcher to simulate multiple trade policy scenarios, including the using of NTMs, changes in tariff rates, and shifts in trade preferences. GSIM is particularly valuable for evaluating the distribution of trade impacts across trading partners and sectors, an essential feature for this study's focus on how EUDR may have uneven effects across exporter types.

3.2 Global Simulation (GSIM) Model

The Global Simulation Model (GSIM), introduced by Francois and Hall (2002), is a tool used to simulate the impact of trade policy at the global level. The model assumes that traded goods are imperfect substitutes, and it works with constant elasticities for demand, supply, and substitution. What makes GSIM useful is its ability to include trade data from various countries and also account for trade with the RoW. This allows the model to estimate the impact of policy changes not only on a country or region, but also on a global scale and for specific industries.

One of the strengths of GSIM is its ability to produce quantitative results that help assess the economic impact on different actors, such as exporters (through producer surplus), importers (through consumer surplus), governments (via tariff revenue), and overall welfare. It also tracks changes in trade flows, production, and prices, making it relevant for stakeholders across the trade system.

The selection of GSIM is based in methodological fit for evaluating trade policy changes. Previous theses have demonstrated its adaptability to diverse trade contexts, Grizaldo (2019) applied GSIM to assess the effects of policy reforms, Campo (2022) and Hoffman (2023) applied GSIM to model trade shocks and sector-specific disruptions. Across these studies, GSIM has proven effective in integrating bilateral trade data, tariff and non-tariff measures, and elasticity parameters to simulate changes in trade flows, prices, and

welfare. Building on these papers, this study extends GSIM's application to the EUDR, a non-tariff measure with asymmetric compliance costs, to capture its differentiated impact on palm oil exporters.

To understand how the GSIM model produces its results, it is important to look at the mathematical framework behind it. The model is built on a set of equations that describe the relationship between trade flows, prices, supply and demand elasticities, and policy changes such as tariffs or non-tariff measures. These equations help simulate how markets react to external shocks or new regulations, providing estimates for changes in trade volumes, prices, and welfare. What follows is a step-by-step explanation of the key formulas used in GSIM and how they support the analysis in this research.

Equation (1), describing import demand equation (Francois and Hall 2002):

$$M_{(i,v),r} = f(P_{(i,v),r}, P_{(i,v),s \neq r}, Y_{(i,v)})$$

$M_{(i,v),r}$	=	Demand product i from country r in country v
$P_{(i,v),r}$	=	Internal price for goods from region r within country v
$P_{(i,v),s \neq r}$	=	Price of other varieties
$Y_{(i,v)}$	=	Total expenditure on imports I in country v

Equation (2) defines composite demand for national product and supply functions varieties (Francois and Hall 2002):

$$P_{(i,v),r} = (1 + t_{(i,v),r})P_{(i,r)}^* = T_{(i,v),r}P_{(i,r)}^*$$

$P_{(i,v),r}$	=	Internal price
$t_{(i,v),r}$	=	Proportional price markup achieved by tariff t
$P_{(i,r)}^*$	=	Export price received by exporter r on world markets
T	=	$1+t$, power of tariff

Equation (3)

$$Xi, r = ks_{i,r} (P^*(i, r))^{es}_{(i,r)}$$

Xi, r	=	Export Supply product i from country r to world markets
ks	=	Constant term
es	=	Elasticities of supply

According to Francois and Hall (2002) composite demand for a country as a constant function of elasticity, for Equation (4):

$$E_{(i,v)} = ka_{(i,v)}P_v^{NAv+1}$$

$E_{(i,v)}$	=	Composite demand
$ka_{(i,v)}$	=	Demand equation set in the calibration
P_v^{NAv+1}	=	Composite elasticity function of the regional composite price Index

GSIM model includes calculations of welfare effects. Producer surplus depicts the area between the export supply curve and the price curve; the consumer surplus is the area between the demand curve and the price curve for the combination of product (Francois and Hall, 2002).

Producer surplus equation (5):

$$\Delta PS_{(i,r)} = R^0_{(i,r)} \cdot \hat{P}_{i,r} * + 1/2 \cdot R^0_{(i,r)} \cdot \hat{P}_{i,r} * \hat{X}_{i,r}$$

$R^0_{(i,r)}$ = Measure export revenue based on world price levels, disaggregated bilaterally or presented as a total.

Francois and Hall (2002) propose the following equation to represent consumer surplus, Equation (6):

$$\Delta CS_{(i,v)} = \left(\sum_r R^0_{(i,v),r} \cdot T^0_{(i,v),r} \right) \cdot \left(1/2 E_{M,(i,v)} \hat{P}_{(i,v)}^2 \cdot \text{sign}(\hat{P}_{(i,v)}) - \hat{P}_{(i,v)} \right)$$

where $\hat{P}_{(i,v)} = \sum_r \theta_{(i,v),r} \hat{P}_r + \hat{T}_{(i,v),r}$

Francois and Hall (2002) define the cross-price elasticity as follows:

Equation (7):

$$N_{(i,v),(r,s)} = \theta_{(i,v),s} (E_m + E_s)$$

Francois and Hall (2002) define the own-price elasticity of demand as:

Equation (8):

$$N_{(i,v),(r,r)} = \theta_{(i,v),r} E_m - \sum_{s \neq r} \theta_{(i,v),s} E_s = \theta_{(i,v),r} E_m - (1 - \theta_{(i,v),r}) E_s$$

The share of demand expenditure at internal prices for a given country, as outlined by Francois and Hall (2002), is given in Equation (8):

$$\theta_{(i,v),r} = M_{(i,v),r} / \sum_w M_{(i,v),s} T_{(i,v),s}$$

Francois and Hall (2002) specify the country's share of total export volume as specified in Equation (9):

$$\phi_{(i,v),r} = M_{(i,v),r} / \sum_w M_{(i,w),r}$$

The result of global equilibrium condition, following multiple substitutions, outlined by Francois and Hall (2002):

$$\begin{aligned} \hat{M}_{i,r} = \hat{X}_{i,r} &\Rightarrow E_{X(i,r)} \hat{P}_{i,r} = \sum_v N_{(i,v),(r,r)} \hat{P}_{(i,v),r} + \sum_v \sum_{s \neq r} N_{(i,v),(r,s)} \hat{P}_{(i,v),s} \\ &= \sum_v N_{(i,v),(r,s)} [P_r^* + \hat{T}_{(i,v),r}] + \sum_{s \neq r} N_{(i,v),(r,s)} [P_s^* + \hat{T}_{(i,v),s}] \end{aligned}$$

3.3 Conversion Method

To better understand the transport-side effects of the EUDR, this research applies a conversion method to translate the change in trade values (USD) into physical quantities (tonnes). This step is essential because in transport and logistics, the actual volume of goods moved is more relevant than their monetary value. For example, ports and shipping lines need to know how many tonnes of palm oil must be handled or shipped, not just how much it is worth.

The conversion process focuses on maritime transport, which is the main mode used for palm oil trade. Knowing the expected tonnage is crucial for port authorities to plan operations, allocate space, and manage equipment like cranes, storage, and quay use. It also supports strategic decisions about infrastructure, such as quay expansion or warehouse capacity. From a logistics and supply chain standpoint, accurate tonnage data enables more efficient planning for loading and unloading schedules, cost forecasting, and turnaround time.

For shipping companies, estimating cargo volume helps determine fleet requirements, vessel deployment, and even pricing strategies. Different vessel types, such as dry bulk carriers or tankers, operate on volume availability. Freight rates are also closely tied to how much cargo is in the market and how far it must travel.

This research adapts a conversion method first applied by ECORYS (2015), changes in trade value (as calculated in the GSIM model) will be converted to tonnage using average unit values (USD/ton) for the relevant commodities. This step allows the research to estimate how EUDR-related trade shifts will translate into actual cargo volumes at sea, helping connect trade policy impacts to real-world transport and infrastructure planning.

To quantify the impact of trade policy on maritime logistics, especially in terms of palm oil shipments, this research applies a step-by-step conversion from trade value (in USD) to shipping volume (in tonnes and TEU). The following method adapts ECORYS (2015) and Campo (2022) as follows:

- Step 1: Identify seaborne trade shares. Start by identifying the portion of total trade that is moved by sea.
- Step 2: Convert trade values to total tonnage shipped by sea. To estimate how much volume (in tonnes) is transported by sea, divide the change in bilateral trade value by the average price per ton of the commodity:

$$\text{Total Tonnage Shipped by Sea} = \frac{\text{Bilateral Trade Value Change (USD)}}{\text{Average Price per Ton (USD/Ton)}}$$

- Step 3: Estimate the amount of containerized cargo. Calculate how much of the total seaborne tonnage is containerized based on the typical degree of container usage for the product:

Containerized Cargo (tons)

$$= \text{Degree of Containerization} \times \text{Total Tonnage Shipped by Sea}$$

- Step 4: Convert containerized cargo into TEUs. To express containerized tonnage in Twenty-Foot Equivalent Units (TEU), use the following formula:

$$\text{Containerized Cargo (TEU)} = \frac{\text{Containerized Cargo (tons)}}{\text{Average Tonnage per TEU}}$$

- Step 5: Calculate bulk cargo volumes. To estimate how much of the total cargo is shipped in bulk (non-containerized), subtract the containerized cargo from the total:

$$\text{Bulk Cargo (Tons)} = \text{Total Tonnage Shipped by Sea} - \text{Containerized Cargo}$$

3.4 Questionnaire Deployment

As an additional method to complement the quantitative modelling and scenario analysis, this study also conducted a brief questionnaire survey to gather primary insights from Indonesian palm oil exporters. The purpose of this questionnaire is to capture the real-world perceptions, estimated cost, concerns, and expectations of stakeholders who are directly affected by the EUDR, particularly among large exporters and SMEs.

This primary data collection adds a layer of grounded perspective to the otherwise model-based projections. While the GSIM model focuses on the macroeconomic and trade dimensions, the questionnaire helps uncover the micro-level compliance dynamics, such as cost burdens, regulatory awareness, and the strategic decision-making process by exporters in responding to the EUDR.

The questionnaire consists of six main items, each designed to capture specific aspects of EUDR-related impacts:

1. Company Classification

Respondents were asked to classify their business scale according to the EUDR criteria. A company is categorized as an SME if it meets two of the following three thresholds: fewer than 250 employees, annual turnover below IDR 950 billion (€50 million), or a balance sheet below IDR 475 billion (€25 million). This classification helps us distinguish the impact on large exporters and SMEs, making the analysis more focused and relevant.

2. Compliance Willingness

This question seeks to gauge whether companies are willing and capable of meeting new export demands under the EUDR framework. It helps assess market continuity and potential trade disruption risks.

3. Estimated Cost of Compliance

Respondents estimate the expected additional cost burden as a percentage of their total export value (1%, 2%, 5%, 10%, and others). This step helps simulate how the EUDR operates as a NTMs and to incorporate the values into the GSIM model simulation.

4. Perceived Compliance Barriers

Exporters choose the most challenging EUDR requirements, including:

- Geolocation to the plot level
- Due diligence documentation
- Supply chain traceability
- Proof of deforestation-free origin

5. Desired Government Support

Exporters identify the types of support they require from the government to achieve compliance. This includes training, financial assistance, digital infrastructure, clearer regulatory guidance, and potential collaboration with larger corporations.

6. Open Feedback

Finally, participants were invited to provide open-ended suggestions or comments on the EUDR implementation. This qualitative input supplements the quantitative analysis with grounded perspectives from the industry.

The decision to keep the survey brief was made to respect the limited time respondents might have and to improve response rates. Anonymity was also important because the topic touches on regulatory pressure, and some companies may be reluctant to share details openly. As suggested by Dalati and Gómez (2018), short and anonymous surveys are effective in encouraging honest responses, especially in business settings where reputational or compliance concerns exist. This method helped the study reach both large exporters and SMEs with relevant but simple questions, and captures how they perceive and prepare for EUDR compliance.

Due to the fragmented nature of Indonesia's palm oil export sector and the absence of centralized data showing which exporters serve the EU market, this study used purposive and snowball sampling to reach the right respondents. The target group includes both

large palm oil companies and SMEs that currently export, or have previously exported, to the EU, as this aligns with the EUDR's scope.

The respondents were selected based on a few key criteria: company size (according to the EUDR's definition), type of product (CPO, PKO, or derivatives), and their orientation toward exports. To make the outreach process smoother and more credible, we contacted several institutions like the Indonesian's palm oil associations, regional customs offices, and local cooperatives. These partners helped by distributing the questionnaire and connecting us to initial contacts.

After this first round, the questionnaire was shared further using a snowball method. Exporters who completed the survey were asked to forward it to others in their network. This approach fits well with how the industry works, as many SMEs rely on informal business connections and are harder to reach through official listings.

Even though this method limits how much we can generalize the results, it helped us collect focused and relevant feedback from companies actually affected by the EUDR. These insights are expected to support policy discussions and give a clearer picture of how different types of exporters in Indonesia are responding to the regulation.

3.5 Data requirements

3.5.1 Country selection

GSIM requires the selection of trading countries to simulate the impacts of a trade policy change. For this study, eight country groups have been selected: Indonesia, Malaysia, Guatemala, India, Pakistan, China, EU-27, and RoW. Each was chosen based on its relevance to the global palm oil supply chain, either as a major producer, exporter, importer, or policy actor related to the European Union Deforestation Regulation (EUDR).

- Indonesia

Indonesia is the world's largest producer and exporter of crude palm oil (HS 1511), accounting for more than half of global supply. It is the main focus of this study, given its dominant role in the palm oil trade and the expected exposure of its exporters, especially SMEs to EUDR requirements.

- Malaysia

Malaysia is the second-largest palm oil exporter globally and shares similar regulatory and production challenges with Indonesia. It provides a useful comparison to observe how another major producer responds to EU policies and whether trade diversion or competition intensifies under EUDR.

- Guatemala

Though much smaller in output, Guatemala is one of the fastest-growing palm oil exporters to Europe and has increasingly adopted sustainability certifications. Including Guatemala helps explore how smaller Latin American producers may fill supply gaps in the EU market if Southeast Asian exporters face compliance challenges.

- India

India is one of the top global importers of palm oil, including sizeable volumes from Indonesia. While not directly affected by EUDR, its import behavior provides insights into potential trade diversion, if EU-bound palm oil is redirected toward alternative markets like India.

- Pakistan

Similar to India, Pakistan is a key market for Indonesian palm oil. It also serves as a strategic alternative destination for exporters that may reduce EU-bound shipments due to rising compliance costs or barriers.

- China

China is another major non-EU importer of palm oil. As a top buyer of Indonesian and Malaysian palm oil, China's role in absorbing diverted exports is critical in assessing global trade shifts and market rebalancing under EUDR scenarios.

- EU-27

The European Union is the regulatory actor behind the EUDR and one of the top five importers of palm oil from Indonesia and Malaysia. This region is central to the model as both the policy initiator and the importer affected by regulation.

- Rest of the World (RoW)

RoW includes all other countries not captured in the specific selection. It functions as a balancing node in the GSIM. Including RoW also ensures that potential leakages, diversions, or unintended effects outside the key countries are not ignored.

Together, these selected countries represent the core of global palm oil trade and allow for robust simulation of both direct and spillover effects of the EUDR.

3.5.2 Bilateral Trade Data

The primary international trade statistics data used in this research was sourced from UN Comtrade. To maintain relevance to the scope of the EUDR and the simulation design, this study only considers Harmonized System (HS) Code 1511, which covers Crude Palm Oil (CPO) and its fractions, whether or not refined.

Using HS1511 as the product category allows the model to focus directly on the key commodity targeted by deforestation-related regulations. While palm oil is traded in various forms, CPO remains the most prominent in volume and value.

For each of the selected countries (Indonesia, Malaysia, Guatemala, EU-27, India, Pakistan, China, and RoW), bilateral trade values were retrieved in USD, representing the annual export flows from each country to their respective trading partners. The year 2023 was chosen as the base year, as it represents the most recent full dataset available. This baseline year offers a reasonable snapshot of pre-policy trade flows, which is essential for conducting an ex-ante simulation.

