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Abstract

This paper assesses Indonesia's strategy of downstreaming crude palm oil (CPO) into biodiesel, with a focus on higher blending mandates (B50 and above) and their implications for energy security, macroeconomic stability, and sustainability. We combine CPO and biodiesel material balance sheets with trade and subsidy accounting to quantify diesel import savings, foregone CPO export earnings, and fiscal needs under alternative blending scenarios. These sectoral results are then integrated into a 207-sector, multiregional computable general equilibrium (CGE) model for Indonesia, calibrated using national and interregional input–output tables, as well as empirically derived shocks for diesel and biodiesel output under B50, B60, and B70. The findings show that while biodiesel blending clearly reduces dependence on imported diesel and supports the government's renewable energy and downstreaming objectives at moderate blend levels, higher mandates generate increasing macroeconomic and fiscal costs. For B50–B70, foregone CPO export revenues systematically exceed diesel import savings, the current account deficit widens, real GDP and household consumption fall, and GRDP declines in all major palm oil–producing provinces. Subsidy requirements rise sharply as biodiesel remains structurally more expensive than diesel. Additionally, the potential land-use change from forest and peat conversion to source feedstock could undermine the net emission benefits of higher blends, raising sustainability concerns. Overall, the results suggest that any move beyond B50 should be conditional on demonstrable improvements in CPO productivity, feedstock diversification, financing architecture, and land-use governance.

Keywords: Biodiesel policy, crude palm oil, downstreaming.
JEL Classifications: C68, F41, Q18. Q42, Q43.

1. Introduction

1.1 Background

Indonesia's energy landscape remains dominated by fossil fuels, exposing the economy to significant structural vulnerabilities. As of 2024, the country's primary energy supply mix is composed of coal, crude oil and petroleum products, and natural gas, while renewable energy contributes only a relatively small share **(see Appendix 1)**. This composition leaves Indonesia highly vulnerable to fluctuations in global energy prices and geopolitical shocks in the international oil and gas markets. In response, the government has set ambitious targets to increase the share of renewable energy to around 19 to 21 percent by 2030 and further to about 70 to 72 percent by 2060 (IEEFA, 2024; IESR, 2024), making the energy transition a central pillar of long-term development policy. Within this broader transition, liquid biofuels, particularly biodiesel, are promoted as a practical bridge fuel that can be blended with conventional diesel using existing infrastructure.

At the macroeconomic level, Indonesia's dependence on imported crude oil and refined petroleum products has had persistent consequences. Oil import bills contribute to a structural trade deficit in the oil and gas sector and put pressure on the current account, thereby increasing the country's exposure to external financing risks and exchange rate volatility (Yang et al., 2022). Reducing this dependence is therefore not only an energy policy objective but also a macroeconomic and financial priority. Biodiesel produced domestically from crude palm oil is expected to serve as an import substitution instrument, reducing diesel imports, improving the trade balance, and alleviating the fiscal burden associated with fuel subsidies and price stabilization measures.

Biodiesel is also closely linked to Indonesia's industrial and trade strategy. Global trade has become more protectionist, with higher tariffs and stricter non-tariff barriers that limit market access for commodity exporters. For a country that is one of the world's largest producers of palm oil, continuing to rely on exports of raw crude palm oil leaves national income vulnerable to external policy shifts and to the capture of value in processing activities abroad. Downstreaming, understood as the shift from exporting raw crude palm oil to producing higher-value energy products such as biodiesel for the domestic market and potentially for export, offers a way to internalize more value added, deepen industrial capabilities, and support rural livelihoods that depend on the palm oil sector.

Viewed from the perspective of national development priorities, biodiesel development operates as a concrete policy instrument that helps translate the broad aspirations of Asta Cita into measurable outcomes. Asta Cita 2 calls for the acceleration of national self-reliance in food, energy, and water. Biodiesel contributes to this agenda by reducing dependence on imported fossil fuels, strengthening the resilience of the national energy mix, and utilizing domestic natural resources more strategically. Furthermore, Asta Cita 5 emphasizes the continuation of downstreaming and industrialization to increase domestic value-added. The palm oil-based biodiesel program directly advances this objective by shifting economic activity from the export of raw commodities to processing, blending, distribution, and supporting services that occur within Indonesia. In other words, biodiesel sits at the intersection of energy self-sufficiency and structural transformation. It creates a collaborative space where the goals of Asta Cita 2 and Asta Cita 5 reinforce one another.

Against this background, Indonesia has progressively increased its biodiesel blending mandates from lower blends toward B50 and higher, with the explicit objective of strengthening national energy self-sufficiency. However, the overall implications of this downstreaming strategy for the national economy remain contested. Higher blends can reduce fossil fuel imports and better utilize domestic commodity advantages, but they may also impact food prices, land use, fiscal risks, and export performance in complex ways. This research, therefore, assesses Indonesia's downstreaming of crude palm oil into biodiesel, with a focus on B50 and above, to examine how current implementation supports the goal of national energy self-sufficiency and its broader impacts on growth, trade, and macroeconomic stability. In doing so, the study aims to provide evidence-based insights for policymakers as they refine biodiesel blending strategies within the country's long-term development agenda and in alignment with the broader priorities outlined in Asta Cita 2 and Asta Cita 5.

1.2 Research Questions

1. How is Indonesia's current palm oil downstreaming into biodiesel implemented, and to what extent does it contribute to national energy self-sufficiency and affect the national economy?
2. What are the key potentials and main challenges in developing palm oil downstreaming towards B50 and higher biodiesel blends in Indonesia?
3. What policy measures are needed to overcome the barriers to biodiesel downstreaming development, particularly for B50 and higher blends?

1.3 Research Objectives

1. Analyzing the Current State of Palm Oil Downstreaming (Biodiesel) Implementation to Support National Energy Self-Sufficiency and Its Impact on the National Economy.
2. Identifying the Potential and Challenges in Developing Downstreaming Toward B50 & Higher Biodiesel.
3. Formulating Policy Recommendations to Overcome Biodiesel Downstreaming Barriers, Including Investment/Financing Strategies.

2. Literature Review

Across many economies, biodiesel blending mandates have become a crucial instrument for reducing dependence on imported fossil fuels, supporting rural producers, and lowering emissions. In most cases, however, mandated blend levels such as B5, B10, or B20 remain relatively modest, and only a few countries have moved beyond B30 **(see Appendix 2)**. Recent reviews of the international biodiesel industry indicate that Indonesia is unique in having already implemented a nationwide B35 mandate, thereby leading the world in the share of biodiesel in its standard diesel blend (Sahara et al., 2022; Wirawan et al., 2024). This trajectory builds on a sequence of earlier mandates that raised the blend stepwise from B15 and B20 to B30, and it is now being extended through trials and preparatory work for B40 and eventually B50. Ahmad et al. (2025) demonstrate that the B35 program has already made a substantial contribution to Indonesia's renewable energy target and generated sizable savings in the fuel import bill, while also identifying technical and institutional challenges for further increases in the blend rate. These developments are embedded in a broader downstreaming strategy, in which crude palm oil is increasingly processed domestically into biodiesel and other higher-value-added products. Dynamic computable general equilibrium simulations indicate that such downstream industries can stimulate growth, investment, and exports. However, they also absorb a larger share of domestic crude palm oil, which may tighten supplies of cooking oil and exportable raw materials (Judijanto, 2025).

The rapid expansion of palm oil biodiesel thus has far-reaching implications for Indonesia's energy system and for the broader economy. Using a national computable general equilibrium model, Sahara et al. (2022) find that fulfilling the B30 mandate improves macroeconomic indicators, raises household incomes, including in rural regions, and reduces reliance on imported diesel, thereby supporting energy security and regional development goals. At the same time, both macroeconomic and system dynamics studies warn that higher biodiesel mandates can intensify the competition between food and fuel uses of crude palm oil, especially when combined with export restrictions and domestic market obligations; these studies highlight emerging risks for domestic cooking oil availability and price stability as more feedstock is locked into the energy sector (Hidayatno et al., 2025; Rifin et al., 2020).

3. Data & Methodology

3.1 Data

This study combines several complementary data sources to capture both the palm oil–biodiesel system and its wider economic linkages in Indonesia **(see Appendix 3)**. Data on domestic crude palm oil and biodiesel use are compiled from APROBI, GAPKI, and the Ministry of Energy and Mineral Resources (ESDM). Detailed fuel consumption by type, including diesel and biodiesel, is sourced from ESDM and the downstream oil and gas regulator, BPH Migas. Trade performance is measured using export volumes and values from GAPKI and commercial databases such as CEIC, complemented by international crude palm oil spot prices from Bloomberg and domestic diesel and biodiesel price series from CEIC to represent relevant market signals. Information on biodiesel-related subsidies is drawn from the Palm Oil Fund Management Agency (BPDP), which provides an estimate of the fiscal cost of the program. To link these sectoral trends with the broader economy, the analysis utilizes the national input-output and interregional input-output tables published by Statistics Indonesia (BPS), which describe how sectors purchase inputs from and sell outputs to each other across regions. These tables serve as the central database for computable general equilibrium simulations that analyze the impact of higher biodiesel blending scenarios, including B50 and above, on production, income, trade, and regional spillovers. In contrast, the time series on production, consumption, prices, trade, and subsidies are used to calibrate the baseline, validate the model, and design the policy experiments.

As part of the supporting methodology, this study complements the quantitative modelling with qualitative evidence from Focus Group Discussions (FGD) and a field survey. The FGDs involved key stakeholders along the biodiesel value chain and policy process, including PT Pertamina Patra Niaga, the Ministry of Energy and Mineral Resources (ESDM), LPEM FEB UI, the National Research and Innovation Agency (BRIN), the Palm Oil Plantation Fund Management Agency (BPDPKS), the biodiesel producers' association APROBI, and the economic think tank INDEF. These institutions provided information on distribution networks, regulatory frameworks, financing arrangements, technological feasibility, production capacity, and macroeconomic implications of higher blending mandates. In addition, a field survey at the Balongan Fuel Terminal (FT Balongan) was conducted to obtain first-hand observations on biodiesel handling, blending procedures, storage management, and distribution flows. Insights from the FGDs and the field survey were used to validate key assumptions in the model and to ensure that the simulations reflect realistic supply chain capacity, operational constraints, and implementation challenges associated with scaling up biodiesel blending in Indonesia.

3.2 Methodology

3.2.1 Impact Assesment: Trade Balance & Subsidy

The empirical analysis begins with the construction of two linked material balance sheets, one for crude palm oil (CPO) and one for biodiesel, in order to trace how palm oil resources are allocated across competing uses under higher blending mandates such as B50 **(see Appendix 4).** The CPO balance sheet records, for each year, the opening stock, domestic production, and imports on the supply side, and then allocates this availability to exports, non-biofuel domestic uses, CPO for biodiesel, and closing stocks. Production is projected from plantation area and yield information, while domestic use is calibrated to observed trends and adjusted to reflect alternative biodiesel blending targets. The biodiesel balance sheet then tracks how CPO intended for energy is converted into Fatty Acid Methyl Ester (FAME), combined with fossil diesel according to the mandated blending ratio, and distributed between domestic biodiesel consumption and potential exports, with corresponding changes in biodiesel stocks. By iterating these two balance sheets under different policy scenarios, the study can assess whether future B50 and higher mandates are compatible with projected CPO availability, identify possible pressure points such as tight stocks or reduced export volumes, and generate consistent volume inputs for subsequent macroeconomic and energy security simulations.

In assessing the impact of higher biodiesel blending on the trade balance, the paper focuses on two key channels: diesel import savings and the potential loss of crude palm oil export revenue. Diesel import saving is defined as the reduction in the value of diesel imports that occurs when part of domestic fuel demand is met by locally produced biodiesel instead of imported diesel. The benchmark, or business-as-usual case without a biodiesel policy, is the total value of diesel that would have been imported, calculated as the international diesel price per kilolitre multiplied by the imported volume of diesel and converted into rupiah using the IDR/USD exchange rate. Under the biodiesel scenario, the model calculates the value of diesel that remains necessary, given domestic biodiesel consumption (from the biodiesel balance sheet), using the same price and exchange rate. Diesel import saving is then the difference between the benchmark import bill and this reduced import bill.

At the same time, diverting domestic CPO into biodiesel production implies a foregone opportunity to export that CPO. The CPO export potential loss is therefore calculated as the quantity of domestic CPO allocated to biodiesel (from the CPO balance sheet) multiplied by the international CPO price per ton and the IDR/USD exchange rate, yielding a rupiah value that represents the export earnings that would have been obtained in the absence of the biodiesel program. The net effect on the external position, proxied by the current account deficit, is measured as diesel import saving minus CPO export potential loss. A positive result indicates that the reduction in diesel imports more than compensates for the foregone CPO export revenue, thereby improving the current account balance. In contrast, a negative result would imply that the opportunity cost of lost CPO exports outweighs the gains from lower diesel imports.

The fiscal implications of higher blending mandates are assessed by estimating the subsidy requirement associated with biodiesel production under each scenario BXX. In this framework, the total subsidy cost is calculated as the product of the government subsidy per liter of biodiesel and the projected biodiesel production volume consistent with a given blend level, expressed as Subsidy Cost (BXX) = Subsidy per Liter × Biodiesel Production Volume (BXX). The subsidy per liter reflects the unit support needed to bridge the gap between biodiesel production costs and the reference fuel price. In contrast, the production volume captures the total quantity of biodiesel required to satisfy domestic blending mandates in each scenario. This transparent but straightforward formulation allows the analysis to compare how moving from lower to higher blends (for example, from B30 to B50, B60, or B70) scales up the budgetary burden of subsidies and to relate these fiscal costs to the corresponding gains in energy security and trade balance.