3.5.3 Tariff and Elasticities

This study also requires the baseline tariff information to set up the GSIM model. Even though the primary focus of the simulation is on non-tariff shocks, it remains necessary to include existing tariffs as part of the model's initial conditions.

For this purpose, AHS Weighted Average data was collected from the UNCTAD World Integrated Trade Solution (WITS) platform. Specifically, the analysis uses the AHS weighted average for agricultural raw materials for each country or region covered in the simulation.

In addition to tariff data, three main types of elasticities are required for the model: composite demand elasticity, substitution elasticity, and export supply elasticity.

For this research, composite demand elasticities were adopted from Rifin (2010), who analyzed palm oil demand in several major markets. His findings indicate a range between -1,44 to -0,65, depending on the country and market structure. Substitution elasticities represent how easily buyers can switch between different source countries when facing relative price changes. This elasticity is particularly important in the GSIM framework when simulating trade diversion effects. Following the approach of Qiu (2014), this study applies a substitution elasticity of 3,22.

Supply elasticities are sourced from Yulismi & Siregar (2007), who estimated supply responsiveness for palm oil exports from various producing countries. The elasticities vary by country from 0.40 to 0,95, reflecting differences in production capacity, market flexibility, and policy environments.

3.5.4 Scenario Development and Non-Tariff Measures (NTMs)

Non-Tariff Measures (NTMs) are policy instruments, aside from traditional tariffs, that may distort international trade through mechanisms such as standards, regulations, certifications, and administrative requirements, including preventing environmental harm UNCTAD (n.d.). NTMs often raise the cost of compliance for exporters and importers. Anderson and van Wincoop (2004) proposed that these trade costs could be understood in terms of Trade Cost Equivalents (TCEs). Quantifying how much trade costs rise as a result of non-price-related regulatory barriers, which is divided into three main components:

- Transportation costs (21%),
- Border-related regulatory barriers (44%), and
- Local supply chain costs from producer to final consumer (55%).

When combined multiplicatively, these components give an initial NTM factor of:

$$\text{Initial NTM} = 1,21 \times 1,44 \times 1,55 = 2,7$$

This value serves as the base estimate of the trade cost equivalent of our scenario. To assess the impact of the EUDR, we simulate two key scenarios by modifying the border-related barrier component (44%), and translated to regulatory burden of EUDR

compliance on palm oil exporters. We use price gap approach to quantify NTMs related to EUDR. Dean et al. (2009), comparing the domestic prices of goods with their border (import) prices, moreover, the difference is attributed to NTMs. According to GlobalData (2025), compliance with the EUDR can add a premium of US\$50–100 per metric ton for palm oil consumers, especially impacting Crude Palm Oil (CPO). With CIF Rotterdam CPO average prices in 2023 at US\$964/ton (GAPKI, 2024), we assume this price gap into an estimated 5% compliance cost for large firms.

We also integrate the source distribution of EU-bound palm oil imports, which consists of 40% from SMEs and 60% from large companies, based on trade association and supply chain data (Figure 5, Chapter 2.8), also stated by Jong (2024). As an addition, we use composition for Large & SMEs for Indonesia is 59:41 (Solidaridad, 2023), for Malaysia 62:38 (Kusumaningtyas, et. al., 2019), and for other countries is 60:40. These shares are used to weight the compliance burden in each scenario.

Scenario 1: Only Large Companies Can Comply with EUDR

In the first scenario, only large companies are assumed to comply with the EUDR requirements, while SMEs face a cost barrier that arranged to excludes them from the EU market. This study adopts an approach following the findings of Rijk & Kuepper (2024), which indicate that compliance costs for SMEs can be up to ten times higher than those for large firms. Given that the baseline compliance cost for large firms is assumed at 5%, the cost burden for SMEs is set at 50%. This figure is interpreted as a maximum compliance cost that functions as a de facto barrier to entry, that leads to the exclusion of SMEs from the EU market in Scenario 1 as a worst case scenario.

Using the adjusted border barrier component and the weighted cost burden, we compute the scenario 1 NTM for Indonesia:

$$\begin{aligned}
 NTM\ Indonesia\ (1) &= 1,21 \times (1 + (44\%(1 + (59\% \times 5\%) + (41\% \times 50\%))) \times 1,55 \\
 &= 2,8942
 \end{aligned}$$

NTM for Malaysia:

$$\begin{aligned}
 NTM\ Malaysia\ (1) &= 1,21 \times (1 + (44\%(1 + (62\% \times 5\%) + (38\% \times 50\%))) \times 1,55 \\
 &= 2,883
 \end{aligned}$$

NTM for Other Countries:

NTM Other Countries (1)

$$= 1,21 \times (1 + (44\%(1 + (60\% \times 5\%) + (40\% \times 50\%))) \times 1,55 = 2,8905$$

This higher NTM shows the adverse effect of losing SME exporters and the higher trade cost faced by EU buyers and Indonesian exporters.

Scenario 2: Both Large and SME Exporters Can Comply

In the second scenario, both large firms and SMEs manage to comply with the EUDR, albeit at varying costs 5% for large firms and 10% for SMEs, following the price gap approach based on GlobalData (2025). Although they have higher cost compliance, but they are not excluded from the market in this scenario.

The adjusted NTM for Indonesia for Scenario 2 is calculated as:

$$\begin{aligned} \text{NTM Indonesia (2)} &= 1,21 \times (1 + (44\%(1 + (59\% \times 5\%) + (41\% \times 10\%))) \times 1,55 \\ &= 2,7588 \end{aligned}$$

NTM for Malaysia:

$$\begin{aligned} \text{NTM Malaysia (2)} &= 1,21 \times (1 + (44\%(1 + (62\% \times 5\%) + (38\% \times 10\%))) \times 1,55 \\ &= 2,7576 \end{aligned}$$

NTM for Other Countries:

NTM Other Countries (2)

$$= 1,21 \times (1 + (44\%(1 + (60\% \times 5\%) + (40\% \times 10\%))) \times 1,55 = 2,7584$$

This second NTM is lower than the first scenario, which shows a less disruption, though still reflecting the burden of compliance for smaller actors.

These adjusted NTMs, will be applied in the both GSIM model as the policy shock variables to simulate trade outcomes, changes in producer and consumer surplus, price effects, and trade diversion patterns. The simulations are designed to demonstrate possible realities starting from the end of 2025, when the EUDR becomes fully enforceable. By comparing the two scenarios, this study offers a structured view of how the EUDR could segment the market and create uneven impacts across exporters. It

reveals the implications for trade fairness, government policy response, and the future competitiveness of palm oil sector.

3.5.5 Data for the Conversion Method

To identify the share of palm oil trade transported by sea, as palm oil is a bulk agricultural commodity exported primarily from Indonesia to distant markets like the EU, China, India, and Pakistan, we assume 100% of these flows are carried by sea. For average price, we use average CIF Rotterdam price 2023 which is approximately US\$964 per ton, which also serves as the benchmark in our compliance cost analysis.

The containerisation rate is based on ECORYS (2015), where vegetable oil have a containerisation rate of approximately 11%. The remaining 89% is assumed to be shipped as bulk cargo. It shows the nature of palm oil logistics, which typically involve specialized tankers and bulk vessels rather than container freight, especially in large-volume trades. To convert containerised tons to TEU (Twenty-Foot Equivalent Units), we use an average loading factor of 24 tons per TEU (Menon, 2022). This conversion will estimate the impact on container terminal throughput and liner shipping networks, especially in cases where trade diversion leads to new routes or port calls.

CHAPTER IV: Results and analysis

This chapter presents the findings from both the simulation model and questionnaire survey on the potential impact of the EUDR. The analysis is structured into several key sections: welfare effects, trade performance (exports and imports), price changes (producer and consumer), and maritime transport outcomes. The results are drawn from two policy scenarios. First, only large exporters comply with the regulation; in the second, both large firms and SMEs comply, though with different compliance costs. Each scenario is used to examine how the EUDR could affect palm oil exports, especially Indonesia, in terms of trade volumes, export values, and market shares with major trading partners.

In addition to the economic simulations, this chapter also presents insights from Indonesia's palm oil exporters through a questionnaire. The chapter closes with a sensitivity analysis to test the reliability of the simulation outcomes and confirm the consistency of the model under varying assumptions.

4.1 Welfare effects

This section discusses the welfare implications arising from the two simulated scenarios under EUDR. Using the GSIM Model, the analysis focuses on changes in producer surplus, consumer surplus, and net welfare across selected trading countries. The first scenario assumes that only large Indonesian palm oil exporters are able to comply with the EUDR, while SMEs are excluded from the EU market.

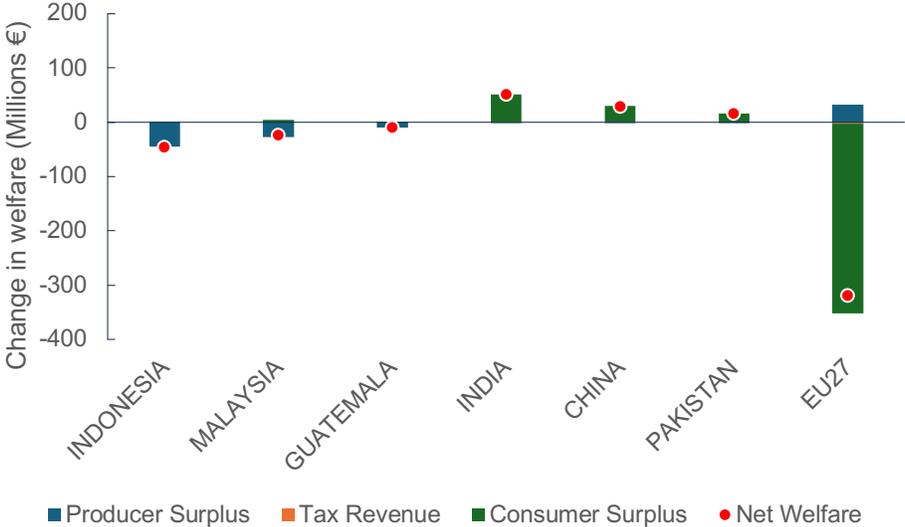
4.1.1 Welfare effects of large company compliance with EUDR (scenario 1)

As reflected by Figure 9, exporting countries such as Indonesia, Malaysia and Guatemala experience welfare losses. This decline is presented in negative changes in producer surplus, with Indonesia and Malaysia recording net welfare losses of €44 million and €22 million. Guatemala faces similar situation, its overall welfare losses of €9 million, mostly caused by negative producer surplus. All of them also have slightly positive consumer surplus and tax revenue, respectively. These figures show the vulnerability of exporters, especially those heavily reliant on SMEs, to restrictive regulation like EUDR.

Consumer markets such as India, China, and Pakistan benefit from welfare gains. These increased access to palm oil diverted from EU-bound flows, lead to net welfare gains of €51 million in India, €29 million in China, and €16 million in Pakistan. For these countries, the minimum compliance burdens, easier and cheaper imports, translates into higher consumer surplus.

Meanwhile, the EU27, despite has positive producer surplus, records a substantial welfare loss of €319 million. This outcome can be linked to increase of import burdens, trade distortions, reduced competition, and the cost of implementing EUDR that excluding the SMEs (scenario 1), who represent a significant portion of the supply base.

Figure 9 Welfare effect of scenario 1



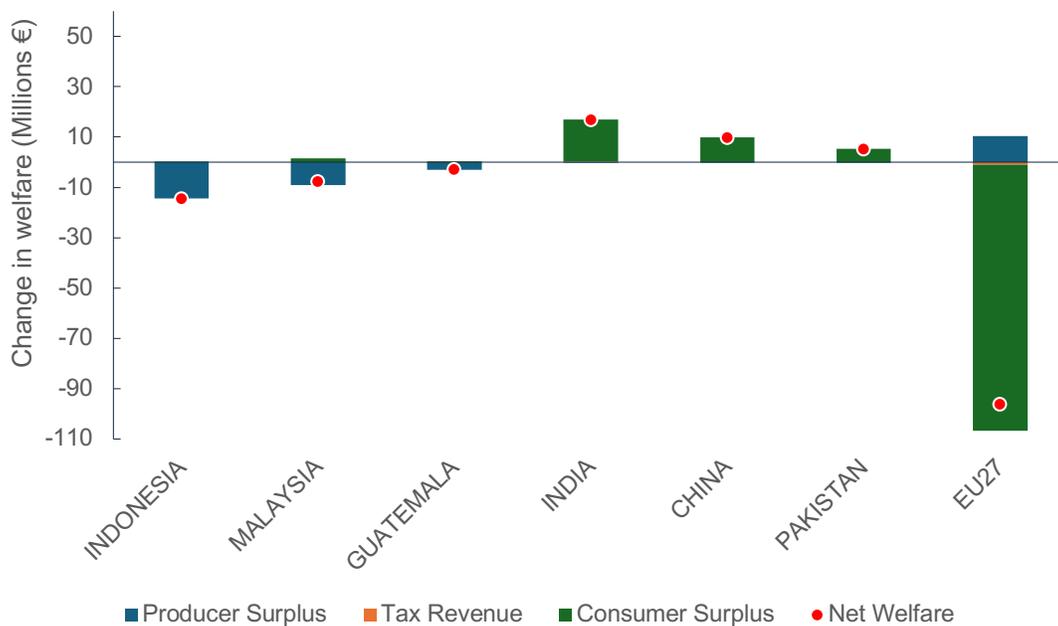
Source: Author’s, adapted from GSIM Results

4.1.2 Welfare effects of both large & SMEs compliance with EUDR (scenario 2)

In the second scenario, where both large exporters and SMEs in Indonesia are assumed to comply with the EUDR (albeit with differentiated compliance costs), the distribution of welfare impact appears less severe compared to the first scenario. Several countries, especially importer countries (except EU), recorded welfare gains, while losses, especially for producers were more contained.

From figure 10, Indonesia still experienced a negative welfare effect (–€14,5 million), yet the amount is reduced from the first scenario (–€44 million). This improvement shows the benefit of broader market access for Indonesian exporters, especially SMEs, which previously faced exclusion in the first scenario. By maintaining their EU market access, even with higher compliance costs, the aggregate producer losses were mitigated. Malaysia followed a similar pattern, with welfare losses reduced to €7,6 million, compared to €22 million on the first scenario.

Figure 10 Welfare effect of scenario 2



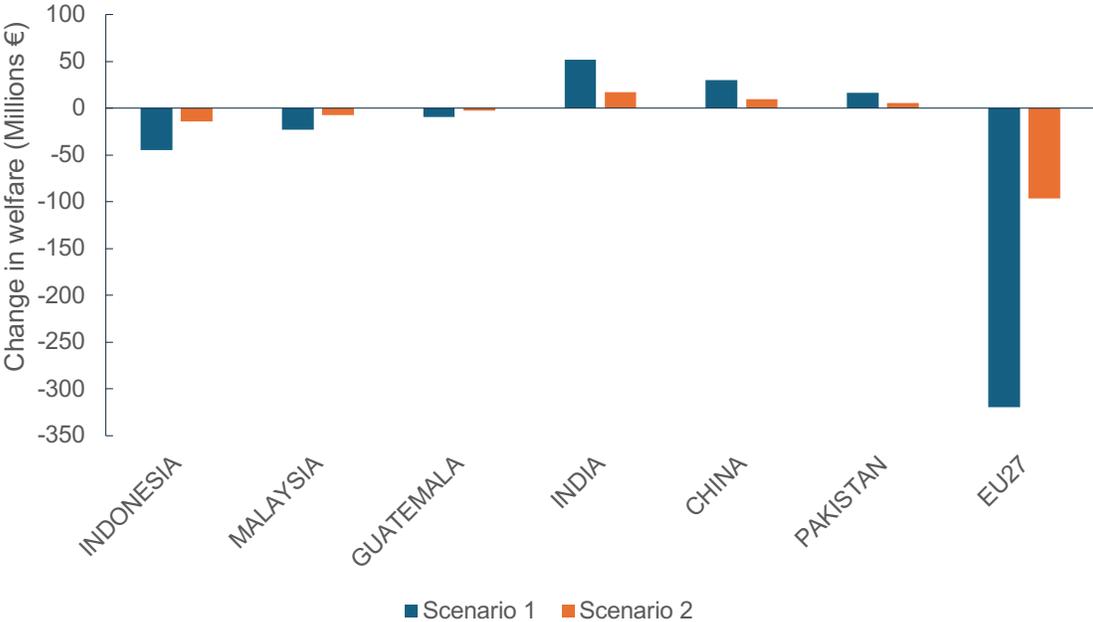
Source: Author's, adapted from GSIM Results

Guatemala also record a negative welfare outcome (–€2,9 million). Caused by the country's reliance on the EU market. Among importing countries, India (+€16 million), China (+€9,7 million), and Pakistan (+€5,2 million) registered welfare gains. These are driven by improved consumer surplus as supply rechannelled into non-EU markets.