3.2.1 Computable General Equilibrium (CGE) Modeling

An Indonesian computable general equilibrium (CGE) model was employed to evaluate the macroeconomic and microeconomic impacts of the B50 biodiesel mandate. The model combines key features of ORANI (Horridge et al., 1999) and the Indonesian variant, WAYANG (Wittwer, 1999). WAYANG extends ORANI by incorporating regional disaggregation. The integrated model captures the economic linkages among industries, households, investors, the government, and external sectors, and is organized into 18 functional blocks, including those for production, intermediate demand, institutions, and trade, to facilitate regional analysis of the B50 policy **(see Appendix 5)**.

Within this structure, particular attention is given to the intermediate input block, since the biodiesel mandate modifies input demand in sectors such as oil refining and basic chemicals. The model is calibrated to a highly disaggregated 207-sector database, in which biodiesel is specified as a distinct industry and commodity, allowing for a more detailed tracing of input substitution between crude palm oil–based biodiesel and conventional petroleum products. Production is modeled following a multistage technology in which one industry can supply multiple commodities, utilizing both intermediate and primary inputs. Labor and capital are sourced domestically and from abroad, while land is supplied domestically. A constant elasticity of substitution specification is applied to represent input–output separability.

In contrast, Leontief technology with fixed input proportions is assumed at the composite level for intermediate inputs, primary factors, and other costs. Agents are assumed to be price takers and to choose cost-minimizing input combinations consistent with a given technology, so that the production function F(input, output) = 0 and X1TOT = G(input) = H(output) describes industry-level activity **(see Appendix 6)**. Under these assumptions, input ratios and prices determine the expenditure shares for each factor and commodity, which in turn define industry output and the resulting economic responses to the B50 mandate.

The production structure, which generates the output of each industry, is specified as a multistage process driven by intermediate activities at the industry level, consistent with Deaton, (1981). At the composite level of commodities, primary factors, and other costs, output is determined using a Leontief production function, represented by fixed input ratios. These input ratios, together with relative input prices, determine industry-level expenditure shares and thus characterize the production function. In this framework, ($X1TOT_i$) denotes total activity in industry (i), ($A1TOT_i$) captures technical change in input use in industry (i), ($X1_{ci\_s}$) represents the composite (domestic and imported) demand for commodity (c) in industry (i), and ($A1_{ci\_s}$) reflects technical change in this composite demand. Furthermore, ($X1PRIM_i$) is the composite of primary factor inputs, with ($A1PRIM_i$) indicating technical change in primary factors, while ($X1OCT_i$) is the demand for other costs in industry (i) and ($A1OCT_i$) denotes the associated technical change; IND refers to the industry set.

$$X1TOT_i = \frac{1}{A1TOT_i}\left\{ \underset{c \in COM}{MIN}\left(\frac{X1_{ci\_s}}{A1_{ci\_s}}\right), \frac{X1PRIM_i}{A1PRIM_i}, \frac{X1OCT_i}{A1OCT_i} \right\} i \in IND,$$

The CGE model encompasses all 34 Indonesian provinces, employing a top-down, multiregional approach, as outlined by Oktaviani (2008, 2011). The key feature of this specification is the regional extension equation, which enables national-level results to be translated into regional outcomes, thereby reflecting policy linkages between national and provincial performance in the model. After the national CGE structure is completed, Interregional Input Output (IRIO) data are applied to disaggregate the system into provincial components.

Key behavioral parameters of the model, including Armington elasticities, elasticities of primary inputs and labor, expenditure elasticities, and export demand elasticities, are summarized in **Appendix 7.** The table shows that Armington, labor, and export demand elasticities are specified identically across sectors. This uniformity is acknowledged as a limitation of the analysis, since it restricts the model's ability to capture sector-specific behavioral responses.

In the policy simulation, higher biodiesel blending mandates are represented as simultaneous output shocks to the fossil diesel and biodiesel sectors. For each scenario, the model assumes that a portion of the diesel fuel supply is replaced by biodiesel, while maintaining the overall energy service to the economy. The size of the shocks is not chosen arbitrarily. However, it is derived from a SARIMA forecast of average diesel and biodiesel output, estimated using monthly data for 2021m1–2025m8 and then projected for 2025m9–2028m12 under alternative blending scenarios with B30 as the baseline. Under the B50 scenario, the SARIMA results indicate that the forecasted diesel output under B50 is approximately 38 percent lower than under B30, while the forecasted biodiesel output is about 27 percent higher. Consequently, the model applies a 38 percent reduction to diesel and a 27 percent increase to biodiesel. Moving to B60, the forecast difference relative to B30 corresponds to a 46 percent decline in diesel and a 33 percent increase in biodiesel. For B70, the gaps widen to 55 percent and 39 percent, respectively. These empirically calibrated shocks provide a consistent method for tracking how progressively higher blending mandates reallocate production between energy subsectors and, in turn, affect the broader economy and Indonesia's progress toward energy self-sufficiency.

4. Result & Findings

4.1 The Current State of CPO Downstreaming

Indonesia's palm oil industry is organized around a highly diversified production tree, in which crude palm oil (CPO) is converted into a variety of downstream products **(see Appendix 8)** (Dermoredjo et al., 2025; Puspitawati et al., 2024). Instead of serving a single market, CPO acts as a platform chemical: a fundamental input that can be processed into cooking oil, oleochemicals (such as soaps and surfactants), specialty fats, and, increasingly, biodiesel (Rachman et al., 2024). In the Indonesian context, this multi-product characteristic of CPO means that any policy promoting higher biodiesel blends (like B50 and beyond) inevitably interacts with other crucial value chains, particularly those related to food security and consumer goods. The production tree illustrates that biodiesel is primarily derived from olein, a key derivative of CPO that serves as the main ingredient for household cooking oil. This structural overlap creates direct competition for feedstock between energy and food applications, which could have significant implications for cooking oil availability, price stability, and broader welfare outcomes if the allocation of feedstock is not managed carefully (Gultom et al., 2024; Hidayatno et al., 2025).

Simultaneously, the production tree illustrates that crude palm oil (CPO) is not exclusively downstreamed into biodiesel through a single pathway. In addition to the primary olein route, there are alternative pathways that utilize by-products of CPO refining, such as Palm Fatty Acid Distillate (PFAD), as potential feedstocks for biodiesel. However, the diagram distinguishes between segments that are "already in production," "in the construction phase," and "not in production." This differentiation is analytically significant, as it indicates that, in practice, Indonesia's biodiesel program continues to rely predominantly on the main CPO–olein–biodiesel chain (De Vos et al., 2021). Meanwhile, various potential by-product-based or technologically advanced routes remain underdeveloped or not yet commercially viable. Under these circumstances, any rapid expansion of biodiesel will, ceteris paribus, divert more CPO from food-related applications, since alternative feedstock sources are not yet available at scale (Khatiwada et al., 2021). In other words, as long as the "not in production" pathways remain inactive, increasing CPO allocation to biodiesel will inevitably diminish the volume of CPO available for cooking oil and other food products. Therefore, Indonesia's initiative to implement higher biodiesel blends must be assessed not only in terms of its impact on energy self-sufficiency but also considering the inherent trade-off it poses between energy policy goals and the stability of the domestic food supply within the broader CPO value chain.

The CPO and biodiesel balance sheets show clearly how Indonesia's downstreaming policy reallocates a fixed CPO supply **(see Appendix 9)**. National CPO availability primarily comes from domestic production, with a small portion from opening stocks and imports. On the demand side, more than half of this CPO is exported, while a large share is used in the domestic biodiesel industry. Another significant portion is used in domestic non-biodiesel applications, such as food processing and oleochemicals, with the remainder held as closing stocks. This structure means that CPO for biodiesel already absorbs a sizeable part of national output, so any additional CPO sent into the biodiesel chain automatically reduces the volume that can be exported, used for cooking oil and other products, or kept as inventory (Hidayatno et al., 2025; Rachman et al., 2024).

The biodiesel balance sheet then translates these CPO flows into fuel supply. The CPO allocated to biodiesel is converted into biodiesel that is primarily consumed in the domestic market, supporting the current B35 blending mandate, where biodiesel (FAME) is blended with diesel in the transport fuel pool. If Indonesia raises the mandate toward B50 and above, biodiesel production must increase unless diesel use falls, which in turn requires even more CPO. Unless CPO production capacity or alternative non-food feedstocks expand simultaneously, higher blending mandates will intensify competition between the energy and food uses of CPO, potentially placing additional pressure on both the trade balance and domestic price stability for basic goods such as cooking oil (Dermoredjo et al., 2025).

4.2 Biodiesel Consumption, Blending Mandates, and its Implications

The time series clearly shows a substitution relationship between CPO used for biodiesel and CPO exports **(see Appendix 10)**. After the strengthening of the B35 and B40 mandates, domestic CPO absorption for biodiesel follows a consistent upward trend, while export volumes move downward with high volatility. The negative correlation coefficient between the two lines indicates that increases in CPO allocation to biodiesel are typically accompanied by declines in CPO exports (Halimatussadiah et al., 2021). This pattern provides concrete evidence of a policy trade off in which expanding biodiesel blending to support domestic energy security reduces the CPO available for export and therefore limits Indonesia's potential export earnings from this commodity (Khatiwada et al., 2021; Rachman et al., 2024).

The utilisation chart indicates that Indonesia's palm oil sector is being asked to support an increasingly ambitious biodiesel agenda without a commensurate expansion in its resource base **(see Appendix 11)**. The plantation area and aggregate CPO output have been broadly stable; however, the share of CPO allocated to biodiesel rises sharply across the B35, B40, and projected B50 scenarios. Under a constant productivity assumption, biodiesel's share is expected to climb from roughly one-fifth to more than one-third of total CPO use, while the export share falls from around three-fifths to well below two-fifths (Ardana et al., 2022; Hidayatno et al., 2025; Sari et al., 2021). In other words, higher blending mandates are being met not by new supply, but by reallocating a fixed volume of CPO away from exports and, at the margin, from food and oleochemical uses (Sahara et al., 2022).

From a policy perspective, this trajectory raises several critical concerns. First, the assumption of constant productivity is strong; if yields or output underperform, the pressure on exports and domestic non-energy uses will be even more acute, amplifying risks to the trade balance and foreign exchange earnings (Khatiwada et al., 2021). Second, a strategy that locks in ever larger volumes of CPO for biodiesel may improve measured energy self-sufficiency, but it also concentrates exposure on a single commodity and may crowd out higher value downstream activities outside the fuel segment (Das & Gundimeda, 2022). Finally, the reallocation implied by a move toward B50 increases the likelihood that shocks to CPO supply or world prices will be transmitted more quickly into domestic food markets and external accounts, suggesting that biodiesel expansion needs to be carefully sequenced with productivity gains, diversification of feedstocks, and safeguards for food- and export-oriented industries (Syaftiani et al., 2025).

4.3 Market Index Price of Diesel Fuel (HIP Solar) vs Market Index Price of Biodiesel Fuel (HIP Biodiesel)

The price series for the market index price of biodiesel and diesel reveals a persistent and sizeable gap, with biodiesel almost always priced above diesel **(see Appendix 12)**. This spread is not a trivial detail, because it is precisely what creates the incentive cost that must be financed through the biodiesel fund managed by BPDPKS in order to keep biodiesel competitive in the retail fuel mix (Halimatussadiah et al., 2021). At the same time, diverting CPO from export to biodiesel reduces potential foreign exchange earnings, while the benefit on the external side comes only from lower diesel import needs. When the value of foregone CPO exports exceeds the value of diesel import savings, the policy generates a net foreign exchange deficit rather than a gain, thereby achieving energy security objectives at the cost of weaker external accounts and higher implicit subsidies (Dermoredjo et al., 2025).

As the mandate shifts from B30 to B35 and toward B40, this problem becomes more acute because the quantity of biodiesel required continues to rise, while the price gap between biodiesel and diesel shows no signs of closing. The result is an expanding deficit gap that must be covered by ever larger transfers from BPDPKS, turning what was initially a manageable support scheme into a growing fiscal and balance of payments risk (Halimatussadiah et al., 2021). If this trajectory continues, the biodiesel program could place persistent pressure on the Rupiah and force tighter macroeconomic policies to offset the external side effects of the blending mandate. This evidence suggests that future biodiesel expansion needs to be closely tied to improvements in cost competitiveness, diversification of feedstocks, and safeguards for external stability, rather than assuming that higher blends can be scaled up indefinitely under the current pricing and incentive structure (Das & Gundimeda, 2022).

4.4 Is Indonesia Saving or Sacrificing in Its Biodiesel Strategy?

The comparison between diesel import savings and potential CPO export losses reveals that Indonesia's biodiesel strategy currently generates a systematic foreign exchange deficit rather than a gain **(see Appendix 13).** Across the B30 and B35 periods and into the forecasted B40 phase, the red bars representing export losses are consistently higher than the blue bars representing import savings, and the shaded area between the two series grows over time. This pattern means that every additional rupiah saved from reduced diesel imports is more than offset by the export earnings that Indonesia forgoes when CPO is diverted from international markets into domestic biodiesel (Dermoredjo et al., 2025). In aggregate, the policy improves a narrow energy indicator, namely lower dependence on imported diesel, but worsens the broader external position by eroding the goods trade balance (Halimatussadiah et al., 2021).

A more critical reading of this evidence suggests that the escalation of the mandate from B30 to B35 and toward B40 has been driven more by energy security and political objectives than by a careful assessment of net macroeconomic benefits (Hidayatno et al., 2025). The chart shows that as the mandate rises, the deficit gap widens rather than stabilises, which implies that proportionate gains from import substitution do not match the additional domestic absorption of CPO for biodiesel. Put differently, the economy is increasingly paying more in lost export opportunities than it saves in lower fuel imports (Khatiwada et al., 2018). This raises questions about the opportunity cost of locking a growing share of CPO into subsidized energy use, primarily when the same commodity could support higher-value-added downstream industries or generate much-needed foreign exchange in periods of external stress (Rachman et al., 2024).

The deficit gap is also highly sensitive to international commodity price movements, which adds another layer of risk. When CPO prices are high relative to crude oil, the opportunity cost of diverting CPO from export markets rises sharply, and the red bars in the chart move further above the blue bars (Halimatussadiah et al., 2021; Gultom et al., 2024). In those episodes, the biodiesel program effectively amplifies external vulnerability: it commits Indonesia to an inflexible domestic use of a commodity whose export value is temporarily desirable, while the savings on imported diesel do not increase at the same pace. Unless future policy design explicitly accounts for this price sensitivity, for example, through more flexible blending rules or more substantial cost competitiveness of biodiesel, the current trajectory risks turning an energy diversification initiative into a structural drag on the balance of payments and a potential source of pressure on Rupiah exchange rate stability (Gultom et al., 2024).

4.4 B50, B60, B70… But At What Macroeconomic Cost?

The simulation results in **Appendix 14** indicate that Indonesia's biodiesel roadmap carries a persistent and rising macroeconomic cost. In all three policy scenarios, the additional current account deficit resulting from the biodiesel trade-off between foregone CPO export earnings and diesel import savings is positive and increasing over time (Dermoredjo et al., 2025). Even in the most conservative configuration, where the blending mandate is maintained at B50, the simulated deficit increases steadily in absolute terms and as a percentage of GDP **(see Appendix 15)**. This pattern suggests that the biodiesel policy behaves not as a one-time adjustment, but as a structural source of pressure on the external account that must be financed continuously through higher net capital inflows or a gradual drawdown of foreign reserves.

The comparison across scenarios further highlights the increasing marginal cost of more ambitious blending targets. Both the gradual and the ambitious paths, which move from B50 towards B60 and B70, generate larger additional current account deficits than the fixed B50 scenario, and the gap between them widens over time (Halimatussadiah et al., 2021; Hidayatno et al., 2025). From an economic perspective, this means that each incremental increase in the mandate yields diminishing gains in energy import substitution while requiring a disproportionately larger sacrifice of CPO export revenue. In an environment of uncertain global financial conditions, a policy configuration that mechanically expands the current account deficit is likely to increase Indonesia's risk premium, erode investor confidence, and heighten the vulnerability of the exchange rate to external shocks (Gultom et al., 2024).

Taken together, these findings indicate that the present biodiesel trajectory is not fully aligned with the objective of external stability. The simulations implicitly assume that the rest of the economy can absorb a growing current account gap without significant adjustment costs, an assumption that is unlikely to hold in practice (Sahara et al., 2022). A more prudent strategy would treat higher blending ratios as conditional targets and link any future move beyond B50 to demonstrable improvements in CPO productivity, diversification of biodiesel feedstocks, and stronger performance in non-CPO export sectors (Ardana et al., 2022; Das & Gundimeda, 2022; Islamiya et al., 2022). Absent such offsets, further escalation of the mandate risks transforming a policy aimed at energy security into a lasting source of current account weakness and macroeconomic fragility.

4.5 Quantifying the Impact of Palm Oil Downstreaming Policies (CGE Approach)

Macroeconomic Impacts of Increasing Biodiesel Blending (B50-B70)

The CGE simulations indicate that higher biodiesel blending ratios systematically weaken Indonesia's macroeconomic performance. For all three scenarios (B50, B60, and B70), real GDP from the expenditure side falls below the baseline, and the decline becomes larger at higher blend levels **(see Appendix 16)**. This suggests that reallocating CPO and capital into FAME production does not simply reorient growth; it reduces it. Resources are diverted from more competitive tradable sectors into a relatively protected biofuel sector, whose expansion is driven by regulation and subsidies rather than underlying productivity. In macroeconomic terms, the biodiesel mandate behaves as a negative supply shock, lowering potential output rather than supporting long-run growth, a finding that contrasts with some previous studies which assumed higher investment elasticity (Puspitawati et al., 2025; Sahara et al., 2022; Nkolo et al., 2018).

Household welfare tends to move in the same direction. Real household consumption contracts in every scenario, with the largest decline under B70, which reflects the combined impact of higher food prices, higher energy prices, and weaker labor income (Hidayatno et al., 2025). These effects are likely to be regressive, since poorer households allocate a larger share of their budget to basic food and transport. At the external margin, export volumes remain below baseline while imports rise sharply, particularly for machinery, intermediate inputs, and complementary fuels (Halimatussadiah et al., 2021). The policy, therefore, incurs a double cost: it reduces domestic welfare while simultaneously worsening the trade balance and current account (Dermoredjo et al., 2025).

Industrial Impacts of FAME Blending Policy (B50) (CGE, 207 Sectors)

The sectoral CGE results for the B50 scenario point to a non-trivial reallocation of resources within the palm oil complex and the broader energy system **(see Appendix 17)**. Output of animal and vegetable oils, which includes processed palm oil for food and industrial uses, contracts by about 0.11 percent. On paper, this decline appears modest, but in a large, staple sector, such a change represents a sizeable diversion of feedstock away from edible and industrial applications toward fuel (Rachman et al., 2024; Sahara et al., 2022). The same pattern is visible, although in smaller magnitudes, in oleochemical sectors such as soap and cosmetics, which experience slight output contractions as they compete with FAME for palm-based fatty acids and alcohols. From a structural perspective, the policy is therefore not simply "adding" a new use for palm oil; it is crowding out part of the existing non-energy downstreaming that tends to generate higher value-added and more diversified export opportunities than bulk biofuel production (Islamiya et al., 2022; Gultom et al., 2024).

By contrast, the simulated impacts on fossil fuel competitors are huge. The output of gasoline, diesel, kerosene, LPG, fuel oil, and LNG falls by around 9.7 percent, indicating a strong substitution effect of biodiesel on conventional fuels (Sahara et al., 2022; Harsono & Subronto, 2013). At first glance, this validates one of the central policy objectives, namely reducing dependence on fossil energy. However, the magnitude of this contraction also underscores the scale of the adjustment being imposed on the petroleum complex, with potential implications for state-owned oil company revenues, fuel tax bases and the financing of energy infrastructure. Since the model results simultaneously show only small gains on the non-energy palm-oil side and sizeable losses in fossil fuel sectors, the B50 blending policy looks less like a balanced structural transformation and more like a forced reallocation from relatively productive and fiscally important industries to a protected biofuel activity whose competitiveness relies on mandates and subsidies (Halimatussadiah et al., 2021). From an industrial policy standpoint, this raises doubts about whether the current form of biodiesel-led downstreaming is the most efficient way to leverage Indonesia's palm oil endowment.

Policy Effects on Leading Palm Oil Provinces (CGE Model)

The CGE results for the B50 blending scenario indicate that biodiesel-driven downstreaming imposes clear output costs on the very regions that supply the feedstock. All ten leading palm oil-producing provinces recorded a decline in GRDP relative to the baseline, with the sharpest contractions in East Kalimantan, Central Kalimantan, and South Sumatra **(see Appendix 18)**. These provinces rely heavily on crude palm oil exports as a driver of local economic activity in agriculture, transportation, trade, and services. When a larger share of crude palm oil is redirected from export markets to domestic biodiesel production, export receipts and associated multiplier effects decline. In contrast, the new demand for biodiesel is mediated through a regulated, subsidy-dependent value chain that does not generate the same spillovers for local economies. In economic terms, the policy weakens the tradable base of these provinces. It replaces it with a narrower, policy-driven market, so regional growth becomes more dependent on central fiscal transfers and the continuation of the mandate (Halimatussadiah et al., 2021; Das & Gundimeda, 2022).

From a regional development perspective, this pattern is problematic because it concentrates the costs of the national biodiesel strategy in Sumatra and Kalimantan while distributing most of the benefits elsewhere. Gains from lower diesel imports and improved energy indicators accrue at the national level and in energy-consuming centers, whereas producing provinces face lower GRDP, weaker export capacity, and higher exposure to policy risk. This finding contrasts with previous studies that projected positive regional growth under lower blending mandates or different investment assumptions (Sahara et al., 2022; Puspitawati et al., 2025). The strategy, therefore, acts as an implicit interregional tax on palm oil regions, implemented through commodity reallocation rather than through the budget, and it does so without a precise compensating mechanism in terms of revenue sharing, infrastructure or industrial diversification. Suppose downstreaming is presented as a tool for inclusive development. In that case, the current configuration falls short of that promise. It may, in fact, deepen regional inequality by slowing the growth of resource-rich provinces that are already structurally dependent on a single commodity (Nkolo et al., 2018)

4.6 Impact of Biodiesel Policy on Subsidies

From 2006 to 2014, funding for Indonesia's national biodiesel program came entirely from the state budget (APBN). This scheme placed fiscal pressure on the government due to the large subsidies required to maintain the economic viability of biodiesel amid global oil price fluctuations. Reliance on the APBN also made the biodiesel program unsustainable and vulnerable to changes in annual budget policy (Halimatussadiah et al., 2021). As part of fiscal reform, in 2015, the government established the Palm Oil Plantation Fund Management Agency (BPDPKS). The agency functions as a fund management institution that administers revenue from export levies on crude palm oil (CPO) and its derivatives, as mandated under Presidential Regulation No. 61 of 2015. BPDPKS serves as a non-budgetary fiscal instrument, enabling the financing of various strategic programs in the plantation sector without directly burdening state finances (Rachman et al., 2024).

Funds collected by BPDPKS are allocated to several core programs, including smallholder oil palm replanting (PSR), research and development, promotion and partnership activities, and, most significantly, biodiesel incentives to bridge the price gap between biodiesel and fossil diesel. According to BPDPKS's financial statements, more than 90% of its annual expenditure is absorbed by the biodiesel incentive program, making it the backbone of Indonesia's mandatory biodiesel policy (B20, B30, and now B40) (Ardana et al., 2022). Nearly 99% of BPDPKS's total revenue is derived from CPO export levies, indicating that the sustainability of the national biodiesel program is highly dependent on export performance and global CPO prices. When exports weaken or CPO prices fall significantly, BPDP's ability to disburse biodiesel incentives becomes constrained (Halimatussadiah et al., 2021).

In 2025, the government revised the institution's mandate by changing its nomenclature to the Plantation Fund Management Agency (BPDP). This change was accompanied by an expansion of its scope to cover not only palm oil but also other strategic plantation commodities such as coconut and cocoa. On one hand, this reform is expected to strengthen BPDP's role as a financing instrument for downstream development and value addition across strategic plantation subsectors. On the other hand, if export levies from non-palm commodities remain low, this could reduce the funding available for biodiesel incentives, potentially constraining the implementation of biodiesel policies (see Rachman et al., 2024).

The total requirement for biodiesel incentive funding is entirely determined by the price differential between the Market Index Price (HIP) of Biodiesel and the HIP of Diesel. The HIP for biodiesel is calculated by the Ministry of Energy and Mineral Resources (ESDM) based on the international CPO price (as reported by Argus or Refinitiv), plus conversion factors, processing costs, and producer margins (Halimatussadiah et al., 2021). Meanwhile, the HIP for diesel is based on global gasoil prices, commonly referenced from the Mean of Platts Singapore (MOPS). The difference between these two benchmark prices determines the incentive per liter of biodiesel paid by BPDP to biofuel producers (BU-BBN). The higher the CPO price, the wider the gap between biodiesel and diesel prices, and the greater the funding required to keep biodiesel economically competitive in the domestic market (Gultom et al., 2024)

Since 2024, the price differential between biodiesel and diesel has widened due to rising global CPO prices and stronger domestic palm oil prices driven by increased demand from the B35 and B40 programs **(see Appendix 19)** (Gultom et al., 2024). This has led to a significant surge in the required incentive budget. In several periods, the biodiesel incentive has exceeded Rp6,000 per liter, while the diesel subsidy is only around Rp500–1,500 per liter. The difference in financing mechanisms between the diesel subsidy (funded by the APBN) and the biodiesel incentive (funded by BPDP) also creates distinct fiscal implications. The diesel subsidy operates within a fixed and predictable budget ceiling. In contrast, the biodiesel incentive fluctuates dynamically in response to global market movements, potentially increasing sharply without direct fiscal controls when CPO prices rise. This makes the BPDP scheme highly sensitive to global volatility, creating risks of liquidity shortfalls and potential indirect fiscal exposure if export levy revenues prove insufficient (Halimatussadiah et al., 2021).