The EU27 remained the main welfare loser in this scenario, with a net loss of – €96 million, which is less severe compared to first scenario (–€319 million). This indicates that the inclusion of SMEs under the EUDR, while not entirely eliminating the negative net welfare, still brings a relatively better outcome compared to excluding them altogether.

Overall, from figure 11, both of the scenarios confirms that enabling compliance for a wider group of exporters leads to smaller aggregate losses and more evenly distributed welfare outcomes across stakeholders. The results suggest that inclusion, even with cost burdens, can be more economically efficient than fragmentation.

Figure 11 Net welfare effect for both scenarios



Source: Author’s, adapted from GSIM Results

4.2 Trade performance

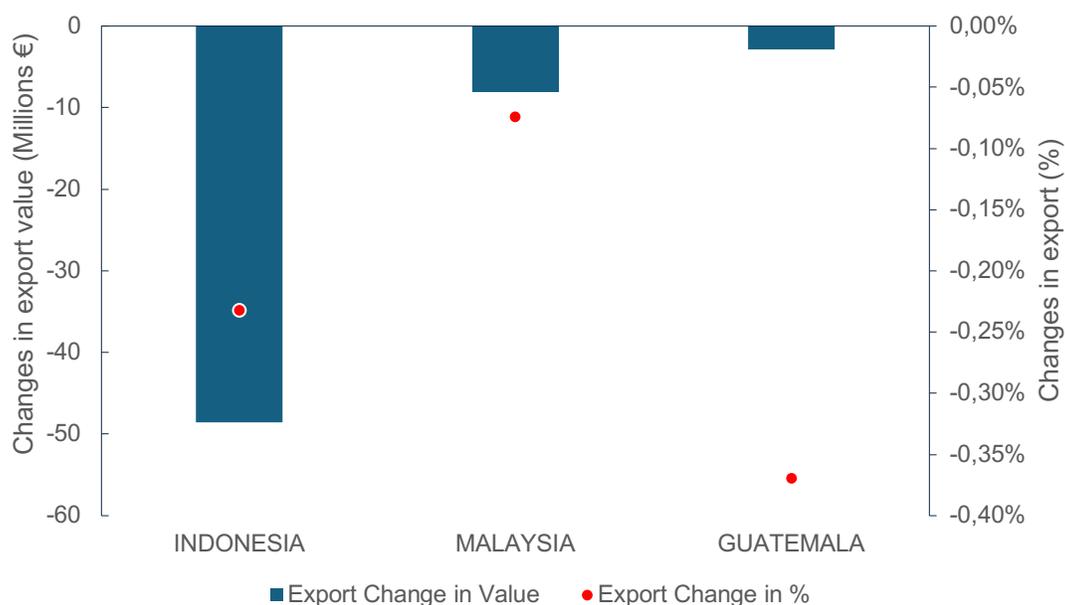
This section examines the trade performance outcomes under each scenario, it focuses on both export and import changes across selected countries. By analysing how trade values shift in response to the implementation of the EUDR, the study aims to capture the broader commercial impact of the regulation beyond welfare outcomes. Export and import performance provide direct indicators of trade competitiveness, market access, and potential diversion effects triggered by compliance costs or supply chain adjustments.

4.2.1 Export performance

Under Scenario 1, where only large companies are assumed to comply with the EUDR, all major exporting countries face a contraction in palm oil exports. As shown in Figure 12, Indonesia experiences the largest decline, with exports falling by €48 million (–

0,23%). The results show Indonesia's reliance on palm oil exports to the EU. Furthermore, the exclusion of SMEs, which form a significant part of the supply chain, also play a role.

Figure 12 Export changes of scenario 1



Source: Author's, adapted from GSIM Results

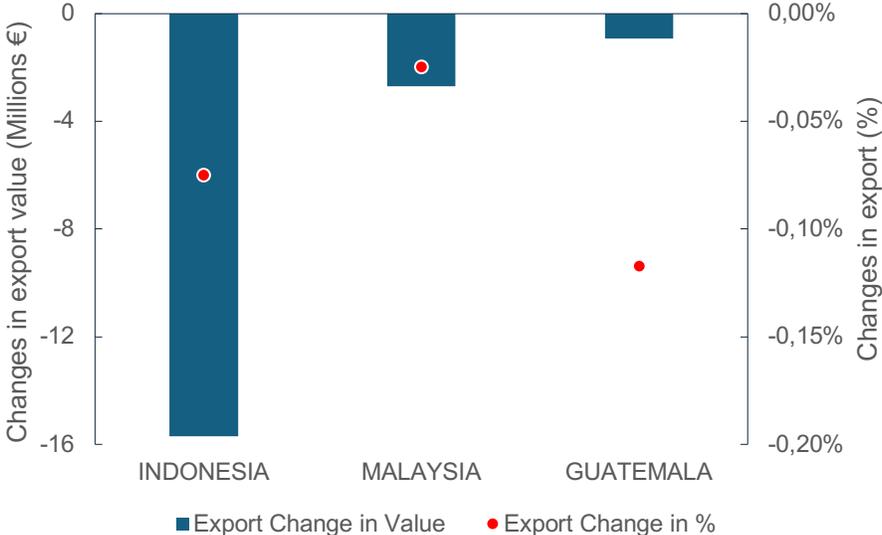
Malaysia also registers a decline of €8,1 million (-0,07%), though the relative loss is smaller compared to Indonesia, given Malaysia's more diversified export destinations. Guatemala, however, suffers a sharper impact of -0,36%, even though its value loss is smaller (-€2,8 million). This outcome reflects Guatemala's vulnerability due to its highly dependence on the EU market for palm oil exports.

These patterns indicate the disruptions in export flows caused by compliance with the EUDR, particularly for countries where SMEs form a substantial share of the palm oil export base.

Under Scenario 2, where both large exporters and SMEs are assumed to comply with the EUDR (albeit with higher compliance costs for SMEs compared to Large companies), exporter countries experience modest changes compared to scenario 1. Indonesia registers a modest negative export performance as we can see from Figure 13. The

export value decrease by €15 million, equivalent to 0,07%. Malaysia, Guatemala, and the RoW, also experience slight export declines. Malaysia's exports drop by about €2,7 million or -0,02%, Guatemala sees highest change in percentage, for -0,1% or €0,9 million, and RoW posts a decline of € 3,2 million or 0,01%. These adjustments indicate the benefit of the proportion of SMEs participating in EU market for exporting countries.

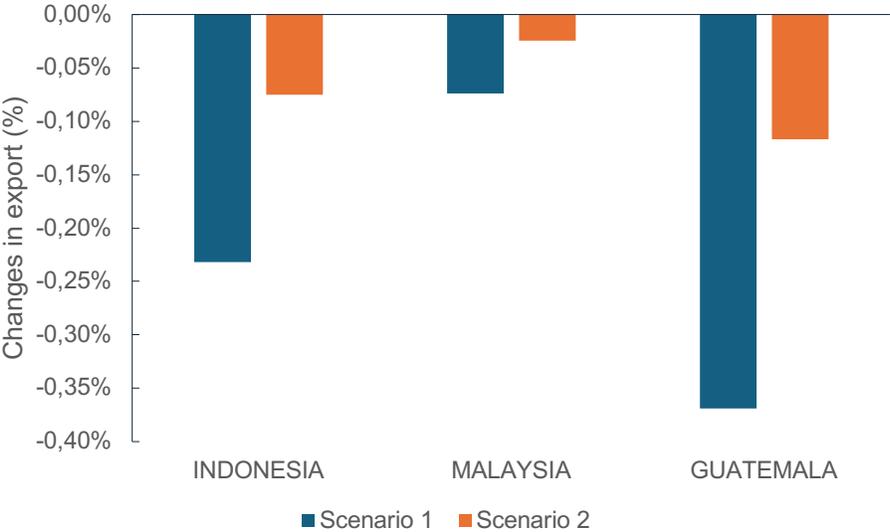
Figure 13 Export changes of scenario 2



Source: Author's, adapted from GSIM Results

When SMEs are also enabled to comply, figure 14 shows that export contractions are less severe across the exporting countries. This suggests that inclusive compliance helps distribute trade opportunities more evenly, reducing both the disruption in global palm oil flows and the risk of exclusion for smaller producers.

Figure 14 Export changes for both scenarios



Source: Author’s, adapted from GSIM Results

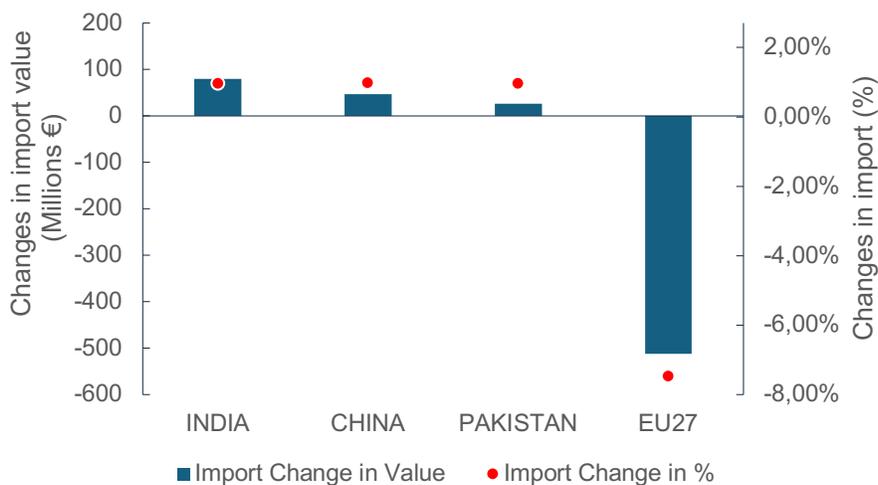
4.2.2 Import changes

In Scenario 1, where only large firms are able to comply with the EUDR, import dynamics across major consumer countries shows an obvious segmentation. The most notable impact is observed in the EU27, where palm oil imports drop by over €511 million, or -7,4% as we can see from Figure 15. This exposes the combined effect of reduced accessibility from non-compliant exporters, primarily SMEs, and the new compliance costs embedded in the supply chain.

In contrast, demand from non-EU markets such as India, China, and Pakistan increases. India records an import growth of €79 million (+0,97%), while China and Pakistan show positive import changes of €44 million (+0,99%) and €26 million (+0,97%) respectively, as China shows the highest percentage of rise. These increases indicate demand

diversion from EU-bound exporters, including SMEs who cannot meet EUDR standards, re-allocated towards less regulated destinations.

Figure 15 Import changes of scenario 1



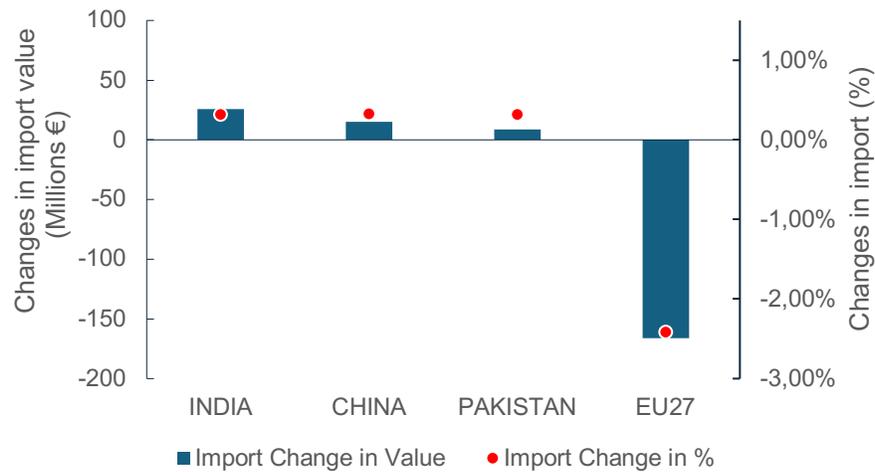
Source: Author's, adapted from GSIM Results

Overall, the import pattern in Scenario 1 is a classic trade diversion effect, where regulation in one market (EU27) reshapes trade flows globally, both in volume and value.

In Scenario 2, some changes observed in Scenario 1 persist, albeit to a lesser extent as we can see from Figure 16. The EU27 still records a decline in palm oil imports, both in value (-€166 million) and percentage (-2,4%). This indicates that although compliance from SMEs has improved access, the overall cost of meeting EUDR requirements continues to suppress total demand. Nonetheless, the drop is far less severe than in Scenario 1, which suggests that the re-entry of SMEs helps cushion the contraction.

Import demand in non-EU markets continues to increase, though moderately. India shows a positive import change of approximately €25 million (+0,31%), while China and Pakistan register modest increases of €15 million and €8,5 million, respectively, as China still has the highest growth of 0,32%. These results show that trade diversion remains a consistent pattern, although to a lesser extent. Importing countries outside the EU continue to take in palm oil that has been redirected from exporters adjusting to compliance costs and changing their trade strategies.

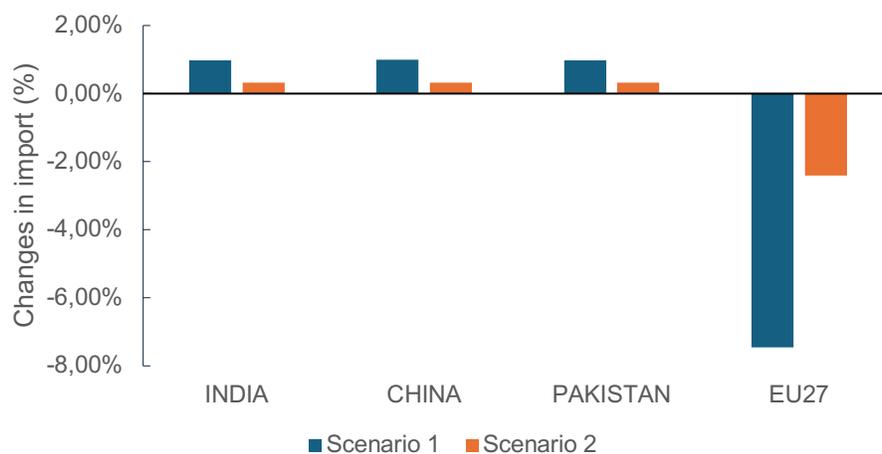
Figure 16 Import changes of scenario 2



Source: Author's, adapted from GSIM Results

Import trend in scenario 2 indicates a partial normalization of trade flows toward the EU, compared to scenario 1, with some demand retained by alternative markets, as depicted by figure 17. This outcome indicates the importance of regulatory adaptability in minimizing trade shift while still advancing policy goals such as sustainability and traceability.