Simulations show that the total incentive requirement is highly dependent on the relationship between the biodiesel (FAME) incentive per liter and the diesel subsidy per liter **(see Appendix 20)**. Two main scenarios illustrate this dynamic. First, when the FAME incentive per liter exceeds the diesel subsidy, any increase in the biodiesel blending ratio directly raises total funding needs. Second, when the FAME incentive per liter is lower than the diesel subsidy, typically when CPO prices fall, or global gasoil prices strengthen, the HIP for biodiesel approaches that of diesel. Under this scenario, increasing the biodiesel blend has a minor impact on fiscal needs and may even result in cost reductions as the price gap narrows. Although fiscally more favorable, this condition is typically temporary and historically rare (Halimatussadiah et al., 2021). Given current projections for global energy commodities, particularly CPO prices, which are expected to remain high in the medium term **(see Appendix 21)**, the dominant scenario is the first, where biodiesel incentives per liter exceed diesel subsidies (Dermoredjo et al., 2025). This suggests that biodiesel incentive requirements will continue to rise in tandem with higher blending ratios and the expansion of Indonesia's biodiesel mandate.

On the other hand, the reliance of biodiesel financing on palm oil export levies poses significant sustainability risks for both fiscal stability and the continuity of renewable energy policies. Technically, BPDP's revenue is sourced from levies imposed on CPO, its derivatives, and palm-based by-products **(see Appendix 22)**. The magnitude of this revenue depends on three key factors: 1) the volume of palm oil exports and derivatives, 2) the CPO reference price, which determines whether levies are applied, and 3) the tiered levy rate structure based on reference prices (progressive scheme) (Rachman et al., 2024).

This mechanism operates under a price threshold system: levies are not applied when the CPO reference price falls below a certain threshold and are reimposed on a graduated scale once prices exceed it. Export levy revenues increase when CPO prices are high; conversely, export levy revenues decline when prices fall, resulting in inconsistent cash flows and potential funding gaps. This occurred in 2019, when CPO prices dropped below the threshold, triggering a suspension of export levies for several months. As a result, BPDP's revenue fell sharply. The impact was felt in 2020, when the government was forced to allocate Rp 2.78 trillion from the state budget (APBN) to cover the shortfall in biodiesel incentives partially (Halimatussadiah et al., 2021). This case illustrates that, although the biodiesel program is formally financed outside the APBN, its fiscal risks can still be transferred to the state budget.

Meanwhile, BPDP's revenue from palm oil export levies has shown a downward trend in recent years, driven by both structural and policy factors **(see Appendix 23)**. This decline reflects not only fluctuations in global CPO prices but also the structural transformation of Indonesia's palm oil industry toward downstream processing and increased domestic consumption (Dermoredjo et al., 2025). The export structure has shifted significantly from crude palm oil (CPO) to refined products and by-products such as RBD Palm Olein and RBD Palm Stearin **(see Appendix 24)**. While this shift supports domestic value addition, it narrows the levy base, as refined products are subject to lower levy rates than crude palm oil. Furthermore, since 2022, the government has changed the levy mechanism from a specific tariff (USD/MT) to an ad valorem rate (as a percentage of the export value).

Although this system is more flexible, it tends to generate lower revenue when CPO prices are moderate or declining compared to the previous fixed-rate system (Gultom et al., 2024). Additionally, growing domestic use of CPO for biodiesel feedstock further reduces CPO export volumes. As a result, BPDP's funding increasingly depends on refined exports with lower levy rates, even as biodiesel incentive needs continue to rise (Halimatussadiah et al., 2021).

4.7 Impact of Biodiesel Policy on Inflation

Data on CPO consumption shows a significant shift in the structure of domestic utilization over the past few years. According to data from GAPKI, CPO consumption for biodiesel production has continued to rise, while export volumes have declined, and food-related uses have gradually decreased (Dermoredjo et al., 2025). The increase in domestic demand for CPO for biodiesel is directly correlated with the mandatory biodiesel policy, which expands the absorption of CPO as a biofuel feedstock **(see Appendix 25)** (Rachman et al., 2024).

However, the growing use of CPO for biodiesel has occurred amid relatively stagnant national CPO production (Ardana et al., 2022). Since production capacity has not increased in line with rising domestic consumption, the allocation of CPO for export and food purposes has become increasingly constrained. At the same time, the Domestic Market Obligation (DMO) policy for cooking oil reserves a fixed portion of CPO for domestic consumption, further limiting export opportunities (Hidayatno et al., 2025). The combination of rising biodiesel demand, cooking oil DMO, and stagnant CPO output has created pressure on both global and domestic supply, driving up CPO prices in international and domestic markets (Gultom et al., 2024).

The increase in domestic CPO prices has had a direct impact on biodiesel prices, particularly in the non-PSO (non–Public Service Obligation) segment. This segment includes manufacturing industries, commercial transportation, mining, and logistics services, which rely on non-subsidized biosolar and do not receive price compensation from the government. For the industrial sector, this translates into higher energy and logistics costs. These cost pressures have a cascading effect on the prices of goods and services, contributing to core inflation and volatile food inflation (Sahara et al., 2022). In parallel, higher CPO prices have also driven up cooking oil prices, adding further pressure to core inflation **(see Appendix 26)** (Gultom et al., 2024; Das & Gundimeda, 2022).

Nevertheless, the simulation results indicate that the estimated impact of rising CPO prices on inflation under the B50 and B60 scenarios is only around 0.01–0.02 percentage points (ppt) as in **Appendix 27**. This relatively low impact is attributable to several factors and aligns with previous CGE findings which observed only mild inflationary shocks from biodiesel mandates (Sahara et al., 2022). First, the share of the energy and logistics sectors in the national inflation basket (CPI) is limited, with the combined weight of diesel fuel and transportation contributing only about 0.00 percentage points to overall inflation. Second, the Domestic Market Obligation (DMO) policy aimed at stabilizing CPO supply for food purposes helps contain the transmission of higher CPO prices to food prices (Hidayatno et al., 2025; Puspitawati et al., 2025).

4.8 Do Higher Biodiesel Blends Truly Reduce Emissions?

The simulation results suggest that progressively higher biodiesel blends, from B5 to B70, can deliver substantial reductions in fuel-related emissions, measured in g CO_2e per MJ **(see Appendix 28)**. As the blend increases, the model shows a steady rise in the percentage reduction relative to pure fossil diesel, reflecting the substitution of fossil fuel with a renewable component (Harsono & Subronto, 2013). However, these gains are achieved by sharply increasing the volumes of biodiesel and crude palm oil required, together with extensive additional land needs for oil palm cultivation. Under realistic agronomic conditions, such quantities cannot be supplied solely through better yields and utilisation of existing plantations; they almost inevitably imply further expansion of planted area (Taheripour et al., 2024; Khatiwada et al., 2018).

Once this land dimension is recognised, the environmental balance of an ambitious biodiesel roadmap becomes far less favourable. In Indonesia, new oil palm areas are still frequently developed at the expense of forests and peatlands (Danielsen et al., 2009). The conversion of these ecosystems releases large stocks of carbon and also raises long-term emissions through drainage, fire risk, and foregone sequestration (Rosa et al., 2022). Suppose the extra feedstock required for high blends, such as B50, B60, and B70, is sourced from such conversion. In that case, the resulting land-use emissions can materially erode, and in extreme cases, overturn the emission savings recorded in the energy sector (Harsono & Subronto, 2013; Hidayatno et al., 2025). In that situation, official statistics would report improved performance for transport emissions while total national emissions fall much less or even increase.

For a country whose past deforestation and peat degradation already dominate its greenhouse gas profile, this asymmetry is not a minor technical detail but a central policy concern (Usmani et al., 2025). Positioning biodiesel as a flagship climate instrument without explicitly controlling the land channel risks creating a misleading narrative of progress: Indonesia would appear to be advancing toward its mitigation and renewable energy targets, while the underlying drivers of land-based emissions remain intact or are even reinforced by higher feedstock demand (Das & Gundimeda, 2022). A credible sustainability strategy, therefore, requires that any move to higher blending levels be explicitly conditional on strict protection of forests and peatlands, demonstrable improvements in plantation productivity, and priority use of degraded or idle land (Danielsen et al., 2009; Harsono & Subronto, 2013). Without such safeguards, the environmental pillar of palm oil downstreaming becomes internally inconsistent, as policies adopted in the name of decarbonisation may end up shifting emissions across sectors rather than reducing them in net terms (Rosa et al., 2022).

4.9 Investment, Financing, and Trade for Biodiesel/Bioenergy: International Perspectives

Investment

International investment patterns are demonstrating a clear pivot away from globalized supply chains and towards protected domestic markets, particularly in the West (Das & Gundimeda, 2022). The United States has initiated a significant inward shift with the introduction of the Inflation Reduction Act (IRA) and its Section 45Z Clean Fuel Production Credit, which took effect in 2025. This policy replaces the Blender's Tax Credit, which benefited importers, with a production credit exclusively for domestic U.S. producers of clean fuels, including biodiesel, renewable diesel, and sustainable Aviation Fuel (SAF). The credit's value, ranging from US0.20 to US US1.00 per gallon based on the carbon intensity of the fuel, creates a powerful incentive for capital investment in the U.S. based production facilities and feedstock optimization (U.S. Internal Revenue Service, 2025; WTO,2023). The result has been a steep decline in U.S. imports, which have fallen to their lowest levels since 2012, as capital is redirected internally, reassuring stakeholders about the resilience of domestic markets.

Similarly, the European Union's Renewable Energy Directive (RED III) and its accompanying EU Deforestation Regulation (EUDR) act as non-tariff barriers to investment (Dermoredjo et al., 2025; Syaftiani et al., 2025). The EUDR, which requires proof that commodities such as palm oil are not linked to deforestation after December 2020, increases compliance costs and risks for producers (European Commission, 2023). Coupled with longstanding anti-dumping duties on Indonesian biodiesel—which the World Trade Organization has found to be unjustified but which remain in place—the EU has created a regulatory environment that actively discourages foreign direct investment in export-oriented biodiesel production in Southeast Asia that does not meet its stringent traceability and sustainability criteria (Sahara et al., 2022). Consequently, global investment is now channeled into two key areas: 1) building domestic production capacity within protected markets like the U.S. and EU, and 2) funding traceability technologies and certification systems to maintain market access (Rosa et al., 2022; Rachman et al., 2024)..

Financing

Indonesia's biodiesel program has become a central instrument for strengthening energy security, reducing diesel imports, and absorbing domestic CPO, with mandates progressing from B20 to B35 and targets for B40 and B50 (Rachman et al., 2024). To date, this expansion has been funded almost entirely through the CPO export levy managed by BPDPKS, which is used to close the price gap between biodiesel and diesel via the market index price mechanism. This levy-based model has been effective in supporting the rollout of B20 and B30 without directly burdening the state budget; however, simulations and policy reviews indicate growing sustainability risks as mandates increase (Halimatussadiah et al., 2021). Higher blending levels, volatile CPO and oil prices, and competing demands on the Palm Oil Fund for smallholder replanting, productivity improvements, and deforestation reduction collectively create a financing dilemma: resources are increasingly stretched between short-term subsidy needs and long-term sustainability goals (Ardana et al., 2022; Hidayatno et al., 2025).

Experiences from other biofuel-producing countries illustrate alternative approaches that rely less on a single levy and more on diversified, performance-based instruments. Brazil's RenovaBio scheme utilizes decarbonization credits that reward certified producers based on their emission reductions relative to fossil fuels, while obligating fuel distributors to purchase these credits to meet their annual targets (Das & Gundimeda, 2022). In the United States, the Renewable Fuel Standard and biodiesel tax credits combine market-based compliance credits with fiscal incentives to promote the production of renewable fuels. Evidence suggests that changes in tax credit design have had a measurable impact on production and trade (Taheripour et al., 2024). In the European Union and Canada, public support is increasingly channelled toward advanced biofuels through grants, concessional loans, and carbon intensity standards in the transport sector, to de-risk early investment while allowing market mechanisms and regulation to shape long-run operations (Nkolo et al., 2018).

These international lessons suggest that Indonesia's current financing model for biodiesel is both narrow and increasingly exposed to external shocks. A more resilient strategy would diversify instruments beyond the CPO export levy, for example, by introducing a fuel carbon intensity standard under which low-emission biodiesel and other biofuels earn tradable domestic credits purchased by fuel distributors, thereby creating a new revenue stream linked to actual emission performance (Rosa et al., 2022). At the same time, BPDPKS funding could be more explicitly balanced between mandate support and structural investments in smallholder replanting and productivity (Ardana et al., 2022). The complementary use of green bonds and green sukuk to finance blending infrastructure and capacity expansion would further shift part of the burden from recurrent subsidies to capital market-based financing. In combination, these measures would reduce the vulnerability of the biodiesel program to commodity cycles and align its financing architecture more closely with Indonesia's broader sustainability objectives (Syaftiani et al., 2025).

Trade

The international biodiesel trade is increasingly shaped by geopolitical maneuvering and overt protectionism, often framed in terms of environmental or sustainability concerns (Syaftiani et al., 2025). Recent measures in the United States (Section 45Z) and India (the "restricted" import policy for fuel purposes) have effectively closed two major destination markets for biodiesel imports, forcing producer countries to redirect flows and seek new outlets (Das & Gundimeda, 2022). These developments signal a shift away from a relatively open, price driven global market toward a more fragmented regime in which climate and sustainability narratives are used to justify trade barriers that primarily serve domestic industrial interests (Dermoredjo et al., 2025).