Figure 17 Import changes for both scenarios



Source: Author's, adapted from GSIM Results

4.3 Bilateral trade change

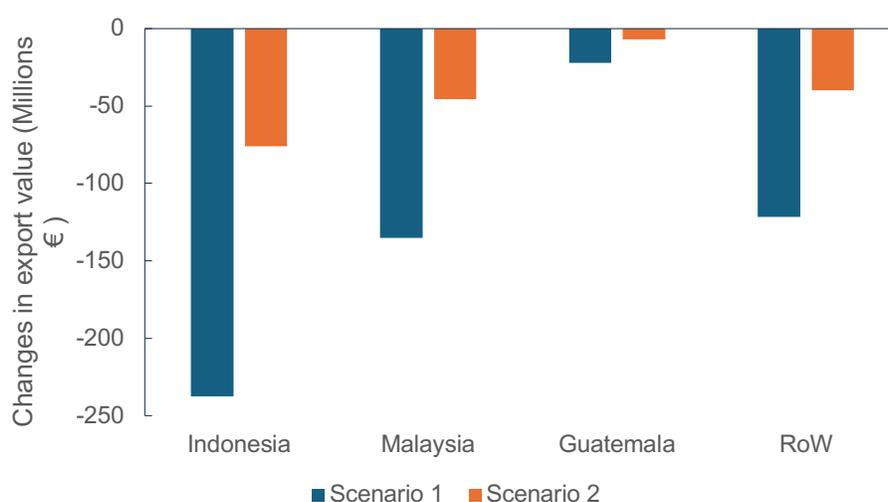
The bilateral trade results reveal the effect of the EUDR on major palm oil exporters and their trading relationships with both the EU and non-EU partners. Since this thesis focuses on Indonesia–EU trade relations, the discussion emphasizes 1) Indonesia as the main exporter and 2) the EU as a key importer, while also showing on spillover effects with other partners such as India, China, and Pakistan.

4.3.1 Changes on import to EU

In Scenario 1, where only large firms comply with EUDR, Indonesia experiences a sharp decline in exports to the EU, with a reduction of €237 million (figure 18). This outcome underlines Indonesia’s dependence on palm oil exports to the EU, and the exclusion of SMEs have significant negative impact for bilateral trade of Indonesia and EU.

Malaysia and Guatemala also face losses of €134,8 million and €21,9 million, respectively, while the RoW loses €121,6 million. The results demonstrate that restricting compliance to large firms alone generates a strong negative shock on bilateral trade with the EU. Indonesia emerges as the most affected supplier, while Guatemala has lowest impact in volume, despite it has high reliance to the EU. In total, EU still has shortage of palm oil import, with current value of €511 million (figure 13).

Figure 18 Changes in bilateral trade towards EU destination (both scenarios)



Source: Author’s, adapted from GSIM Results

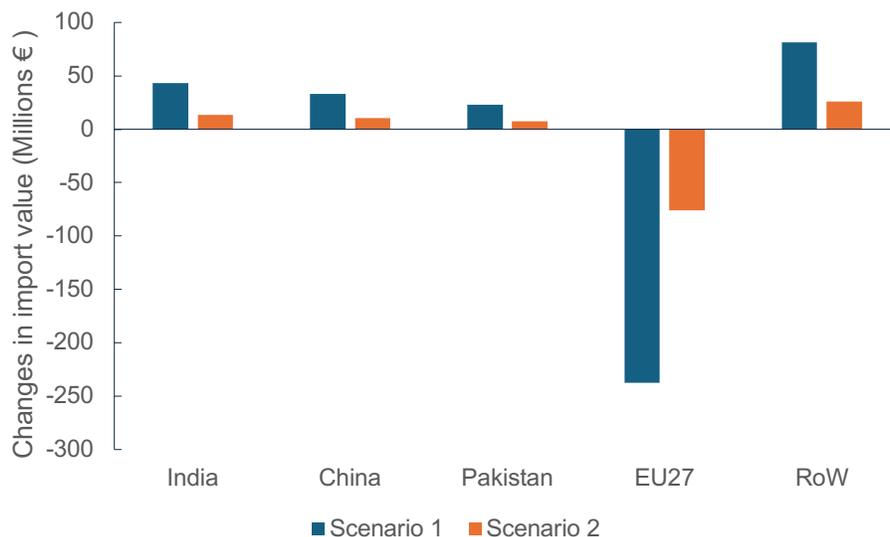
In Scenario 2, where SMEs are also included in compliance, the decline in Indonesia's bilateral trade with the EU is less severe, at -€75 million (figure 18), compared to -€237 million of scenario 1. Losses for Malaysia and Guatemala also decrease to €45 million and €6,7 million, respectively. Lastly, for RoW, that shows reduced loss (-€39,6 million), compared to loss by €121,6 million under Scenario 1. Even so, in aggregate, EU still has shortage of palm oil import, with current loss of €166 million (figure 16).

This reduction shows the role of SMEs in sustaining trade volumes, as their participation helps offset part of the market loss and cushions the overall impact of the regulation. Albeit trade still decreases, the scale of the decline suggests that inclusive compliance mechanisms can significantly mitigate export disruptions.

4.3.2 Changes on export from Indonesia

In Scenario 1, where only large firms are able to comply with EUDR requirements, Indonesia faces a severe contraction in exports to the EU for €237,7 million. This decline is not compensated by trade reallocation, leaving Indonesia highly exposed to market exclusion, as shown by figure 19. However, partial diversion of exports toward alternative partners, particularly India, China, and Pakistan, helps offset some of the losses. Gains of €43,1 million to India, €33,3 million to China, and €22,9 million to Pakistan shows the trade diversion effect, while an additional €81,3 million is absorbed by the RoW. Even so, these shifts do not fully recover the value lost from EU access, with the current aggregate loss of €48 million (figure 12), emphasizing Indonesia's reliance on the European market.

Figure 19 Changes in bilateral trade for Indonesia's export (both scenario)



Source: Author's, adapted from GSIM Results

In Scenario 2, the contraction in Indonesia's exports to the EU is reduced to -€75 million (figure 19). The broader participation of SMEs maintains market continuity, which cushions the overall shock. While trade diversion still occurs to India for €13,6 million, China €10,6 million, and Pakistan €7,3 million, the scale is more modest compared to Scenario 1, since a larger share of trade remains with the EU. Exports to the RoW also increase by €25,9 million, but again, at a lower intensity than in Scenario 1. Furthermore, it also does not fully recover the value lost from EU market, with current total export loss for -€15 million (figure 13).

4.4 Price effects

This section discusses the changes in prices along the palm oil supply chain as a result of the EUDR-related trade shock. In the GSIM model, both producer and consumer prices adjust in response to shifts in trade costs, output, and market access. Since the scenarios involve non-tariff measures that reshape market participation, particularly for SME exporters, price dynamics offer an insight into how different actors in the supply chain are affected. We begin with an analysis of producer price movements across key exporting countries, followed by the implications for consumer prices in major importing markets.

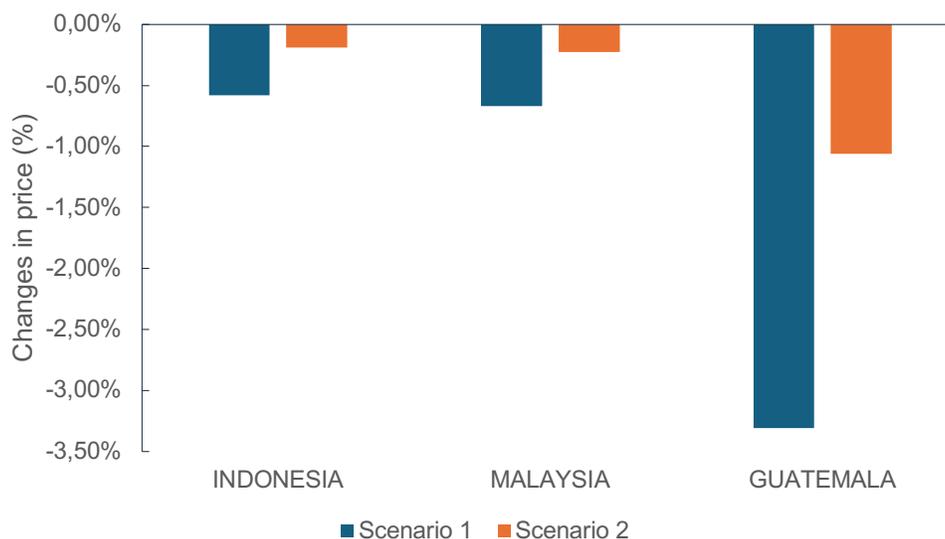
4.4.1 Producer price effects

In the first scenario, the simulation shows a broad-based decline in producer prices across all exporting regions. This result indicates the demand contraction in a key market (EU27), which has implications for price formation along the supply chain.

The sharpest drop is observed in Guatemala, with producer prices falling by -3,3% as we can see from Figure 20. This result aligns with Guatemala's high exposure to the EU market. Given its reliance on palm oil exports to Europe, the exclusion of SMEs from the EU supply chain reduces demand for Guatemalan output, which then puts downward prices at the origin.

Indonesia, despite being the largest exporter, also records a price drop of -0,57%. Malaysia also sees a decline of around -0,66%, slightly worse than Indonesia. This trends can be explained by the fragmented structure of its palm oil sector. With share of exports previously sourced from SMEs, their exclusion leads to a reallocation of non-certified SMEs supply, while the excess stock from SMEs is redirected to lower-value or less regulated markets, thereby creating oversupply domestically and pushing prices down.

Figure 20 Producer price impacts of both scenarios



Source: Author's, adapted from GSIM Results

In Scenario 2, from figure 20, the decline in producer prices is generally smaller compared to Scenario 1, which is a less severe market adjustment due to the inclusion of both large firms and SMEs in meeting EUDR compliance. Indonesia, despite seeing a price reduction of -0,18%, fares better than Guatemala, which faces a deeper decline at -1,05%. Malaysia experiences moderate decreases of -0,22%. This result shows that when both large and small exporters are able to follow the EUDR rules, the overall market disruption is smaller. The shock to the supply chain becomes less intense, meaning price and trade impacts are more stable compared to a scenario where only large exporters can comply.

4.3.2 Consumer prices

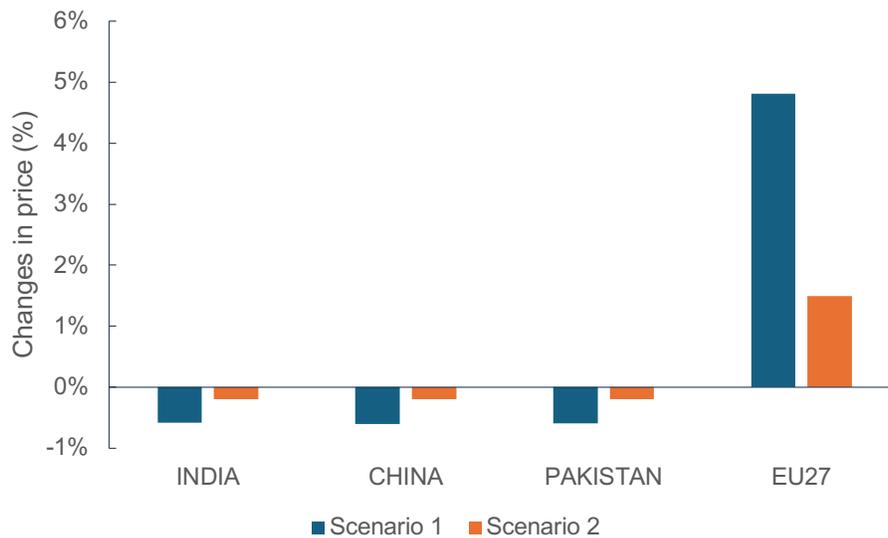
The consumers of palm oil and its derivative, it is not only the final end-households, but also include large number of industries that use palm oil as a key input in their production processes (Pacheco, et.al, 2017). These range from the food sector, such as cooking oil, margarine, and processed foods to non-food industries like cosmetics, detergents, and biofuels. As such, consumers in the GSIM of palm oil trade simulation, refer to aggregate demand side in the importing markets (Francois & Hall, 2002), including industries and

households. This section discusses the changes in price that consumers must bear as a result of the EUDR.

In Scenario 1, where only large firms are able to comply with EUDR, the EU27 experiences a highest increase in consumer prices, rising by 4,81%, the highest among all importing regions as shown at figure 21. It is tied to the limited number of exporters able to comply with the EUDR requirements, which constrains supply to the European market. Since only large firms, with better resourced and already aligned with traceability and sustainability standards are able to meet the EUDR's stringent compliance thresholds, the exclusion of SMEs narrows the supply base. It is resulting to upward price pressure.

This phenomenon can be characterized as greenflation: a form of inflation driven by environmental regulations that increase compliance costs and reduce available supply. As defined by Olovsson & Vestin (2023), greenflation refers to the inflationary pressure that can emerge as a consequence of transitioning towards a greener economy. In this context, higher costs from traceability, geo-location, and documentation requirements are absorbed into the supply chain and ultimately passed on to EU consumers. As demand remains relatively inelastic in the short term, particularly in sectors such as food (Andreyeva, et.al, 2010), the price increases caused by the regulation tend to have a stronger and more visible effect. Thus, the EUDR introduces not only a non-tariff measure but also a structural price shift in the EU market, with broader implications for the affordability of sustainable palm oil imports.

Figure 21 Consumer price impacts of both scenarios



Source: Author's, adapted from GSIM Results

On the other hand, importing countries outside the EU, such as India, China, and Pakistan, record a decline in consumer prices ranging from 0,5% to 0,6%. This decline shows the redirection of palm oil that can no longer enter the EU market. With this surplus diverted to markets with fewer regulatory restrictions, consumer prices in those regions fall due to increased supply and competition. It means that, while EUDR pushes prices up within the EU by tightening standards, it also creates a spillover effect that improves affordability for consumers in non-EU markets.

In scenario 2, the shift in consumer prices across key importing markets is lower compared to scenario 1 (Figure 21). Most notably, in the EU27, consumer prices rise by approximately 1,4%, which is a more modest from the sharp 4,8% increase in scenario 1. This outcome emphasizes the importance of broader market participation in dampening cost pass-throughs to end consumers.

This milder price escalation can be attributed to the higher volume of palm oil available in the market. By allowing SMEs to continue supplying the EU, despite suffering higher compliance costs, overall supply conditions are improved. This mitigates the earlier

supply-side constraint seen in scenario 1, where the exclusion of SMEs caused a supply shock and led to a steeper rise in consumer prices.

Consumer prices in importing countries like India, China, and Pakistan, still decline, but more moderately (–0,17% to –0,19%) compared to the drops in scenario 1 (–0,5% to –0,6%). It shows that while these markets continue to absorb redirected supply, the spillover effect is less intense when SMEs retain access to the EU. In scenario 1, their exclusion led to a larger supply shift to less-regulated markets, keeps pressure on prices downward.

The results also provide an insight into how inclusive compliance policies, rather than restrictive approaches, can help mitigate the inflationary effects of green regulations. This scenario illustrates a more balanced allocation of regulatory costs across the supply chain, thereby lowering the risk of greenflation pressures in importing markets such as the EU.

4.5 Maritime Transport Effect

To capture the broader implications of EUDR beyond trade and welfare, this section explores how changes in palm oil trade flows affect maritime sector. As explained by Stopford, (2009), maritime economics is shaped by commodity trade flows as these determine shipping demand. Any disruption in the flow of commodities, whether by war, political shifts, or regulation, will reshapes the dynamics of shipping.

Palm oil exports are predominantly seaborne, with bulk (liquid) carriers accounting for the majority of shipments (89%), while containerized transport represents the remaining share 11% based on ECORYS (2015). These minority proportion of palm oil and its derivatives are usually value-added products with specialized buyer, such as the food, cosmetic, and pharmaceutical. They are using the likes of ISO-tanks, flexi-tanks, or intermediate bulk containers to transport the products (Musim Mas, 2022).

This segmentation allows us to trace the effect of policy-induced trade shifts not only in terms of value and volume, but also in logistical flows, which have direct implications for port operations, tank storages, shipping demand, and associated infrastructure, both in bulk and container carrier.