The most prominent example is the ongoing dispute between the European Union and Indonesia (Sahara et al., 2022). The EU has imposed countervailing duties on Indonesian biodiesel on the grounds that Indonesian producers benefit from government support, including grants and access to raw materials at below market prices. However, a recent World Trade Organization ruling found in favour of Indonesia, concluding that export duties and levies on palm oil do not constitute actionable subsidies and that the EU had failed to demonstrate material injury to its domestic industry (World Trade Organization, 2023; Syaftiani et al., 2025). The EU's reluctance to remove these measures despite the ruling suggests that the dispute is driven less by legal or environmental considerations than by political pressures from agricultural lobbies seeking to shield higher cost European producers from competitive Indonesian biodiesel (Dermoredjo et al., 2025).

In this emerging landscape of "green trade barriers" (Syaftiani et al., 2025), Indonesia and other major biodiesel exporters need to adopt a more strategic and diversified response. This includes continued use of the WTO dispute settlement system to contest measures that violate multilateral rules, proactive diversification of export destinations toward less restrictive markets in Africa and Latin America, and upgrading along the value chain to develop and export higher value, non-fuel palm-based products such as biolubricants and green chemicals that are less exposed to fuel specific trade restrictions (Rachman et al., 2024). Under these conditions, long term success will depend not only on cost competitiveness, but also on the capacity to meet evolving traceability and sustainability demands (Rosa et al., 2022), to negotiate favourable trade arrangements, and to reposition palm oil–based industries in segments less vulnerable to protectionist interventions in fuel markets (Gultom et al., 2024).

4.9 Anecdotal Evidence

Java

Java serves as the strategic downstream hub of Indonesia's biodiesel ecosystem, concentrating processing, distribution, and final consumption near the country's leading industrial and transportation demand centers. The case of PT Batara Elok Semesta Terpadu in East Java illustrates this role: the company has adjusted from B20 to B35, supplies both PSO and non-PSO markets, and utilises bonded zone status to serve domestic and export demand. Growing commercial demand from the non-PSO segment has raised capacity utilisation and signalled the emergence of a market-driven biodiesel segment beyond government-subsidised channels. At the same time, regional event analysis for Java shows that the interaction between biodiesel mandates, CPO exports, and cooking oil inflation is complex rather than linear. The shift to B30 coincided with lower CPO exports as expected. However, under B35, CPO exports surged, while cooking oil inflation turned negative, suggesting that global prices, post-pandemic recovery, and other market forces significantly shape regional outcomes.

Against this background, industry perspectives from Java highlight structural vulnerabilities in supply, technology, and policy governance. Higher blending targets, such as B40 and B50, intensify dependence on CPO feedstock from Sumatra and Kalimantan in a setting where a moratorium constrains plantation expansion, and firms identify the variability of CPO supply as a primary operational risk. Technical concerns about engine compatibility with higher blends suggest a bottleneck in end-user adoption unless fuel quality standards and vehicle technologies continue to improve. Most critically, producers emphasise uncertainty around the biodiesel market index price, citing differing interpretations among government agencies and the associated risk of ex post restitution, which undermines investment incentives. This is compounded by public misperceptions that BPDPKS price compensation is a pure subsidy, which can erode social support for palm oil downstreaming. Combined, these issues demonstrate that Java's competent downstream industry is simultaneously at the forefront of market development and the most vulnerable to upstream constraints and policy inconsistencies, reinforcing the need for a more transparent, predictable, and integrated governance framework for biodiesel.

Sumatra

Sumatra remains the core of Indonesia's palm oil economy, hosting more than 60 percent of the country's oil palm plantations and serving as the main base for crude palm oil production and export. Recent data indicate a strong rebound in Sumatra's CPO exports, both in volume and value, with the latter growing faster, signaling a gradual shift from primary CPO exports toward higher-value downstream products, such as second-stage and third-stage derivatives. This pattern reflects an ongoing structural transformation in which Indonesia is transitioning from a role as a raw material supplier to a producer of processed palm-based goods, including oleochemicals and processed food products, thereby strengthening export competitiveness, broadening domestic value creation, and supporting more inclusive regional development. The resilience of exports has been underpinned by robust demand from key partners such as India and China. At the same time, market share analysis indicates promising diversification prospects in Pakistan, Africa, Europe, and the United States, particularly in the context of new trade arrangements such as IE CEPA and prospective lower tariffs for Indonesian CPO.

Looking ahead, Sumatra's palm oil sector is expected to maintain a positive growth trajectory, supported by firm domestic demand for cooking oil, continued implementation of the B40 and B50 biodiesel program, and the expansion of downstream energy products that stabilise the domestic market and absorb output from both smallholders and large plantations. At the same time, rising domestic use of biodiesel creates a strategic trade-off, as a larger share of CPO allocated to energy can constrain export supply and potentially push up global prices, with implications for Indonesia's price competitiveness vis-à-vis other exporters. Policymakers therefore face the task of carefully balancing domestic energy security objectives with the need to preserve export performance and market share, particularly in key destinations such as India, China, and Pakistan that rely heavily on Indonesian CPO for food and energy security. If managed through productivity gains, efficiency improvements in upstream production, and continued downstream upgrading, this dual demand from domestic and international markets can anchor a more sustainable, value-driven, and globally competitive palm oil industry centred in Sumatra.

5. Implication / Policy Recommendation

In light of the macroeconomic, fiscal, and environmental risks identified in this study, Indonesia's biodiesel strategy should be recalibrated through a phased approach that distinguishes clearly between short-, medium-, and long-term priorities. In the short term, the primary objective is to mitigate the immediate risks associated with a potential move to B50. Before any escalation of the mandate, policymakers should conduct a comprehensive impact assessment that incorporates trade, fiscal, financial, and food-price channels, and then sequence implementation accordingly. A flexible blending mechanism that allows the effective blend to adjust in response to movements in international diesel, biodiesel, and CPO prices would help stabilise the current account, subsidy needs, and domestic inflation during adverse commodity cycles. At the same time, expanding smallholder replanting and actively promoting Indonesia's recent WTO wins and trade agreements would strengthen productivity and enhance global bargaining power in the palm oil market.

In the medium term, policy should focus on reinforcing the structural fundamentals that determine the sustainability of any blending roadmap. A credible energy transition cannot rely indefinitely on CPO-based biodiesel alone; research, development, and demonstration efforts need to be scaled up for alternative low-carbon fuels such as waste-based bioethanol and other advanced biofuels that ease pressure on land and food commodities. Ensuring a sustainable CPO supply also requires strict enforcement of the moratorium on new forest and peatland conversion, investment in drought-resistant and higher-yielding seeds, and improvements in agricultural extension services that raise productivity on existing plantations rather than pushing the agricultural frontier outward. These measures would gradually reduce the biodiesel program's vulnerability to land constraints, environmental criticism, and climate-related shocks.

Over the longer term, biodiesel policy should be placed within a comprehensive roadmap for structural transformation toward a more sustainable energy and industrial base. The path of blending levels must be explicitly synchronized with projected domestic CPO production, downstream capacity, and external balance conditions, so that higher blends are treated as conditional targets and are achieved only when supply, infrastructure, and financing are sufficient. As production capacity grows, a larger share of the additional CPO should be directed to higher-value downstream products beyond fuel, such as oleochemicals, biolubricants, and green chemicals, which generate stronger export, fiscal, and employment gains. In this process, Bank Indonesia and other key institutions can play a strategic advisory role by assessing the macroeconomic implications of alternative roadmaps and ensuring that choices on blending, trade, and downstreaming remain aligned with broader objectives for growth, inflation, external stability, and environmental sustainability.

6. Conclusion and Further Research

This study concludes that Indonesia's biodiesel strategy delivers clear upside gains but also generates significant macroeconomic, social, and environmental risks that escalate at higher blending levels. On the positive side, biodiesel blending reduces dependence on imported diesel, narrows the trade deficit in fossil fuels, and strengthens energy security. The program also supports the national downstreaming agenda by transforming crude palm oil into higher-value energy products and contributing to renewable energy and emission reduction targets. These benefits are particularly evident at moderate blending levels, where import savings and domestic value added rise without yet triggering the most severe pressures on the current account, fiscal position, and upstream supply.

At the same time, the downside results are non-trivial and become more pronounced as the mandate approaches B50, B60, and B70. The CGE simulations show that higher blends worsen the current account, reduce real GDP and household consumption, weaken exports, and increase imports. Fiscal risks arise because incentive needs grow with volumes, while CPO levy revenues are volatile. Price and inflation risks are evident in higher CPO prices, which are transmitted to cooking oil and other basic goods. Meanwhile, regional simulations indicate GRDP contractions in all central palm oil-producing provinces, especially those that heavily depend on crude CPO exports. The environmental analysis reinforces these concerns. Although Appendix 28 shows that higher blends significantly reduce fuel-related emissions per unit of energy, the associated surge in biodiesel and CPO demand implies large additional land requirements. Under realistic conditions, this demand would likely be met in part through new plantations on forests and peatlands, generating land use emissions that can erode or even reverse the emission savings recorded in the energy sector.

These findings suggest several priorities for further research. First, future work should link energy sector modelling with explicit land use and peat emission dynamics, for example, by integrating CGE and land use change models or by coupling this framework with spatially explicit data on plantation expansion. Such approaches would allow more accurate estimation of net national emissions and would clarify the conditions under which higher blends remain environmentally beneficial. Second, a more granular analysis is needed on the distributional impacts of biodiesel policy across regions and households, including the effects on smallholders, wage workers, and low-income consumers who are most exposed to food price changes and regional output shocks. Micro-level survey data combined with regional CGE or microsimulation techniques could help identify appropriate compensation or safety net mechanisms.

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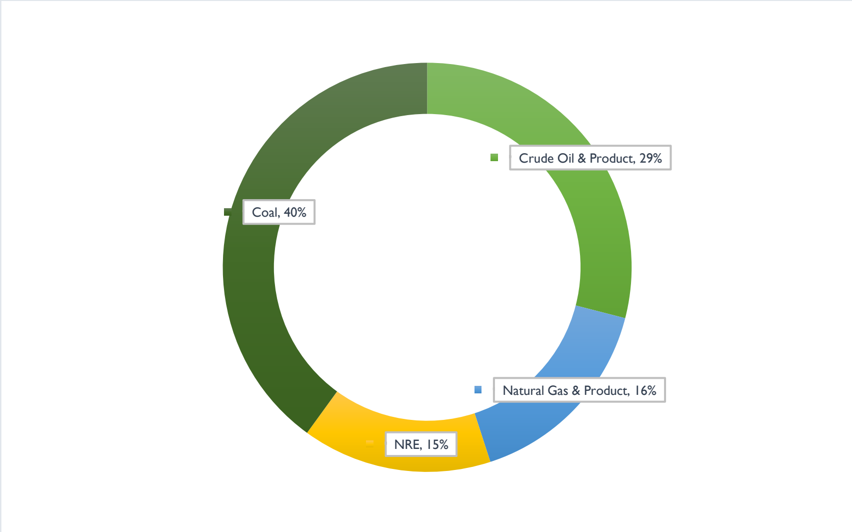
Appendix

Appendix 1. Indonesia's Primary Energy Supply Mix 2024



Appendix 2. Mandatory Biodiesel Policies Around the World

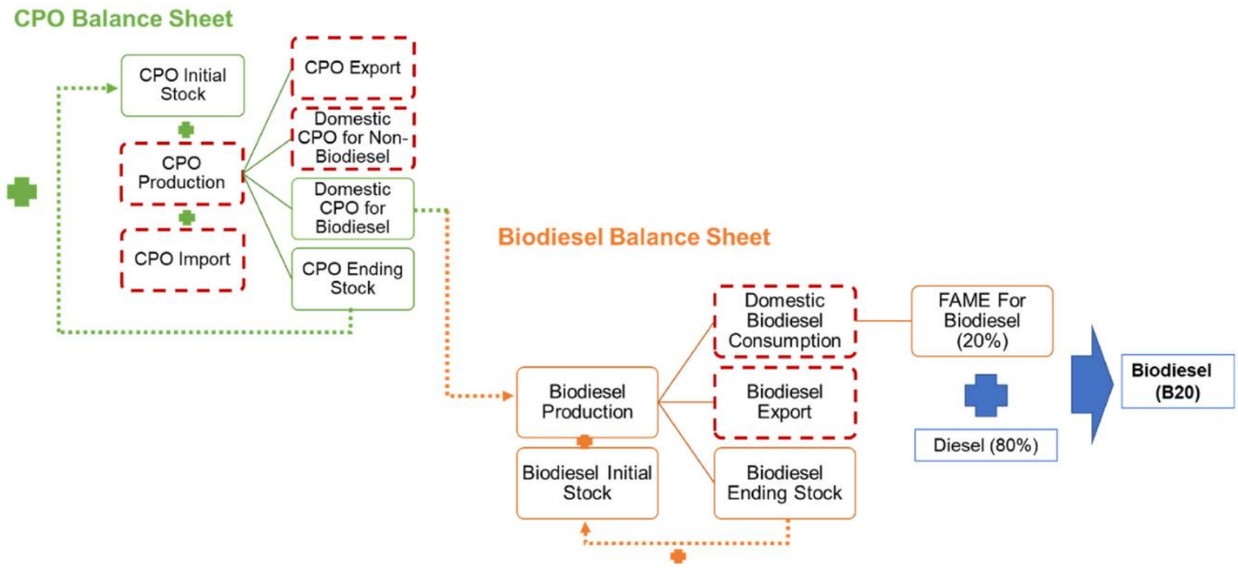
Country	Regulation
Argentina	B10 since April 2016, est. 750 million gallons/year. Decision to underblend in 2021 due to COVID
Brazil	B2 in 2008. In 2017 increased to B8, B10 in 2019, B12 in 2020, and B27.5 in 2025
Colombia	B10 mandate nationwide since 2018
Costa Rica	B20 mandate in place
Ecuador	B5 mandate since May 2013
European Union	New directive, RED II for 2021 - 2030 proposed biofuel reduction from 7% to 3.8% in 2030.
Norway	B3.5 as current mandate. Increased from B2.5 in 2012
Australia	Queensland: 0.5% biodiesel New South Wales: B2 mandate
Indonesia	**B15 in 2015, B20 since 2016, B30 mandate since 2020, B35 mandate since 2023, B40 Mandates start 2025**
Malaysia	B10 with consideration towards B20 or B30
Peru	B2 mandate in January 2019, plan to boost to B5 over the next five years
Philippines	B2 mandate, using coconut oil
South Korea	B2.5 mandate since August 2015
Thailand	B10 mandate in effect in 2018 with plan for subsidized B20 in trucks on voluntary basis
Uruguay	B6 mix in gasoil