4.5.1 Maritime Impact Scenario 1

Bulk maritime palm oil shipments under Scenario 1, measured in tons, are presented in Table 2. The table should be read such that the exporting countries are listed in the left-hand rows, while the importing destinations are displayed in the top columns. For example, the figure in the row Indonesia (ID) and the column EU represents Indonesia's palm oil exports to the EU. Negative values (in red) indicate reductions in trade flows, while positive values show increases. The final column ("Total") shows the overall change in exports for each country across all destinations, while the final row ("Total") aggregates the changes in imports from all exporters.

The most notable shift is the drop in Indonesia's bulk exports to the EU, which decline by 237.466,5 tons. This aligns with the exclusion of SMEs from EUDR-compliant supply chains, a diversion of cargo toward alternative destinations. Consequently, there is an increase in Indonesian shipments to less-regulated markets: India (+43.049 tons), China (+33.225 tons), Pakistan (+22.914 tons), and the RoW (+81.187 tons). These reallocation patterns indicate a redistribution of trade flows that bypass the EU, emphasize market response created by the regulation.

Table 2 Maritime bulk trade impact of scenario 1 (in ton)

	ID	MY	GT	IN	CN	PK	EU	ROW	Total
ID	0	8.436,4	102,2	43.049,8	33.225,8	22.914,3	-237.466,5	81.187,6	-48.550,3
MY	14,0	0	0	30.669,4	13.716,6	3.436,4	-134.858,0	78.923,5	-8.098,1
GT	0	0	0	0	0	0	-21.956,3	19.083,9	-2.872,4
IN	0	0	0	0	0	0	-91,2	59,1	-32,1
CN	0,2	0	0	0	0	0	-9,5	-63,1	-72,5
PK	0	-0,1	0	0	0	0	0	0	-0,1
EU	-11,2	-0,6	0	0	-0,5	-13,3	4.736,2	-601,4	4.109,2
ROW	3,5	346,1	286,6	5.272,6	23,4	11,2	-121.473,1	105.616,1	-9.913,4
Total	6,5	8.781,9	388,8	78.991,8	46.965,4	26.348,7	-511.118,5	284.205,8	-65.429,7

Source: Author's, adapted from GSIM Results

Malaysia presents a similar but less severe pattern. Its exports to the EU drop by 134.858 tons, and slightly redirected to RoW (+78.923 tons). Guatemala's total volume to EU also

shows adjustments for -21.956 tons. with 19.083 tons diversions to RoW, indicating its capacity to reorient exports. The total bulk trade redirected from the EU toward other markets reaches 511.118 tons. Overall, the results show that global palm oil bulk shipping decreased for 65.429 tons, this portion of palm oil output finds no alternative market or route and is therefore not shipped at all.

Table 3 Maritime containerized trade impact scenario 1 (in TEU, rounded up)

	ID	MY	GT	IN	CN	PK	EU	ROW	Total
ID	0	44	1	222	172	118	-1223	419	-251
MY	1	0	0	158	71	18	-695	407	-42
GT	0	0	0	0	0	0	-114	99	-15
IN	0	0	0	0	0	0	-1	1	-1
CN	0	0	0	0	0	0	-1	-1	-1
PK	0	0	0	0	0	0	0	0	0
EU	-1	0	0	0	0	-1	25	-4	22
ROW	1	2	2	28	1	1	-626	544	-52
Total	-1	46	3	407	214	136	-2.633	1.464	-337

Source: Author's, adapted from GSIM Results

In terms of TEU, it shows similar patterns with the bulk trade. Table 3 shows that Indonesia sees a net decrease of 251 TEUs in containerized palm oil export trade, driven by lower shipments to EU (-1223), even though there are reallocation of trade to ROW, India, and China, it still could not offset the loss from EU market. Malaysia and Guatemala record moderate losses, while EU imports decline sharply by -2.633 TEUs. These shifts confirm a reorientation of containerized trade away from the EU toward less regulated markets, as a trade response caused by the EUDR. In aggregate, global containerized palm oil shipment shrink by -337 TEUs.

4.5.2 Maritime Impact Scenario 2

The maritime bulk trade impact in Scenario 2 is illustrated in Table 4, showing how the inclusion of SMEs in EUDR compliance results in a more balanced redistribution of trade. Indonesia's palm oil exports records a negative net change of -15.681 tons, driven by

decreased exports to EU by -75.898 tons despite an increased exports to India, China, Pakistan.

Table 4 Maritime bulk trade impact scenario 2 (in Ton)

	ID	MY	GT	IN	CN	PK	EU	ROW	Total
ID	0,0	2.711,1	32,7	13.676,1	10.592,0	7.343,3	-75.898,9	25.862,3	-15.681,4
MY	4,6	0,0	0,0	10.342,4	4.642,2	1.166,3	-45.412,3	26.554,5	-2.702,2
GT	0,0	0,0	0,0	0,0	0,0	0,0	-6.736,6	5.825,5	-911,1
IN	0,0	0,0	0,0	0,0	0,0	0,0	-29,3	18,9	-10,4
CN	0,1	0,0	0,0	0,0	0,0	0,0	-3,1	-20,6	-23,7
PK	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
EU	-3,6	-0,2	0,0	0,0	-0,2	-4,3	1.495,1	-195,5	1.291,3
ROW	1,1	114,1	93,7	1.716,6	7,7	3,7	-39.607,6	34.432,4	-3.238,3
Total	2,2	2.825,0	126,3	25.735,1	15.241,7	8.509,0	-166.192,7	92.477,4	-21.275,9

Source: Author's, adapted from GSIM Results

Malaysia still faces a moderate contraction (-2.702 tons), while Guatemala declines slightly (-911 tons). Overall, EU bulk imports shrink by -166.192 tons, and the global shipment decreased by 21.275 tons (compared to 65.429 tons of scenario 1). These figures show a less fragmented diversion pattern compared to Scenario 1, and suggesting a more integrated global reallocation rather than a complete EU market bypass.

In case of TEU for scenario 2 as shown by table 5, it has similar pattern with bulk trade. With a net decrease of -81 TEUs moving globally, Indonesia remains the central exporting hub. It transports container flows toward India, China, Pakistan, and the RoW, despite still seeing a decline in shipments to the EU (-391 TEUs). This shift depicts partial market reallocation, supported by SME inclusion in EU compliance.

Table 5 Maritime containerized trade impact scenario 2 (in TEU, rounded up)

	ID	MY	GT	IN	CN	PK	EU	ROW	Total
ID	0	14	1	71	55	38	-391	134	-81
MY	1	0	0	54	24	7	-234	137	-14
GT	0	0	0	0	0	0	-35	30	-5
IN	1	0	0	0	0	0	-1	1	-1
CN	1	0	0	0	0	0	-1	-1	-1

PK	0	0	0	0	0	0	0	0	0
EU	-1	0	0	0	0	-1	8	-2	7
ROW	1	1	1	9	1	1	-204	178	-17
Total	1	15	1	133	79	44	-856	477	-110

Source: Author's, adapted from GSIM Results

Meanwhile, Malaysia continues to diminish in key corridors, particularly to the EU (-234 TEUs), with the net loss by -14 TEUs. EU's import also decline by 856 TEUs, and global shipment of palm oil decrease by 110 TEUs. The overall pattern displays a more moderate of global trade landscape under a more inclusive regulatory framework.

The shift in volume not only illustrates the trade diversion caused by the EUDR but also shows potential implications for shipping dynamics. Tanker or liquid bulk vessels demand previously directed to EU will be reduced, or re-allocated to alternative routes. These results can alter the freight rate of liquid bulk vessel. In the long run, this also could influence the vessel demand in both the newbuilding and second-hand chemical or liquid tanker markets. Palm oil shipment from Indonesia and Malaysia to EU, that typically goes through Suez canal, are expected to decreased. Guatemala's transatlantic shipment will also be reduced. This contraction will affect port activities related to liquid bulk handling and tank storage, with much of this activity likely redirected to regional hubs outside Europe. This reduction shows how compliance barriers under the EUDR do not only affect trade values but also directly translate into lower seaborne cargo movements, creating inefficiencies across maritime logistics and reducing overall fleet utilization.

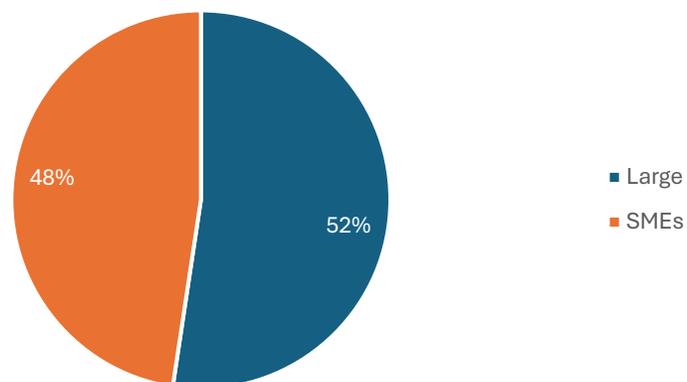
4.6 Exporter perspectives

To complement the model-based analysis, this section presents findings from a targeted questionnaire aimed at palm oil exporters. A total of 21 respondents participated, that represent a mix of SMEs and large companies. All respondents are actively engaged in international markets, including the EU. These perspectives add depth to the quantitative results, that offer a clearer view of how the EUDR may shape trade behaviour on the ground. A detailed list of the full questionnaire and responses provided by exporters can be found in Appendix VIII.

4.5.1 Company size classification

The first question in the survey aimed to categorize the respondents according to firm size, using the European Union Deforestation Regulation (EUDR) criteria. Out of the 21 total respondents, 10 firms (48%) identified themselves as SMEs (“Selain Perusahaan Besar”), while 11 firms (52%) fell under the category of Large Enterprises (“Perusahaan Besar”), as it shown from figure 22.

Figure 22 Company size on questionnaire

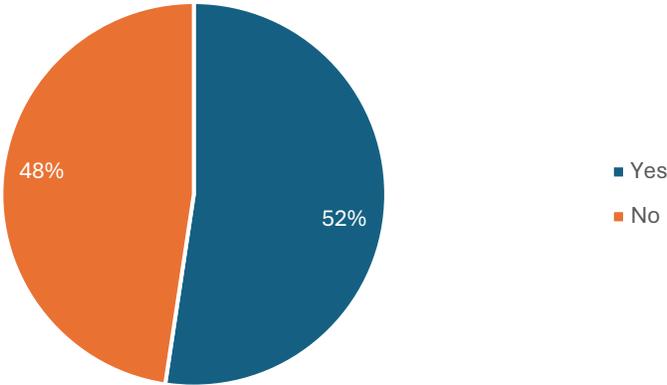


Source: Questionnaire results

4.5.2 Willingness to serve EU market under EUDR

Question 2 explores exporters' willingness to respond to demand from the EU under the EUDR. Out of 21 respondents, 11 firms indicated “Ya” (Yes), expressing their readiness to comply with the regulation, while 10 firms answered “Tidak” (No), signalling either constraints or reluctance to meet the compliance standards.

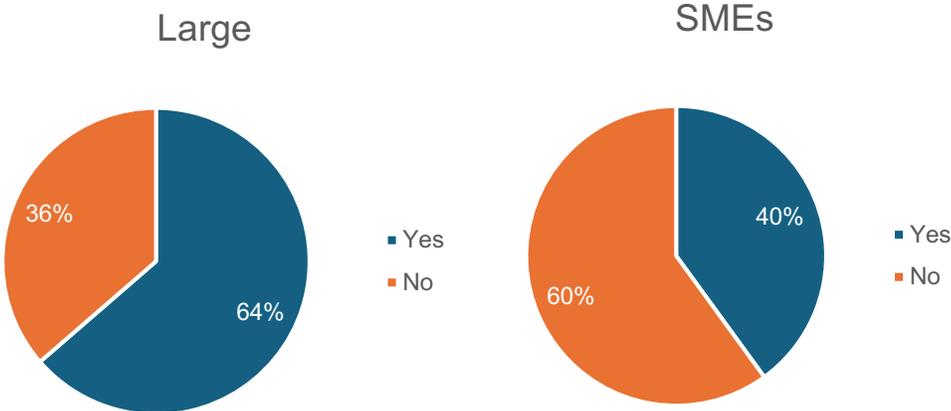
Figure 23 Willingness to serve EU market under EUDR



Source: Questionnaire results

As it shown from figure 24, among large firms, 7 out of 11 (63%) stated that they were willing to comply with the regulation should EU demand arise. In contrast, only 4 out of 10 SMEs (40%) expressed similar readiness, while the remaining 6 SMEs (60%) indicated unwillingness.

Figure 24 Willingness to serve EU market under EUDR based on company size



Source: Questionnaire results

This contrast depicts a gap in compliance readiness. Larger companies, backed by more robust systems and resources, are generally better prepared to handle the administrative and traceability requirements set by the EUDR. In comparison, SMEs show lower readiness, it underscores the ongoing concern that the regulation can unintentionally sideline smaller exporters. Without targeted assistance or transitional support, SMEs face the real possibility of being shut out of the EU market, that widened the existing inequalities in global trade.

4.5.3 Estimated compliance cost

In Question 3, respondents were asked to estimate the additional cost burden of complying with EUDR, expressed as a percentage of total export value. The responses reveal a clear divergence between large firms and SMEs. Among large companies, cost estimates vary from as low as 1% to 10%, with most clustering around the 1–5% range, four of them estimate the highest bracket of 10%, and with the average of 5%. It suggests that while the compliance process is expected to add costs, many large exporters anticipate a manageable financial impact. This aligns with their earlier indication of readiness to comply, and their confidence in their existing infrastructure and traceability systems.

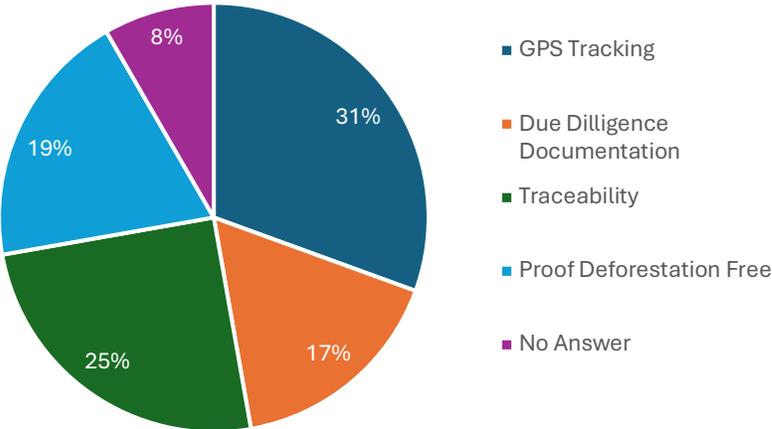
By contrast, SMEs estimate the cost burden at the upper end of the scale, with 5 out of 10 respondents selecting 10%, and 5% selected by the rest, with the average value of 8%. No SME reported costs below 5%, indicates their limited absorptive capacity and higher relative adjustment costs. These results support the perception that EUDR compliance is disproportionately costly for smaller exporters, and has potential to jeopardizing their competitiveness and access to regulated markets like the EU.

4.5.4 Most challenging EUDR criteria

Result from Question 4, as shown from Figure 25, the geo-location requirement, specifically GPS tracking down to the plot level, is considered the most difficult EUDR criteria, selected by 31% of respondents. This is followed by traceability across the supply chain (25%) and the need for proof of deforestation-free origin (19%), both emphasize

the technical challenges of complying with upstream sourcing requirements, especially within fragmented production systems.

Figure 25 Most challenging EUDR criteria according to exporters

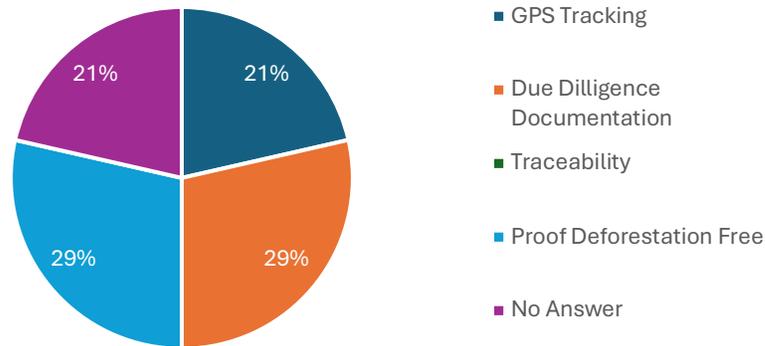


Source: Questionnaire results

Due diligence documentation is also viewed as a challenge (17%), particularly for firms lacking the institutional capacity to carry out full compliance checks. A small number of respondents (8%) reported no particular difficulties. These results underline that the most demanding aspects of EUDR compliance are not limited to legal thresholds, but also involve logistical and data infrastructure gaps, especially for exporters relying on smallholder networks with low digital traceability.

Figure 26 shows that among large exporters, the most commonly cited compliance challenges under the EUDR were proof of deforestation-free origin and due diligence documentation, each selected by 29% of respondents. GPS tracking followed closely, noted by 21% of firms. Interestingly, no large company identified traceability as the most difficult criterion, suggesting that for larger firms, that many of them already operate under established internal supply chain controls, traceability requirements may be less disruptive. The remaining 21% did not provide an answer, indicating either uncertainty or unwillingness to disclose.

Figure 26 Most challenging EUDR criteria according to large exporters

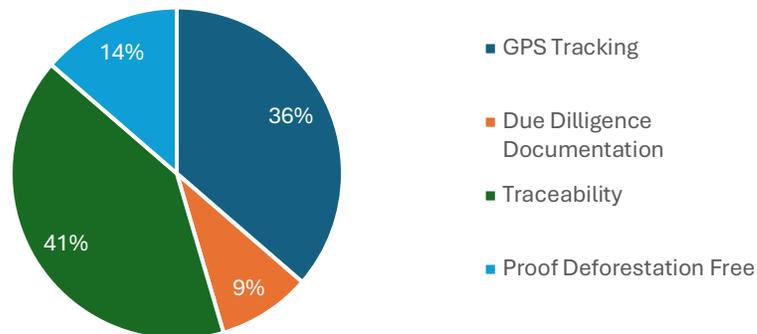


Source: Questionnaire results

The responses explain that while documentation and spatial verification pose real challenges, larger firms may already have baseline systems in place to manage traceability.

Among SME exporters, as shown from figure 27, the most commonly cited challenge in complying with the EUDR is traceability, selected by 41% of respondents. It shows the structural limitations many small firms face in mapping their supply chains down to the farm level.

Figure 27 Most challenging EUDR criteria according to SMEs exporters



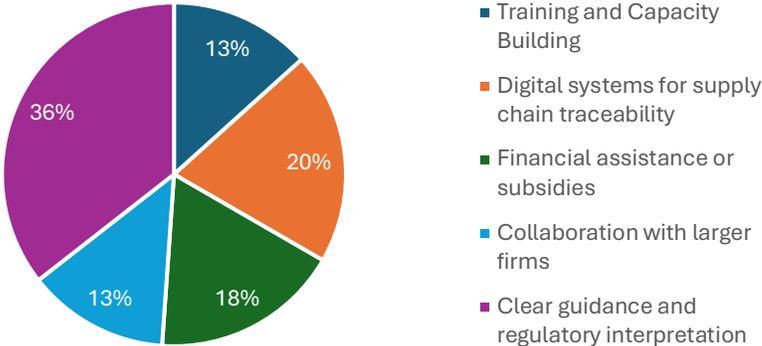
Source: Questionnaire results

GPS tracking was the second-most cited difficulty (36%), it suggests that technical capacity for spatial monitoring is also a major barrier. In contrast to large firms, a smaller share of SMEs identified due diligence documentation (9%) and deforestation-free proof (14%) as their main concern. The responses reveal how the technical requirements of the EUDR disproportionately affect SMEs. The demands for traceability and geolocation go beyond simple paperwork, they require fundamental changes to sourcing models, digital capabilities, and operational structure, all of which are more difficult for SMEs to absorb.

4.5.5 Types of government assistance needed

As illustrated in Figure 28, 36% of respondents identified clearer guidance and interpretation of the regulation as their top priority assistance from the government. Many firms are still unsure about what exactly the rules demand in practice.

Figure 28 Governmental assistance needed



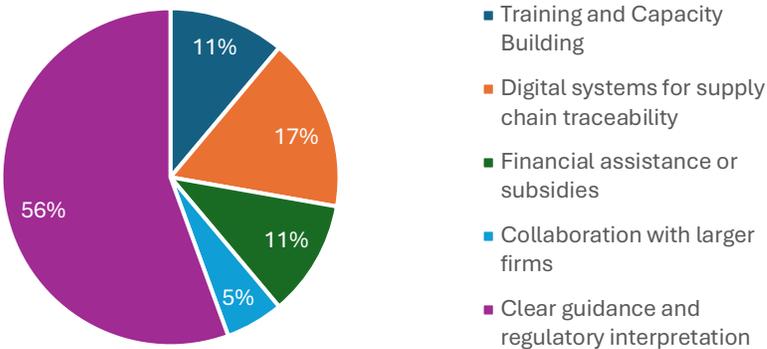
Source: Questionnaire results

Ahead of clarity, companies highlighted the need for practical tools and support. 20% of respondents said digital systems for supply chain traceability will help them adapt more easily, while 18% pointed to financial assistance or subsidies to offset compliance costs. and both 13% proportion for collaboration with bigger company and training program. This is particularly relevant for smaller firms that lack the resources or internal infrastructure to make the necessary adjustments. Complying with EUDR is not just a matter of

willingness, it also depends on whether firms have the tools, guidance, and resources to make it feasible.

Among large exporters, as shown from figure 29, the most needed assistance is for clearer regulatory guidance with 56%. It shows the demand for clarity on how to interpret and implement EUDR rules in practice, despite these firms already having the internal capacity to manage technical and administrative requirements. Their main challenge lies not in capability, but in translating the regulatory ambiguity.

Figure 29 Governmental assistance needed for large firm

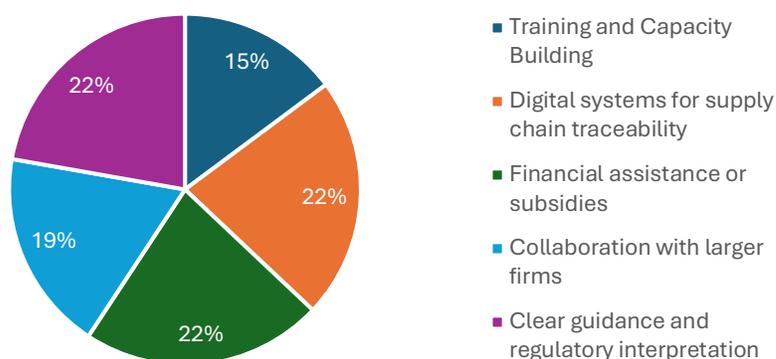


Source: Questionnaire results

Requests for support in areas like digital traceability systems (17%) and financial assistance (11%) are less chosen, it suggest that large firms are generally equipped with the necessary infrastructure. Very few pointed out the need for training or partnerships, their concern is not about readiness, but about how to align their operations with a regulation that remains open to interpretation.

Figure 30 shows that support needs among SME exporters are relatively evenly spread across key categories, it underscores the span of challenges they face under the EUDR. Financial support, digital systems for supply chain traceability, and clear regulatory guidance, each account for 22% of responses.

Figure 30 Governmental assistance needed for SMEs



Source: Questionnaire results

This balanced distribution suggests that no single issue dominates; rather, SMEs are simultaneously constrained by limited access to capital, insufficient digital infrastructure, and regulatory ambiguity.

This contrasts with larger firms, whose needs are more concentrated. For SMEs, the even split shows the structural gaps they face across multiple fronts. These exporters typically lack the financial resilience to absorb additional compliance costs, the systems to trace supply origins with precision, and the institutional clarity to interpret and apply complex rules. Meanwhile, collaboration with larger firms (19%) and training or capacity building (15%) round out the support needs, it demonstrate the importance of knowledge transfer and sector linkages. Taken together, the results point to a need for integrated support strategies that address both technical and institutional barriers for smaller exporters.

4.5.6 Suggestions and feedback on EUDR implementation

The final section of the questionnaire invited respondents to provide open-ended feedback regarding the implementation of the EUDR. The responses uncover a number of common themes that offer important qualitative insight into how the policy is perceived on the ground.

A frequent sentiment was an acknowledgement of the EUDR's environmental objective. Several exporters explicitly stated their support for the regulation in principle, in advancing sustainability. The supports suggest that opposition is not rooted in idea, but rather in the burden of its operational requirements.

However, the most dominant theme across responses was the call for more robust government support. Many exporters stressed the need for clearer technical guidance, financial assistance, and institutional coordination to meet compliance demands. This is particularly pressing for SMEs, which expressed their concern over their limited capacity to absorb the administrative and financial costs associated with the regulation. Without targeted government assistance, these firms risk exclusion from high-value markets.

Respondents also emphasised the need for better alignment between EU requirements and Indonesia's regulatory framework. Several pointed to gaps and ambiguities in implementation guidelines, calling on the Indonesian government to harmonise domestic standards with EU expectations. Exporters especially underlined the need for regulations to be adjusted to local conditions, so that the practical realities of production on the ground are not ignored when trying to meet compliance requirements.

Feedback from SME respondents also stressed the need for flexibility and inclusion. Their suggestions for transitional periods, special treatment, or softer enforcement are not meant to reject the regulation, but to reveal the real challenges they face. Without such supports, the regulation is likely to deepen the competitive divide between large and small exporters.

A smaller group of respondents suggested to look for export markets outside the EU, or even maximize the domestic consumption. This shows that some exporters are already thinking about ways to reduce risk, as they worry about being left out in the long run due to stricter sustainability rules. Although this is not the majority opinion, it shows the sense of uncertainty that the regulation has created for businesses.

Other respondents proposed more incentive-based mechanisms to support compliance. These included premium pricing for compliant products and improved market access as

compensation for the additional cost burden. Such feedback signals that exporters are not only focused on extra cost avoidance, but are seeking fair value in return for their investment in sustainable practices.

Importantly, several exporters went further by offering practical recommendations for implementation. Suggestions included the use of blockchain and satellite technology for supply chain monitoring, development of simplified certification systems for SMEs, and partnerships between smallholders and larger firms for joint verification and training. These inputs indicate a constructive stance, exporters are not only identifying problems but also proposing workable solutions.

In summary, exporters are willing to adapt but lack of adequate support to meet the new rule such as EUDR. The regulation's success will depend not only on enforcement but also on the availability of enabling mechanisms that reduce compliance barriers especially for SMEs. Without this, EUDR risks worsen existing inequalities in global trade, and possibly fails to achieve the environmental improvements it aims for.

4.6 Sensitivity analysis

To assess the reliability of the GSIM results, a sensitivity analysis was carried out by modifying the demand, substitution, and supply elasticities by $\pm 10\%$. Sensitivity analysis, as defined by Vipond (n.d.), is a technique used to test how the results of a model respond to changes in underlying assumptions. This allows us to evaluate whether the outcomes are stable, or if they change intensely with minor adjustments in parameters. After modify the demand elasticities to $\pm 10\%$, the values are returned to their original value, Furthermore, the substitution elasticity is adjusted, and the same approach carried out, including the supply elasticities. Since the same elasticities are applied across all GSIM models, it was considered sufficient to alter only one GSIM to test the model's validity. In this study, scenario 1 was selected as the focus, given its role as worst case scenario for the exposure to the EUDR.

The results show that adjusting demand elasticities produced small shifts in both output and welfare across countries. Table 6 depicts that for Indonesia, output and welfare moved symmetrically by $\pm 0,004\%$. In contrast, noticeable changes were seen in

Guatemala for the welfare and output change, the results show 0,026% to 0,022% change. The EU also showed modest sensitivity, with welfare changing between –0,004% and +0,003%. In general, these small changes in net welfare and output still below the value of modified change in the demand elasticities, therefore it can be concluded that the chosen demand elasticities are reasonable.

Table 6 Sensitivity analysis of demand elasticities

Factor	Change in Output		Change in Welfare	
	(-10%)	(+10%)	(-10%)	(+10%)
INDONESIA	-0,004%	0,004%	-0,004%	0,004%
MALAYSIA	0,000%	0,000%	0,001%	-0,001%
GUATEMALA	0,026%	-0,022%	0,026%	-0,022%
INDIA	0,017%	-0,014%	-0,002%	0,002%
CHINA	-0,051%	0,043%	-0,002%	0,002%
PAKISTAN	-0,083%	0,074%	-0,003%	0,003%
EU27	-0,055%	0,046%	-0,004%	0,003%
ROW	-0,018%	0,015%	-0,005%	0,005%

Source: Author's, adapted from GSIM Results

By contrast, modifying substitution elasticities generates larger variations. From table 7, it can be seen that, for Indonesia, modified elasticities change the output and net welfare -0,019% to 0,022%. The EU results range from -0,12% to 0,139% for change in output, and -0,011% to 0,012% for change in welfare. Guatemala still hold the highest change in welfare by -0,063% to 0,055%.

Table 7 Sensitivity analysis of substitution elasticities

Factor	Change in Output		Change in Welfare	
	(-10%)	(+10%)	(-10%)	(+10%)
INDONESIA	0,022%	-0,019%	0,022%	-0,019%
MALAYSIA	0,003%	-0,002%	-0,002%	0,001%
GUATEMALA	-0,062%	0,053%	-0,063%	0,055%
INDIA	-0,019%	0,018%	0,018%	-0,015%
CHINA	0,156%	-0,140%	0,016%	-0,014%
PAKISTAN	0,194%	-0,167%	0,019%	-0,017%
EU27	0,139%	-0,120%	0,012%	-0,011%
ROW	0,049%	-0,043%	0,022%	-0,019%

Source: Author's, adapted from GSIM Results

Similarly, from table 8, it can be depicted that supply elasticity adjustments also generated larger effects compared to demand. For Indonesia, a $\pm 10\%$ modified supply elasticity resulted in a decrease $-0,083\%$ in output to an increase of $0,085\%$, while for the welfare, ranging from $-0,016\%$ to $0,016$. EU27 experience the highest change in output of $\pm 0,109\%$, and the opposite occurred in net welfare change, with the lowest, of $\pm 0,001\%$.

Table 8 Sensitivity analysis of supply elasticities

Factor	Change in Output		Change in Welfare	
	(-10%)	(+10%)	(-10%)	(+10%)
INDONESIA	0,085%	-0,083%	-0,016%	0,016%
MALAYSIA	0,084%	-0,083%	-0,006%	0,006%
GUATEMALA	0,088%	-0,087%	-0,003%	0,003%
INDIA	0,080%	-0,076%	-0,012%	0,012%
CHINA	0,068%	-0,063%	-0,014%	0,013%
PAKISTAN	0,074%	-0,071%	-0,015%	0,015%
EU27	0,109%	-0,109%	0,001%	-0,001%
ROW	0,083%	-0,081%	-0,011%	0,010%

Source: Author's, adapted from GSIM Results

These results show that while the size of welfare and output changes does vary across these adjustments, the magnitude of change remains smaller than the applied modification in elasticities. In other words, even when the parameters are shifted, the overall results do not move beyond the scale of the variation imposed.

This consistency indicates that the welfare and output outcomes generated by the GSIM are not overly sensitive to changes in parameter values. The relative impacts remain within reasonable bounds, therefore, the analysis supports the conclusion that the model is robust.

CHAPTER V: CONCLUSIONS

This chapter concludes the study by summarising the main findings from the simulation and questionnaire analysis, which point out their implications for the implementation of the EUDR in Indonesia's palm oil export sector. There are two scenarios, one excluding SMEs from EU supply chains and another enabling their compliance, shape trade flows, welfare, prices, and maritime transport. The chapter also addresses the limitations of the research, and offers recommendations for future studies to build on these results.