Country	Regulation
USA	Minnesota: B20 mandate since 2008, will be fully implemented in summer months (Apr-Sep) Oregon: B5 for transportation solar supply

Appendix 3. Data Source

Variable	Source	Definition
CPO Production	GAPKI	Annual & monthly CPO production
CPO Consumption	GAPKI	Biodiesel consumption often published
CPO Export	CEIC, GAPKI	Export volumes and values
Biodiesel Production	APROBI, ESDM	Often published annually; monthly data may be limited
Biodiesel Consumption	ESDM, BPH Migas	Detailed fuel consumption by type (solar, gasoline, etc.)
Subsidy	BPDP	Total annual subsidy
CPO (International Spot Price)	Bloomberg	The current global market price of crude palm oil traded in international market
Diesel/biodiesel prices	CEIC	The market prices of solar and biodiesel fuels
Input-Output Table	BPS	A matrix showing how each sector of the economy buys from and sells to other sectors in a given period (data for CGE modelling).
Interregional IO (IRIO)	BPS	An input–output table that also tracks flows of goods and services between regions (data for CGE modelling).
Behavioral Parameters	Oktaviani (2001) & Oktaviani et al. (2011)	Armington elasticity, primary input elasticity, labor elasticity, and export demand elasticity.

Appendix 4. The CPO & Biodiesel Balance Sheet

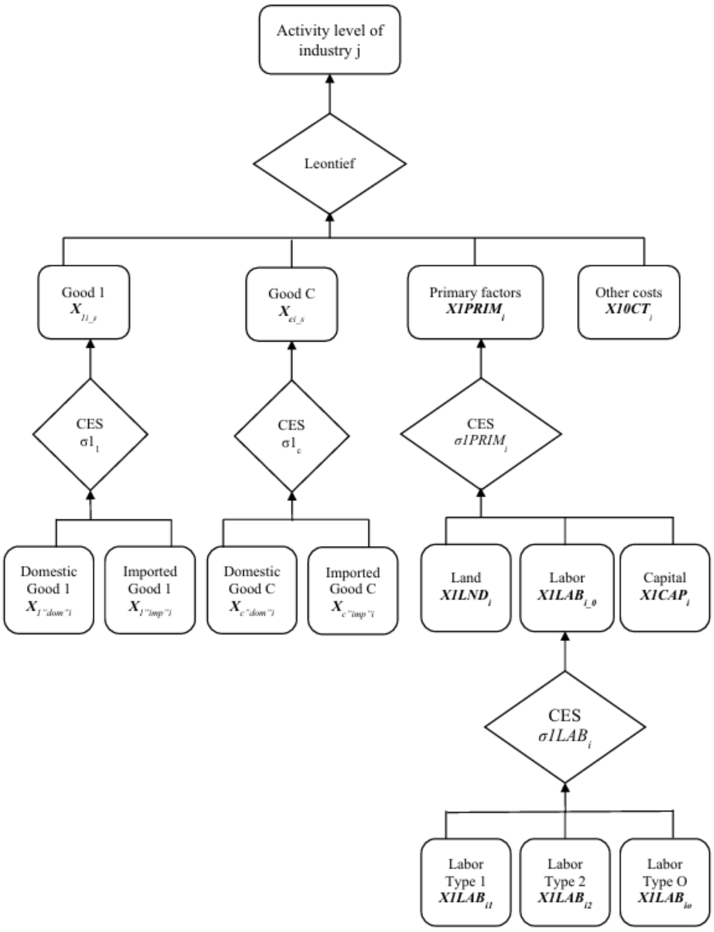


Source: Halimatussadiah et al. (2021)

Appendix 5. List of equation blocks in the model

No	Equation blocks
1	Labor demand
2	Primary factors demand
3	Intermediary inputs demand
4	A composite of intermediate inputs and primary factors
5	A composite of output by industry
6	Investment goods demand
7	Demand from households
8	Export demand
9	Margin demand
10	Prices of purchasing agents
11	Market clearing
12	Indirect taxes
13	Income and expenditure gross domestic product (GDP)
14	Balance of trade other aggregates
15	Rates of return
16	The accumulation of investment capital
17	The accumulation of debt
18	The extension of regions

Appendix 6. Structure of production in the Indonesian CGE model for biodiesel policy



Source: Sahara et al. (2022)

Appendix 7. Elasticities in the model

Sector	Armington Elasticity	Export Demand Elasticity	Primary Input Elasticity	Labor Elasticity
1 Padi	2.000	-0.500	0.710	0.500
2 Jagung	2.000	-0.500	0.710	0.500
3 UbiJalar	2.000	-0.500	0.710	0.500
4 UbiKayu	2.000	-0.500	0.710	0.500
5 Umbian	2.000	-0.500	0.710	0.500
6 KcngTnh	2.000	-0.500	0.710	0.500
7 Kedelai	2.000	-0.500	0.710	0.500
8 KacanganLain	2.000	-0.500	0.710	0.500
9 PadiBhnMknLa	2.000	-0.500	0.710	0.500
10 Sayuran	2.000	-0.500	0.710	0.500
11 TanHias	2.000	-0.500	0.710	0.500
12 Tebu	2.000	-0.500	0.710	0.500
13 Tembakau	2.000	-0.500	0.710	0.500
14 TanSerat	2.000	-0.500	0.710	0.500

Sector	Armington Elasticity	Export Demand Elasticity	Primary Input Elasticity	Labor Elasticity
15 HslKebunLa	2.000	-0.500	0.710	0.500
16 Buahan	2.000	-0.500	0.710	0.500
17 TanBiofarma	2.000	-0.500	0.710	0.500
18 Karet	2.000	-0.500	0.710	0.500
19 Kelapa	2.000	-0.500	0.710	0.500
20 KlpSawit	2.000	-0.500	0.710	0.500
21 Kopi	2.000	-0.500	0.710	0.500
22 The	2.000	-0.500	0.710	0.500
23 Kakao	2.000	-0.500	0.710	0.500
24 Cengkeh	2.000	-0.500	0.710	0.500
25 JambuMete	2.000	-0.500	0.710	0.500
26 TernakHslny	2.000	-0.500	0.710	0.500
27 SusuSegar	2.000	-0.500	0.710	0.500
28 Unggas	2.000	-0.500	0.710	0.500
29 HslHwnLain	2.000	-0.500	0.710	0.500
30 JsTaniHutIk	2.000	-0.500	0.710	0.500
31 Kayu	2.000	-0.500	0.710	0.500
32 HslHutanLain	2.000	-0.500	0.710	0.500
33 Ikan	2.000	-0.500	0.710	0.500
34 UdangCrus	2.000	-0.500	0.710	0.500
35 BiotaAirLain	2.000	-0.500	0.710	0.500
36 RumputLaut	2.000	-0.500	0.710	0.500
37 Batubara	2.000	-0.500	0.620	0.500
38 MinyakBumi	2.000	-0.500	0.620	0.500
39 GasBumi	2.000	-0.500	0.620	0.500
40 PanasBumi	2.000	-0.500	0.620	0.500
41 PasirBijihBs	2.000	-0.500	0.620	0.500
42 BjhTimah	2.000	-0.500	0.620	0.500
43 BijihBauksit	2.000	-0.500	0.620	0.500
44 BijihTembaga	2.000	-0.500	0.620	0.500
45 BijihNikel	2.000	-0.500	0.620	0.500
46 BrgTmbgLogLa	2.000	-0.500	0.620	0.500
47 BjhEmas	2.000	-0.500	0.620	0.500
48 BjhPerak	2.000	-0.500	0.620	0.500
49 BrgGalSglJns	2.000	-0.500	0.620	0.500
50 TmbgMinNoLog	2.000	-0.500	0.620	0.500
51 GaramKasar	2.000	-0.500	0.620	0.500
52 JsMykBumiGas	2.000	-0.500	0.620	0.500
53 JsTmbgGali	2.000	-0.500	0.620	0.500
54 HslPotHewan	2.000	-0.500	0.620	0.500
55 HslOlahHwn	2.000	-0.500	1.210	0.500
56 IkanKrngAsin	2.000	-0.500	1.210	0.500
57 HslOlhIkan	2.000	-0.500	1.210	0.500
58 HslOlahBhSyr	2.000	-0.500	1.210	0.500
59 MnykHwnNbati	2.000	-0.500	1.210	0.500
60 Kopra	2.000	-0.500	1.210	0.500

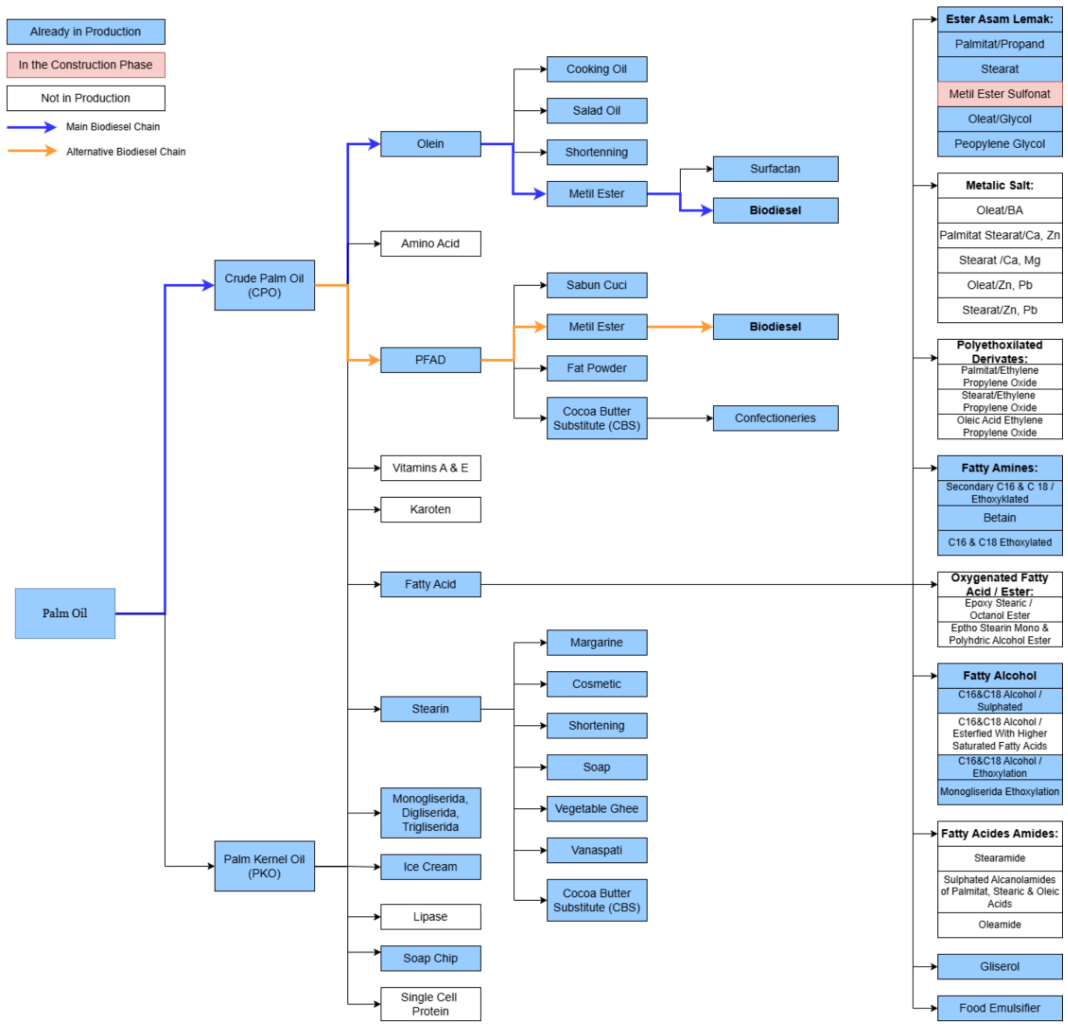
Sector	Armington Elasticity	Export Demand Elasticity	Primary Input Elasticity	Labor Elasticity
61 MaMinDrSusu	2.000	-0.500	1.210	0.500
62 TepungLain	2.000	-0.500	1.210	0.500
63 TGandumMesln	2.000	-0.500	1.210	0.500
64 GilPadiBeras	2.000	-0.500	1.210	0.500
65 RotiBisk	2.000	-0.500	1.210	0.500
66 Gula	2.000	-0.500	1.210	0.500
67 CoklatKmbgGu	2.000	-0.500	1.210	0.500
68 MieMacaroni	2.000	-0.500	1.210	0.500
69 KopiOlah	2.000	-0.500	1.210	0.500
70 TehOlah	2.000	-0.500	1.210	0.500
71 KedelaiOlah	2.000	-0.500	1.210	0.500
72 MakLain	2.000	-0.500	1.210	0.500
73 MakHwnOlah	2.000	-0.500	1.210	0.500
74 MinAlkohol	2.000	-0.500	1.210	0.500
75 MinTakAlkohl	2.000	-0.500	1.210	0.500
76 Rokok	2.000	-0.500	1.210	0.500
77 TmbakauOlah	2.000	-0.500	1.210	0.500
78 Benang	2.000	-0.500	1.210	0.500
79 Tekstil	2.000	-0.500	1.210	0.500
80 Permadani	2.000	-0.500	1.210	0.500
81 BrgTekstil	2.000	-0.500	1.210	0.500
82 BrgRajutan	2.000	-0.500	1.210	0.500
83 PakaianJadi	2.000	-0.500	1.210	0.500
84 HslAwetKulit	2.000	-0.500	1.210	0.500
85 BrgKulit	2.000	-0.500	1.210	0.500
86 AlasKaki	2.000	-0.500	1.210	0.500
87 KayuOlah	2.000	-0.500	1.210	0.500
88 KayuLapis	2.000	-0.500	1.210	0.500
89 BhnDrKayu	2.000	-0.500	1.210	0.500
90 BrgLainKayu	2.000	-0.500	1.210	0.500
91 BuburKrts	2.000	-0.500	1.210	0.500
92 Kertas	2.000	-0.500	1.210	0.500
93 BrgKrtsKrtn	2.000	-0.500	1.210	0.500
94 BrgCetak	2.000	-0.500	1.210	0.500
95 BrgLainNoLog	2.000	-0.500	1.210	0.500
96 Premium	2.000	-0.500	1.210	0.500
97 Pertamax	2.000	-0.500	1.210	0.500
98 ADO	2.000	-0.500	1.210	0.500
99 IDO	2.000	-0.500	1.210	0.500
100 Kerosene	2.000	-0.500	1.210	0.500
101 LPG	2.000	-0.500	1.210	0.500
102 Fueloil	2.000	-0.500	1.210	0.500
103 Biopremium	2.000	-0.500	1.210	0.500
104 Biosolar	2.000	-0.500	1.210	0.500
105 Otheroil	2.000	-0.500	1.210	0.500
106 Bioethanol	2.000	-0.500	1.210	0.500

Sector	Armington Elasticity	Export Demand Elasticity	Primary Input Elasticity	Labor Elasticity
107 Biodiesel	2.000	-0.500	1.210	0.500
108 LNG	2.000	-0.500	1.210	0.500
109 KimiaDasar	2.000	-0.500	1.210	0.500
110 Pupuk	2.000	-0.500	1.210	0.500
111 BhnPlastik	2.000	-0.500	1.210	0.500
112 Psetisida	2.000	-0.500	1.210	0.500
113 CatTinta	2.000	-0.500	1.210	0.500
114 VernisLak	2.000	-0.500	1.210	0.500
115 Sabun	2.000	-0.500	1.210	0.500
116 Kosmetik	2.000	-0.500	1.210	0.500
117 BrgKimia	2.000	-0.500	1.210	0.500
118 PrdFarmasi	2.000	-0.500	1.210	0.500
119 ObtTradisi	2.000	-0.500	1.210	0.500
120 Ban	2.000	-0.500	1.210	0.500
121 KaretRemah	2.000	-0.500	1.210	0.500
122 BrgKaret	2.000	-0.500	1.210	0.500
123 BrgPlastik	2.000	-0.500	1.210	0.500
124 Kaca	2.000	-0.500	1.210	0.500
125 TnhLiatKrmk	2.000	-0.500	1.210	0.500
126 Semen	2.000	-0.500	1.210	0.500
127 BesiBaja	2.000	-0.500	1.210	0.500
128 LogamNoBesi	2.000	-0.500	1.210	0.500
129 BrgCorLogam	2.000	-0.500	1.210	0.500
130 BhnKonstrLog	2.000	-0.500	1.210	0.500
131 SenjataAmuni	2.000	-0.500	1.210	0.500
132 AlatDapurRT	2.000	-0.500	1.210	0.500
133 BrgLogamLain	2.000	-0.500	1.210	0.500
134 BrgElekKom	2.000	-0.500	1.210	0.500
135 AltUkurOptik	2.000	-0.500	1.210	0.500
136 PbagkitLstrk	2.000	-0.500	1.210	0.500
137 MesinListrik	2.000	-0.500	1.210	0.500
138 BateraiAki	2.000	-0.500	1.210	0.500
139 AltLstrkLain	2.000	-0.500	1.210	0.500
140 AltLstrkRT	2.000	-0.500	1.210	0.500
141 MsnGerakMul	2.000	-0.500	1.210	0.500
142 MsnKntorAkun	2.000	-0.500	1.210	0.500
143 MesinLain	2.000	-0.500	1.210	0.500
144 AutoKecMotor	2.000	-0.500	1.210	0.500
145 KepalJasa	2.000	-0.500	1.210	0.500
146 KAJasa	2.000	-0.500	1.210	0.500
147 PswatJasa	2.000	-0.500	1.210	0.500
148 AltLain	2.000	-0.500	1.210	0.500
149 SpdMotor	2.000	-0.500	1.210	0.500
150 PerabotRTKtr	2.000	-0.500	1.210	0.500
151 Perhiasan	2.000	-0.500	1.210	0.500
152 AlatMusik	2.000	-0.500	1.210	0.500

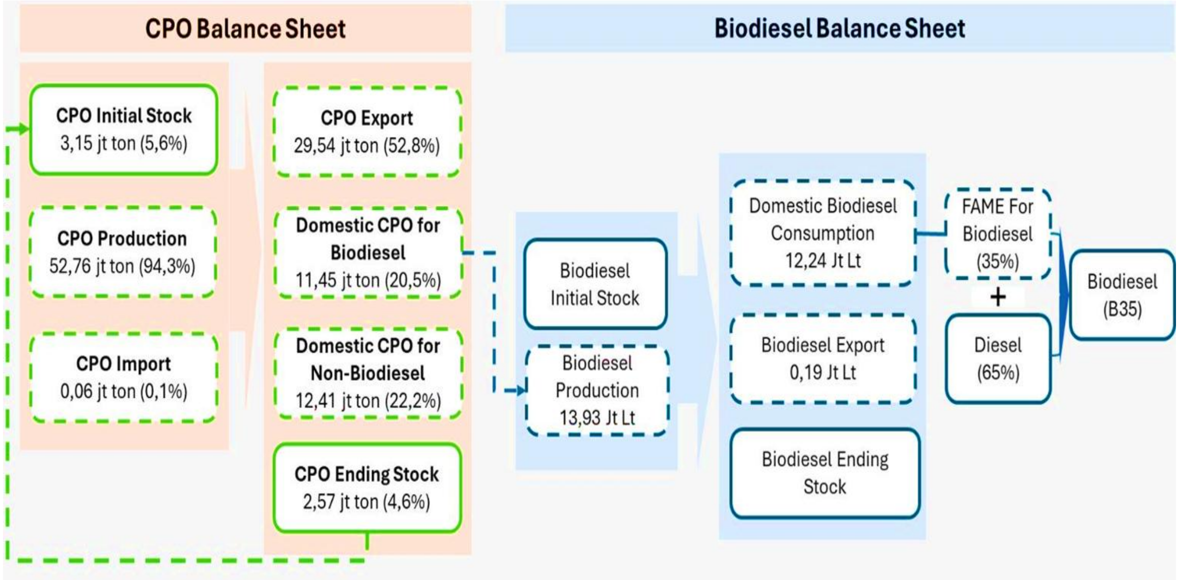
Sector	Armington Elasticity	Export Demand Elasticity	Primary Input Elasticity	Labor Elasticity
153 AlatOlahRaga	2.000	-0.500	1.210	0.500
154 MainanAnak	2.000	-0.500	1.210	0.500
155 AlatDokter	2.000	-0.500	1.210	0.500
156 IndustriLain	2.000	-0.500	1.210	0.500
157 JsRepairMsn	2.000	-0.500	1.210	0.500
158 PLTA	2.000	-0.500	1.210	0.500
159 PLTU	2.000	-0.500	1.210	0.500
160 PLTD	2.000	-0.500	1.210	0.500
161 PLTG	2.000	-0.500	1.210	0.500
162 PLTP	2.000	-0.500	1.210	0.500
163 PLTGU	2.000	-0.500	1.210	0.500
164 PLTB	2.000	-0.500	1.210	0.500
165 PLTS	2.000	-0.500	1.210	0.500
166 PLTBiomasa	2.000	-0.500	1.210	0.500
167 PLTN	2.000	-0.500	1.210	0.500
168 GasAlam	2.000	-0.500	1.210	0.500
169 AirBersih	2.000	-0.500	1.210	0.500
170 SmpahDaurUlg	2.000	-0.500	0.500	0.500
171 Bangunan	2.000	-0.500	1.470	0.500
172 InstalLGAKom	2.000	-0.500	1.470	0.500
173 PrasaranTani	2.000	-0.500	1.470	0.500
174 JlJmbtnPlbhn	2.000	-0.500	1.470	0.500
175 BangunanLain	2.000	-0.500	1.470	0.500
176 DagangMobMtr	2.000	-0.500	1.470	0.500
177 RepairMobMtr	2.000	-0.500	1.470	0.500
178 Perdagangan	2.000	-0.500	0.340	0.500
179 JasaKA	2.000	-0.500	0.340	0.500
180 JasaAngDarat	2.000	-0.500	0.340	0.500
181 JasaAngLaut	2.000	-0.500	0.340	0.500
182 JasAngSungai	2.000	-0.500	0.340	0.500
183 JasaAngUdara	2.000	-0.500	0.340	0.500
184 JsPnujgAngkt	2.000	-0.500	0.340	0.500
185 JasaPosKur	2.000	-0.500	0.340	0.500
186 Akomodasi	2.000	-0.500	0.340	0.500
187 Restoran	2.000	-0.500	0.340	0.500
188 HslPnerbitan	2.000	-0.500	0.340	0.500
189 PnyiaranFilm	2.000	-0.500	0.340	0.500
190 Telekomuniks	2.000	-0.500	0.340	0.500
191 JsKonsKompTI	2.000	-0.500	0.340	0.500
192 KeuBank	2.000	-0.500	0.340	0.500
193 Asuransi	2.000	-0.500	0.340	0.500
194 DanaPensiun	2.000	-0.500	0.340	0.500
195 LemKeuLain	2.000	-0.500	0.340	0.500
196 RealEstate	2.000	-0.500	0.340	0.500
197 ProfesIlmiah	2.000	-0.500	0.340	0.500
198 Persewaan	2.000	-0.500	0.340	0.500

Sector	Armington Elasticity	Export Demand Elasticity	Primary Input Elasticity	Labor Elasticity
199 JsPmrnthUmum	2.000	-0.500	0.340	0.500
200 PdidiknPmrth	2.000	-0.500	0.340	0.500
201 KshtanPmrth	2.000	-0.500	0.340	0.500
202 JsPmrnthLain	2.000	-0.500	0.340	0.500
203 PdidiknSwsta	1.500	-0.500	0.340	0.500
204 KshtnSosSwst	1.500	-0.500	0.340	0.500
205 SeniHiburan	1.500	-0.500	0.340	0.500
206 RepairBrgRT	1.500	-0.500	0.340	0.500
207 JasaLainnya	1.500	-0.500	0.340	0.500