5.1 Key Findings

This section summarises the main results of the study by addressing the six sub-research questions set out in Chapter 1. Firstly, three main aspects were examined in this study. First, trade aspects include changes in export and import values, export and import share across key destinations, which show the effect of the regulation on Indonesia's competitive position. Second, economic aspects cover changes in producer and consumer welfare, measured as variations in surplus, alongside distributional impacts between Indonesia, competitor countries, and importing markets. Third, transport aspects focus on shifts in maritime trade flows, including changes in export tonnage and containerized cargo, to capture the logistical implications of altered trade patterns. By addressing these three aspects together, the study provides an integrated understanding of how the EUDR can reshape trade outcomes, economic gains, and transport dynamics in the Indonesian palm oil supply chain.

Second, before the introduction of EUDR, palm oil trade followed established routes, with Indonesia and Malaysia, as key exporters. Indonesia's largest markets were in Asia, particularly India, China, and Pakistan, while the EU remained an important but smaller destination. Existing sustainability standards, such as ISPO and RSPO, were mostly voluntary and less strict, meaning compliance did not create major market segmentation. As a result, Indonesia maintained broad market access and competitive participation in both Asian and European markets.

Third, Indonesia's palm oil sector is highly fragmented, with production shared between large-scale, vertically integrated companies and SMEs, including smallholder-linked mills.

Large firms typically operate with greater economies of scale, integrated supply chains, and established traceability systems, which enable them to meet stringent sustainability and documentation requirements more easily. SMEs, in contrast, often rely on mixed-sourcing from multiple smallholder suppliers, where supply chains are less transparent and record-keeping is inconsistent. This gap means SMEs face higher relative compliance costs structure and greater operational difficulties, particularly in implementing traceability systems, GPS mapping, and due diligence documentation. This increases their risk of being excluded under stricter regulations such as the EUDR.

Fourth, The Global Simulation Model (GSIM) is the most suitable tool to address this study, as it can simultaneously capture economic, trade, and transport impacts. It has partial equilibrium framework for detailed analysis of sector-specific policy changes, such as the EUDR, while accounting for bilateral trade flows, price adjustments, and welfare effects across countries. GSIM has also been widely applied in similar trade policy assessments, that ensures methodological relevance and comparability.

Fifth, to reduce the compliance gap between large firms and SMEs, the results suggest to the need for targeted support from the government. Large firms mainly require clearer regulatory guidance, alignment with Indonesia's regulation, e.g. the adjust the definition of deforestation to give legal clearness, aligning palm oil (and other commodities) regulation with EUDR outline, including enhance the certification scheme. Furthermore, government need to develop digital traceability systems to support the regulation. SMEs need a wider addition of assistance, including financial support, digital tools, training, and partnerships with larger companies. If the government provides support, it can help protect trade flows and fiscal revenues while enabling more exporters to access the EU market under the EUDR.

Lastly, the EUDR can be improved by aligning its compliance requirements with the capacities of different exporter groups, and adopt a more flexible and phased approach. A gradual implementation schedule will allow large exporters to comply first, while SMEs are given extended timelines to adjust, for more than 6 months. The regulation can also formally recognise credible national certification schemes, such as ISPO and MSPO, or

RSPO, to avoid duplicating audit and reporting processes. In parallel, targeted technical and financial assistance, particularly for SMEs, will help strengthen traceability systems and geolocation capabilities. Allowing flexible data submission formats and developing collaborative monitoring platforms between the EU, national authorities, and industry associations can further streamline verification. Finally, SMEs can be permitted to use mass balance traceability during a defined transition phase, with a clear plan for moving toward full physical segregation over time.

At the same time, this emphasizes the importance of active diplomacy by the Indonesian government to ensure that these concerns are communicated at the international level. Without government engagement in negotiations with the EU, the risk remains that compliance rules will be shaped solely by European perspectives, leaving little room for local realities. Stronger diplomatic efforts could help bridge this gap by advocating for flexibility, transitional arrangements, or recognition of national sustainability standards, thereby protecting Indonesia's export position while still supporting global environmental goals.

5.2 Limitations of the Research

This study provides a focused assessment of the trade, economic, and transport impacts of the EUDR on Indonesian palm oil exports, but several limitations must be acknowledged. First, the analysis uses the Global Simulation (GSIM) model rather than a Computable General Equilibrium (CGE) model. While GSIM enables detailed bilateral trade analysis for palm oil, it does not capture intersectoral linkages or broader macroeconomic effects. Second, gaps in trade and tariff data required the use of proxies and assumptions based on comparable countries, which may introduce uncertainty. Similarly, NTM cost estimates rely on scenario assumptions, which could diverge from actual costs once the EUDR is fully enforced. Third, the model's aggregated product categories mean transport effects are estimated using literature-based conversion factors rather than sector-specific data. Finally, the survey component, though valuable, is based

on responses from 21 exporters and may not fully represent the diversity of Indonesia's palm oil industry.

5.3 Suggestions for Future Research

There are areas that can be explored to strengthen and expand the analysis from this study. First, future research can explore comparative analysis across commodities included under the EUDR, such as coffee, cocoa, or wood. By doing so, policymakers can better identify common barriers and design support mechanisms that work across sectors rather than in isolation. Second, future work will benefit from a larger and more representative sample of exporters. Expanding the survey base will allow for a more robust statistical analysis and provide a clearer picture of how different actors within the supply chain perceive and prepare for compliance. Finally, more detailed transport and logistics analysis will be valuable. As compliance alters trade flows, future studies can investigate the resulting effects on freight costs, shipping routes, and port activity, which are only partially addressed in this thesis.

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Appendixes

Appendix I: Initial and final tariffs

Since it is focused on NTMs shocks, initial and final tariffs are unchanged for scenario 1 and 2.

	INDONESIA	MALAYSIA	GUATEMALA	INDIA	CHINA	PAKISTAN	EU27	ROW
INDONESIA	1	1,0122	1,0012	1,0701	1,0488	1,0221	1,0134	1,0307
MALAYSIA	1,0045	1	1,0012	1,0701	1,0488	1,0221	1,0134	1,0307
GUATEMALA	1,0045	1,0122	1	1,0701	1,0488	1,0221	1,0134	1,0307
INDIA	1,0045	1,0122	1,0012	1	1,0488	1,0221	1,0134	1,0307
CHINA	1,0045	1,0122	1,0012	1,0701	1	1,0221	1,0134	1,0307
PAKISTAN	1,0045	1,0122	1,0012	1,0701	1,0488	1	1,0134	1,0307
EU27	1,0045	1,0122	1,0012	1,0701	1,0488	1,0221	1	1,0307
ROW	1,0045	1,0122	1,0012	1,0701	1,0488	1,0221	1,0134	1,0307

Appendix II: Elasticities

ELASTICITIES	INDONESIA	MALAYSIA	GUATEMALA	INDIA	CHINA	PAKISTAN	EU27	ROW
composite D	-1,44	-0,98	-0,65	-0,65	-0,65	-0,65	-0,65	-0,65
substitution	3,22	3,22	3,22	3,22	3,22	3,22	3,22	3,22
supply	0,40	0,11	0,11	0,96	1,09	0,11	0,09	0,11

Appendix III: Initial and final NTMs scenario 1

Initial NTMs

	INDONESIA	MALAYSIA	GUATEMALA	INDIA	CHINA	PAKISTAN	EU27	ROW
INDONESIA	1,5	2,7	2,7	2,7	2,7	2,7	2,7	2,7
MALAYSIA	2,7	1,5	2,7	2,7	2,7	2,7	2,7	2,7
GUATEMALA	2,7	2,7	1,5	2,7	2,7	2,7	2,7	2,7
INDIA	2,7	2,7	2,7	1,5	2,7	2,7	2,7	2,7
CHINA	2,7	2,7	2,7	2,7	1,5	2,7	2,7	2,7
PAKISTAN	2,7	2,7	2,7	2,7	2,7	1,5	2,7	2,7
EU27	2,7	2,7	2,7	2,7	2,7	2,7	1,5	2,7
ROW	2,7	2,7	2,7	2,7	2,7	2,7	2,7	2,7

Final NTMs

	INDONESIA	MALAYSIA	GUATEMALA	INDIA	CHINA	PAKISTAN	EU27	ROW
INDONESIA	1,5	2,7	2,7	2,7	2,7	2,7	2,8942	2,7
MALAYSIA	2,7	1,5	2,7	2,7	2,7	2,7	2,883	2,7
GUATEMALA	2,7	2,7	1,5	2,7	2,7	2,7	2,8905	2,7
INDIA	2,7	2,7	2,7	1,5	2,7	2,7	2,8905	2,7
CHINA	2,7	2,7	2,7	2,7	1,5	2,7	2,8905	2,7
PAKISTAN	2,7	2,7	2,7	2,7	2,7	1,5	2,8905	2,7
EU27	2,7	2,7	2,7	2,7	2,7	2,7	1,5	2,7
ROW	2,7	2,7	2,7	2,7	2,7	2,7	2,8905	2,7

Appendix IV: Initial and final NTMs scenario 2

Initial NTMs

	INDONESIA	MALAYSIA	GUATEMALA	INDIA	CHINA	PAKISTAN	EU27	ROW
INDONESIA	1,5	2,7	2,7	2,7	2,7	2,7	2,7	2,7
MALAYSIA	2,7	1,5	2,7	2,7	2,7	2,7	2,7	2,7
GUATEMALA	2,7	2,7	1,5	2,7	2,7	2,7	2,7	2,7
INDIA	2,7	2,7	2,7	1,5	2,7	2,7	2,7	2,7
CHINA	2,7	2,7	2,7	2,7	1,5	2,7	2,7	2,7
PAKISTAN	2,7	2,7	2,7	2,7	2,7	1,5	2,7	2,7
EU27	2,7	2,7	2,7	2,7	2,7	2,7	1,5	2,7
ROW	2,7	2,7	2,7	2,7	2,7	2,7	2,7	2,7

Final NTMs

	INDONESIA	MALAYSIA	GUATEMALA	INDIA	CHINA	PAKISTAN	EU27	ROW
INDONESIA	1,5	2,7	2,7	2,7	2,7	2,7	2,7588	2,7
MALAYSIA	2,7	1,5	2,7	2,7	2,7	2,7	2,7576	2,7
GUATEMALA	2,7	2,7	1,5	2,7	2,7	2,7	2,7584	2,7
INDIA	2,7	2,7	2,7	1,5	2,7	2,7	2,7584	2,7
CHINA	2,7	2,7	2,7	2,7	1,5	2,7	2,7584	2,7
PAKISTAN	2,7	2,7	2,7	2,7	2,7	1,5	2,7584	2,7
EU27	2,7	2,7	2,7	2,7	2,7	2,7	1,5	2,7
ROW	2,7	2,7	2,7	2,7	2,7	2,7	2,7584	2,7

Appendix V: Detailed welfare (in Euro)

Welfare of scenario 1

	Producer Surplus	Tax Revenue	Consumer Surplus	Net Welfare
INDONESIA	-44.865.747	6	2.572	-44.863.168
MALAYSIA	-27.200.409	19.601	4.430.157	-22.750.650
GUATEMALA	-9.519.425	67	233.824	-9.285.533
INDIA	-12.319	806.224	50.627.874	51.421.778
CHINA	-24.625	333.695	29.494.935	29.804.006
PAKISTAN	-479	84.787	16.130.472	16.214.781
EU27	32.897.552	-2.760.576	-349.318.541	-319.181.564
ROW	-33.337.753	1.269.475	175.502.047	143.433.769

Welfare of scenario 2

	Producer Surplus	Tax Revenue	Consumer Surplus	Net Welfare
INDONESIA	-14.519.821	2	889	-14.518.931
MALAYSIA	-9.096.483	6.318	1.438.922	-7.651.243
GUATEMALA	-3.054.353	22	76.481	-2.977.850
INDIA	-4.016	263.199	16.636.559	16.895.742
CHINA	-8.054	108.516	9.656.335	9.756.797
PAKISTAN	-155	27.436	5.254.214	5.281.495
EU27	10.281.710	901.101	-105.694.336	-96.313.727
ROW	10.906.011	414.122	57.588.951	47.097.063

Appendix VI: Percentage change in bilateral trade

Scenario 1

	ID	MY	GT	IN	CN	PK	EU	ROW
ID	NA	1,16	1,15	0,95	0,928	0,94	-12,29	1,04
MY	2	NA	NA	1,24	1,22	1,24	-10,93	1,34
GT	NA	NA	NA	NA	NA	NA	-3,68	10,51
IN	3,67	NA	NA	NA	NA	NA	-10,23	2,99
CN	0,46	-0,06	NA	NA	NA	-0,28	-13,01	-0,18
PK	NA	-0,014	NA	NA	NA	NA	-12,96	-0,13
EU	-7,06	-7,56	-7,57	-7,76	-7,785	-7,76	0,21	-7,67
ROW	1,22	0,68	0,67	0,47	0,44	0,46	-12,35	0,56

Scenario 2

	ID	MY	GT	IN	CN	PK	EU	ROW
ID	NA	0,37	0,36	0,30	0,29	0,30	-3,93	0,331
MY	0,66	NA	NA	0,41	0,41	0,42	-3,68	0,45
GT	NA	NA	NA	NA	NA	NA	-1,12	3,21
IN	1,16	NA	NA	NA	NA	NA	-3,28	0,95
CN	0,14	-0,01	NA	NA	NA	-0,09	-4,264	-0,06
PK	NA	-0,004	NA	NA	NA	NA	-4,24	-0,04
EU	-2,28	-2,45	-2,45	-2,52	-2,53	-2,52	0,06	-2,49
ROW	0,39	0,22	0,22	0,15	0,14	0,15	-4,02	0,18

Appendix VII: Percentage change in export, import, producer price and consumer price

Scenario 1

	% change in export	% change in producer price	% change in import	% change in consumer prices
INDONESIA	-0,23	-0,58	0,53	-0,22
MALAYSIA	-0,07	-0,67	1,14	-0,57
GUATEMALA	-0,37	-3,31	0,76	-0,46
INDIA	-1,12	-1,17	0,97	-0,59
CHINA	-0,22	-0,20	1,00	-0,60
PAKISTAN	-0,02	-0,21	0,98	-0,59
EU27	0,20	2,25	-7,46	4,81
ROW	-0,05	-0,43	0,87	-0,53

Scenario 2

	% change in export	% change in producer price	% change in import	% change in consumer prices
INDONESIA	-0,07	-0,19	0,18	-0,08
MALAYSIA	-0,02	-0,22	0,37	-0,18
GUATEMALA	-0,12	-1,06	0,25	-0,15
INDIA	-0,36	-0,38	0,32	-0,19
CHINA	-0,07	-0,06	0,32	-0,20
PAKISTAN	-0,01	-0,07	0,32	-0,19
EU27	0,06	0,70	-2,41	1,49
ROW	-0,02	-0,14	0,28	-0,17

Appendix VIII: Questionnaire and responses

Questions

Bahasa Indonesia	English Translation
1. Apa skala perusahaan anda? (Kriteria EUDR: pegawai kurang dari 250 orang, net turnover (pendapatan bersih) kurang dari Rp. 950 Milyar, laporan neraca (balance sheet) kurang dari Rp. 475 Milyar. Apabila memenuhi 2 dari 3 syarat tersebut, masuk kategori " Selain Perusahaan Besar (SME) ")	1. What is the scale of your company? (EUDR criteria: fewer than 250 employees, net turnover of less than Rp. 950 billion, and balance sheet total of less than Rp. 475 billion. If two out of three criteria are met, the company falls into the category of " Other than Large Company (SME) ").
2. Dengan aturan terbaru EUDR, apabila ada permintaan ekspor produk kelapa sawit ke Eropa, apakah perusahaan anda bersedia untuk memenuhinya?	2. With the new EUDR regulation, if there is a demand for palm oil exports to Europe, is your company willing to meet it?
3. Berapa kemungkinan penambahan biaya untuk memenuhi kriteria EUDR, dibandingkan dengan total nilai ekspor?	3. What is the estimated additional cost of meeting the EUDR criteria, compared to the total export value?
4. Menurut anda, apa kriteria yang paling sulit dipenuhi pada EUDR?	4. In your opinion, which criteria are the most difficult to fulfill under the EUDR?
5. Bentuk dukungan apa yang diperlukan dari pemerintah agar perusahaan anda dapat memenuhi kriteria EUDR?	5. What type of support do you need from the government to enable your company to meet the EUDR criteria?
Saran dan masukan atas penerapan EUDR:	Suggestions and feedback on the implementation of EUDR:

Responses in Bahasa Indonesia

1	2	3	4	5	Saran dan masukan atas penerapan EUDR:
Perusahaan Besar	Ya	2%	Proof of deforestation-free origin (bukti bebas degradasi hutan)	Petunjuk dan aturan yang lebih jelas	Penerapan EUDR juga merupakan perlindungan bagi daerah perkebunan kelapa sawit
Perusahaan Besar	Ya	2%	Geo-location (GPS tracking sampai pada level bidang tanah), Due Dilligence Documentatio n (Uji tuntas dokumentasi)	Pelatihan dan Bimbingan, Petunjuk dan aturan yang lebih jelas	Menurut saya eudr sudah bagus di karnakan untuk menjaga lingkungan.
Selain Perusahaan Besar (SME)	Tidak	10%	Traceability (Keterlacakan Rantai Pasok)	Dukungan finansial/ Subsidi	harga jual yang lebih baik

Selain Perusahaan Besar (SME)	Tidak	10%	Geo-location (GPS tracking sampai pada level bidang tanah), Traceability (Keterlacakan Rantai Pasok)	Sistem Digital untuk Keterlacakan Rantai Pasok, Kerja sama dengan perusahaan yang lebih besar	kelonggaran untuk pengusaha kecil menengah
Selain Perusahaan Besar (SME)	Tidak	10%	Geo-location (GPS tracking sampai pada level bidang tanah), Traceability (Keterlacakan Rantai Pasok), Proof of deforestation-free origin (bukti bebas degradasi hutan)	Pelatihan dan Bimbingan, Sistem Digital untuk Keterlacakan Rantai Pasok, Dukungan finansial/ Subsidi, Kerja sama dengan perusahaan yang lebih besar, Petunjuk dan aturan yang lebih jelas	butuh support pemerintah
Selain Perusahaan Besar (SME)	Ya	5%	Geo-location (GPS tracking sampai pada level bidang tanah), Traceability (Keterlacakan Rantai Pasok)	Pelatihan dan Bimbingan, Dukungan finansial/ Subsidi	aturan yang lebih jelas dan lebih berpihak ke pengusaha menengah dan kecil
Perusahaan Besar	Ya	10%	Proof of deforestation-free origin (bukti bebas degradasi hutan)	Petunjuk dan aturan yang lebih jelas	Saran: <ul style="list-style-type: none"> - Tingkatkan transparansi rantai pasok dengan teknologi monitoring seperti blockchain dan satelit. - Libatkan petani dan komunitas lokal dalam verifikasi dan pelatihan praktik berkelanjutan. - Perkuat regulasi dan penegakan hukum terkait

					<p>pelanggaran EUDR.</p> <ul style="list-style-type: none"> - Dorong penggunaan bahan baku ramah lingkungan dan akses pembiayaan untuk praktik berkelanjutan. - Sosialisasikan dan edukasikan pelaku usaha dan konsumen tentang kewajiban EUDR. <p>Masukan:</p> <ul style="list-style-type: none"> - Terapkan regulasi yang kontekstual sesuai kondisi lokal agar tidak memberatkan pelaku usaha. - Fokus pada pengawasan berdasarkan tingkat risiko deforestasi di rantai pasok. - Kembangkan sistem sertifikasi terintegrasi yang mudah diakses dan diakui. - Sediakan pendampingan teknis dan finansial khususnya bagi petani dan produsen kecil.
Perusahaan Besar	Ya	10%	tidak ada	Petunjuk dan aturan yang lebih jelas	Butuh dukungan dari pemerintah.

Perusahaan Besar	Ya	10%	tidak ada	Petunjuk dan aturan yang lebih jelas	Semoga dapat dukungan dari pemerintah mengenai syarat syarat yang harus dipenuhi dalam penerapan EUDR.
Selain Perusahaan Besar (SME)	Ya	5%	Geo-location (GPS tracking sampai pada level bidang tanah)	Petunjuk dan aturan yang lebih jelas	-
Perusahaan Besar	Tidak	5%	Geo-location (GPS tracking sampai pada level bidang tanah)	Dukungan finansial/ Subsidi	Okeh
Selain Perusahaan Besar (SME)	Ya	5%	Geo-location (GPS tracking sampai pada level bidang tanah), Due Dilligence Documentatio n (Uji tuntas dokumentasi), Traceability (Keterlacakan Rantai Pasok), Proof of deforestation-free origin (bukti bebas degradasi hutan)	Sistem Digital untuk Keterlacakan Rantai Pasok, Kerja sama dengan perusahaan yang lebih besar, Petunjuk dan aturan yang lebih jelas	Agar terdapat harga premium
Perusahaan Besar	Tidak	10%	Geo-location (GPS tracking sampai pada level bidang tanah)	Pelatihan dan Bimbingan, Sistem Digital untuk Keterlacakan Rantai Pasok, Dukungan finansial/ Subsidi, Kerja sama dengan perusahaan yang lebih besar, Petunjuk dan aturan yang lebih jelas	-

Selain Perusahaan Besar (SME)	Tidak	10%	Traceability (Keterlacakan Rantai Pasok)	Sistem Digital untuk Keterlacakan Rantai Pasok, Dukungan finansial/ Subsidi, Petunjuk dan aturan yang lebih jelas	agar pemerintah dapat menyelaraskan peraturan indonesia dan eropa (EUDR)
Selain Perusahaan Besar (SME)	Tidak	10%	Geo-location (GPS tracking sampai pada level bidang tanah), Traceability (Keterlacakan Rantai Pasok)	Kerja sama dengan perusahaan yang lebih besar, Petunjuk dan aturan yang lebih jelas	tujuan baik namun perlu diperhatikan kondisi di indonesia yang beragam
Perusahaan Besar	Tidak	Tdk tahu	Tdk tahu	Petunjuk dan aturan yang lebih jelas	.
Perusahaan Besar	Tidak	5%	Due Dilligence Documentatio n (Uji tuntas dokumentasi)	Petunjuk dan aturan yang lebih jelas	Walaupun EUDR menysasar banyak komoditas dan bukan hanya sawit, namun sebagai komoditas expor non migas andalan dari Indonesia, kita perlu berinovasi secepatnya untuk memaksimalkan penggunaan produk sawit dan turunannya secara domestik dan menciptakan pangsa pasar internasional selain Uni Eropa.
Perusahaan Besar	Ya	1%	Due Dilligence Documentatio n (Uji tuntas dokumentasi), Proof of deforestation-free origin	Sistem Digital untuk Keterlacakan Rantai Pasok, Petunjuk dan aturan yang lebih jelas	Peraturan diperjelas

			(bukti bebas degradasi hutan)		
Perusahaan Besar	Ya	1%	Due Dilligence Documentatio n (Uji tuntas dokumentasi), Proof of deforestation-free origin (bukti bebas degradasi hutan)	Sistem Digital untuk Keterlacakan Rantai Pasok, Petunjuk dan aturan yang lebih jelas	Di beri bimbingan dan latihan
Selain Perusahaan Besar (SME)	Ya	5%	Geo-location (GPS tracking sampai pada level bidang tanah), Traceability (Keterlacakan Rantai Pasok)	Pelatihan dan Bimbingan, Sistem Digital untuk Keterlacakan Rantai Pasok, Dukungan finansial/ Subsidi	aturan yang bagus, namun perlu penyesuaian dengan kondisi indonesia
Selain Perusahaan Besar (SME)	Tidak	5%	Geo-location (GPS tracking sampai pada level bidang tanah), Due Dilligence Documentatio n (Uji tuntas dokumentasi), Traceability (Keterlacakan Rantai Pasok), Proof of deforestation-free origin (bukti bebas degradasi hutan)	Pelatihan dan Bimbingan, Sistem Digital untuk Keterlacakan Rantai Pasok, Dukungan finansial/ Subsidi, Kerja sama dengan perusahaan yang lebih besar, Petunjuk dan aturan yang lebih jelas	bimbingan kepada pengusaha kecil menengah

Responses in English translation

1	2	3	4	5	Suggestions and feedback on the implementatio n of EUDR:
Large Company	Yes	2%	Proof of deforestation-free origin	Clear guidance and regulatory interpretation	Implementatio n of EUDR is also a form of protection for palm oil plantation areas.

Large Company	Yes	2%	Geo-location (, Due Dilligence Documentatio n.	Training and Capacity Building, Clear guidance and regulatory interpretation	In my opinion, EUDR is good because it helps protect the environment.
SME	No	10%	Traceability	Financial assistance or subsidies	Better selling price.
SME	No	10%	Geo-location, Traceability	Digital systems for supply chain traceability, Collaboration with larger firms	Flexibility for SMEs.
SME	No	10%	Geo-location, Traceability, Proof of deforestation-free origin	Training and Capacity Building, Digital systems for supply chain traceability, Financial assistance or subsidies, Collaboration with larger firms, Clear guidance and regulatory interpretation	Government support needed
SME	Yes	5%	Geo-location, Traceability	Training and Capacity Building, Financial assistance or subsidies	Clearer regulations that are more favorable to SMEs.
Large Company	Yes	10%	Proof of deforestation-free origin	Clear guidance and regulatory interpretation	Suggestions: Improve supply chain transparency through monitoring technologies such as blockchain and satellites. Involve farmers and local communities in verification and training

					<p>on sustainable practices. Strengthen regulations and law enforcement related to EUDR violations. Promote the use of environmentally friendly raw materials and provide access to financing for sustainable practices. Conduct outreach and education for businesses and consumers on EUDR obligations.</p> <p>Feedback: Implement regulations that are contextual and aligned with local conditions so as not to burden businesses. Focus monitoring efforts based on the level of deforestation risk within the supply chain. Develop an integrated certification system that is accessible and widely recognized. Provide technical and financial</p>
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					assistance, particularly for smallholders and small producers.
Large Company	Yes	10%	Nothing	Clear guidance and regulatory interpretation	Need support from the government.
Large Company	Yes	10%	Nothing	Clear guidance and regulatory interpretation	Hopefully there will be government support regarding the requirements that must be met in the implementation of the EUDR.
SME	Yes	5%	Geo-location	Clear guidance and regulatory interpretation	-
Large Company	No	5%	Geo-location	Financial assistance or subsidies	Okay
SME	Yes	5%	Geo-location, Due Dilligence Documentatio n, Traceability, Proof of deforestation-free origin degradasi	Digital systems for supply chain traceability, Collaboration with larger firms, Clear guidance and regulatory interpretation	Premium price expectation
Large Company	No	10%	Geo-location	Training and Capacity Building, Digital systems for supply chain traceability, Financial assistance or subsidies, Collaboration with larger firms, Clear guidance and regulatory interpretation	-
SME	No	10%	Traceability	Digital systems for	Alignment of Indonesia's

				supply chain traceability, Financial assistance or subsidies, Clear guidance and regulatory interpretation	regulation with EUDR
SME	No	10%	Geo-location, Traceability	Collaboration with larger firms, Clear guidance and regulatory interpretation	The goal is good, but attention must be paid to the diverse conditions in Indonesia.
Large Company	No	don't know	don't know	Clear guidance and regulatory interpretation	.
Large Company	No	5%	Due Dilligence Documentatio n	Clear guidance and regulatory interpretation	Although the EUDR targets many commodities and not only palm oil, as a key non-oil export commodity from Indonesia, we need to innovate quickly to maximize the use of palm oil and its derivatives domestically and to create international markets beyond the European Union.
Large Company	Yes	1%	Due Dilligence Documentatio n, Proof of deforestation-free origin	Digital systems for supply chain traceability, Clear guidance and regulatory interpretation	Regulations should be clarified.
Large Company	Yes	1%	Due Dilligence Documentatio n, Proof of	Digital systems for supply chain	Provide guidance and training.

			deforestation-free origin	traceability, Clear guidance and regulatory interpretation	
SME	Yes	5%	Geo-location, Traceability	Training and Capacity Building, Digital systems for supply chain traceability, Financial assistance or subsidies	The regulation is good, but it needs to be adjusted to Indonesia's conditions.
SME	No	5%	Geo-location, Due Dilligence Documentatio n, Traceability, Proof of deforestation-free origin	Training and Capacity Building, Digital systems for supply chain traceability, Financial assistance or subsidies, Collaboration with larger firms, Clear guidance and regulatory interpretation	Guidance should be given to SMEs.

Appendix IX: Sensitivity analysis on demand, supply, and substitution elasticities

Demand elasticities

Factor	Change in Output %			Welfare Change		
	(-10%)	Original	(+10%)	(-10%)	Original	(+10%)
INDONESIA	-0,23	-0,23	-0,23	-48.746.690	-48.547.958	-48.364.762
MALAYSIA	-0,07	-0,07	-0,07	-24.589.143	-24.619,251	-24.638.868
GUATEMALA	-0,36	-0,37	-0,38	-9.783.508	-10.048.191	-10.270.460
INDIA	-1,10	-1,12	-1,14	55.781.726	55.645.253	55.514.999
CHINA	-0,23	-0,22	-0,21	32.312.891	32.251.927	32.191.166
PAKISTAN	-0,03	-0,02	-0,02	17.602.796	17.546.565	17.493.754
EU27	0,21	0,20	0,19	-346.709.808	-345.397.212	-344.288.307
ROW	-0,05	-0,05	-0,05	156.047.759	155.214.553	154.472.745

Substitution elasticities

Factor	Change in Output %			Welfare Change		
	(-10%)	Original	(+10%)	(-10%)	Original	(+10%)
INDONESIA	-0,23	-0,23	-0,24	-47.493.606	-48.547.958	-49.447.836
MALAYSIA	-0,07	-0,07	-0,07	-24.656.546	-24.619.251	-24.587.509
GUATEMALA	-0,39	-0,37	-0,35	-10.681.933	-10.048.191	-9.499.834
INDIA	-1,14	-1,12	-1,10	54.658.343	55.645.253	56.491.979
CHINA	-0,18	-0,22	-0,25	31.721.692	32.251.927	32.704.333
PAKISTAN	-0,02	-0,02	-0,03	17.206.552	17.546.565	17.836.763
EU27	0,17	0,20	0,22	-341.196.040	-345.397.212	-349.052.406
ROW	-0,05	-0,05	-0,05	151.830.749	155.214.553	158.138.538

Supply elasticities

SA Supply	Change in Output %			Welfare Change		
	(-10%)	Original	(+10%)	(-10%)	Original	(+10%)
INDONESIA	-0,21	-0,23	-0,25	-49.335.362	-48.547.958	-47.784.688
MALAYSIA	-0,07	-0,07	-0,08	-24.757.261	-24.619.251	-24.483.735
GUATEMALA	-0,34	-0,37	-0,40	-10.083.157	-10.048.191	-10.013.581
INDIA	-1,03	-1,12	-1,20	56.326.255	55.645.253	54.983.446
CHINA	-0,20	-0,22	-0,23	32.692.386	32.251.927	31.824.300
PAKISTAN	-0,02	-0,02	-0,03	17.809.781	17.546.565	17.291.209
EU27	0,18	0,20	0,22	-345.037.248	-345.397.212	-345.746.448
ROW	-0,04	-0,05	-0,05	156.844.320	155.214.553	153.628.044