Appendix 8. The Palm Oil Industry Tree

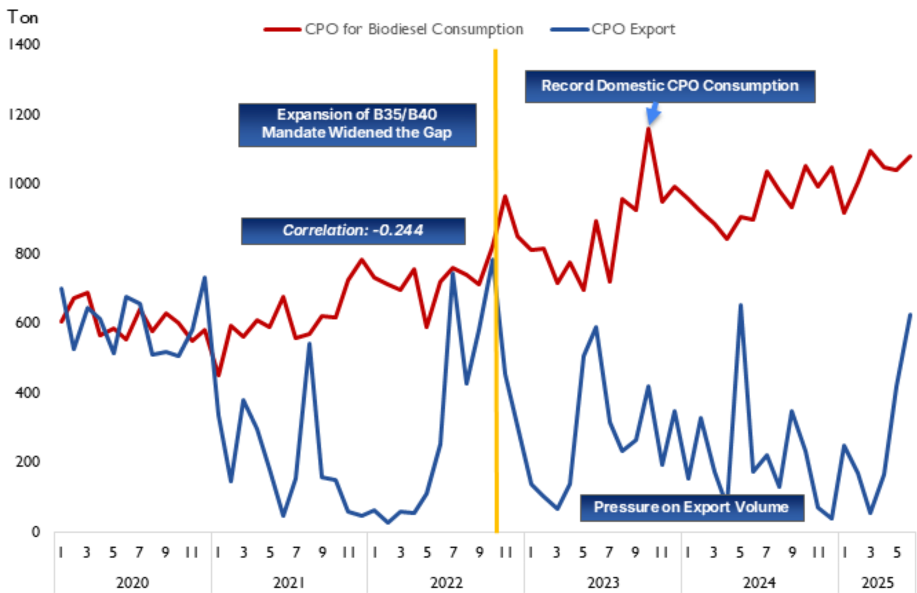


Appendix 9. CPO & Biodiesel Balance Sheet Overview

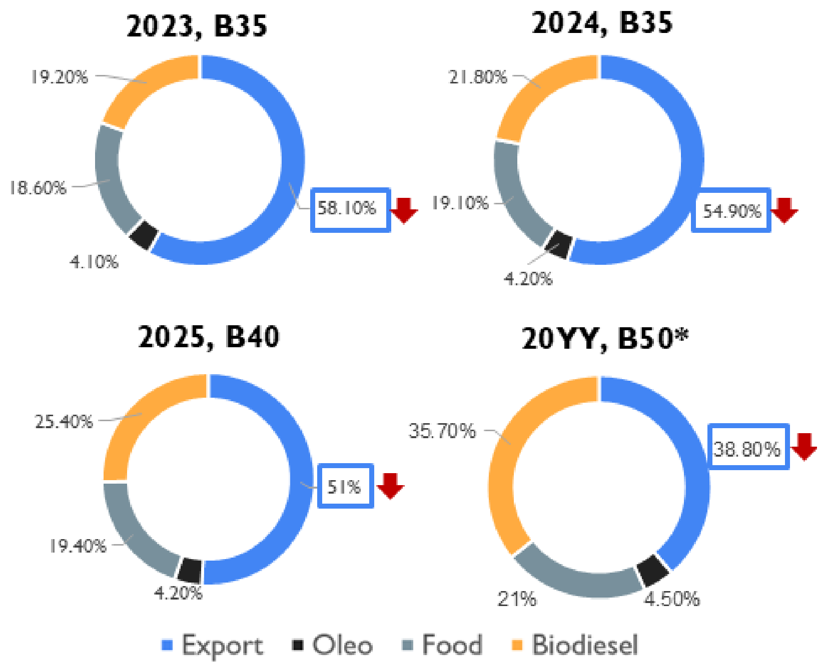


Source: Halimatussadiah et al. (2021)

Appendix 10. CPO for Biodiesel Consumption & Export

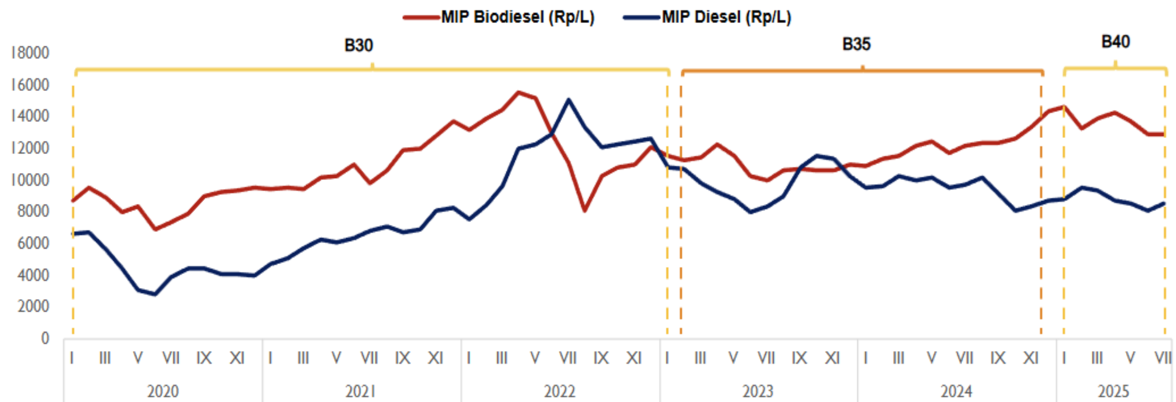


Appendix 11. The Utilisation of Palm Oil for Biodiesel Production

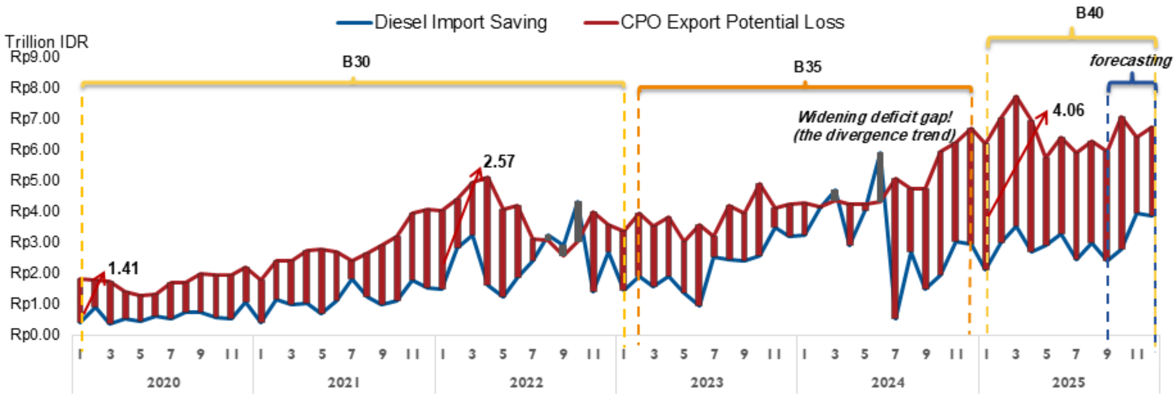


* *Assumption with constant productivity*

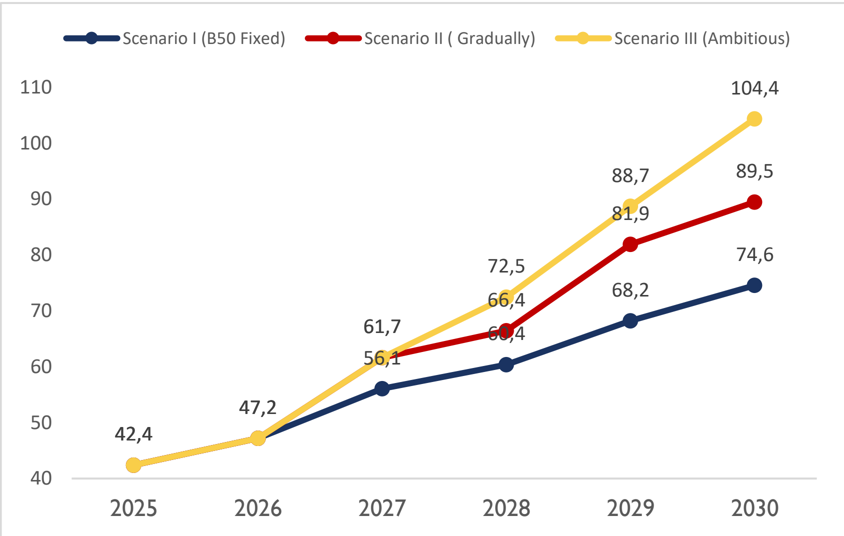
Appendix 12. Market Index Price of Diesel Fuel (HIP Solar) vs Market Index Price of Biodiesel Fuel (HIP Biodiesel)



Appendix 13. Existing Conditions: Import Savings vs Potential Export Losses



Appendix 14. Current Account Deficit



Appendix 15.

Year	Scenario I	Scenario II	Scenario III	Deficit/GDP Scenario I (%)	Deficit/GDP Scenario II (%)	Deficit/GDP Scenario III (%)
2025	42.4	42.4	42.4	0.18%	0.18%	0.18%
2026	47.2	47.2	47.2	0.20%	0.20%	0.20%
2027	56.1	61.7	61.7	0.24%	0.27%	0.27%
2028	60.4	66.4	72.5	0.26%	0.29%	0.31%
2029	68.2	81.9	88.7	0.29%	0.35%	0.38%
2030	74.6	89.5	104.4	0.32%	0.38%	0.45%

Appendix 16. Macroeconomic Impacts of Increasing Biodiesel Blending (B50-B70)

No	Description	B50	B60	B70
1	Real GDP from expenditure side (%).	-0.54	-0.71	-0.78
	Real GDP (if baseline is 5.04%)	5.013%	5.004%	5.001%
2	Real household consumption (%).	-0.19	-0.45	-0.47
3	Export volume index (%).	-0.33	-0.26	-0.23
4	Import volume index. C.I.F. weights (%).	1.99	2.2	2.71

Appendix 17. Industrial Impacts of FAME Blending Policy (B50) (CGE, 207 Sectors)

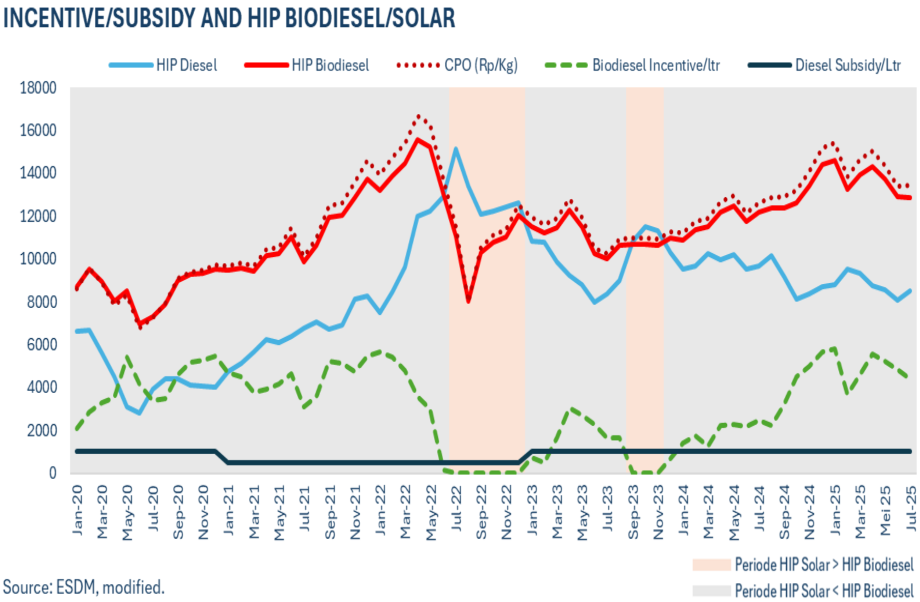
Category	No	Sector	Description	Δ(%)
Core Palm Biodiesel	59	Animal & Veg. Oils	Animal & vegetable oils (incl. processed palm oil)	-0.1134
Oleochemical	115	Soap	Soap (uses fatty acids/alcohols from palm-based oils)	-0.0381
	116	Cosmetics	Cosmetics & personal care products using oleochemicals	-0.0147
Fossil Fuel Competitors	96	Premium	Gasoline (fossil fuel)	-9.7206
	97	Pertamax	High-octane gasoline (fossil)	-9.7199
	98	ADO	Automotive solar oil (fossil solar)	-9.7193
	99	IDO	Industrial solar oil	-9.7188
	100	Kerosene	Kerosene	-9.7183
	101	LPG	Liquefied petroleum gas	-9.7175

Category	No	Sector	Description	Δ(%)
	102	Fueloil	Fuel oil (heavy fuel)	-9.7174
	105	Otheroil	Other petroleum fuels	-9.7156
	108	LNG	Liquefied natural gas	-9.714

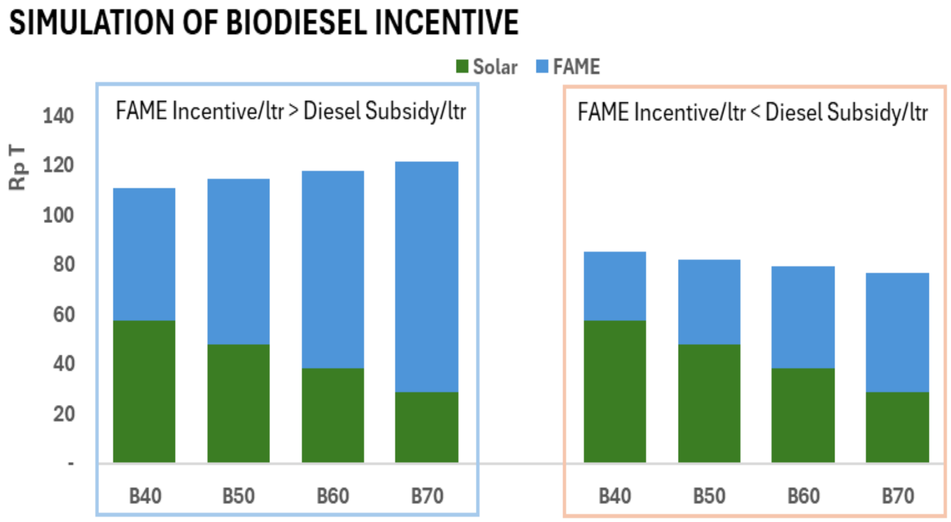
Appendix 18. Policy Effects on 10 Palm Oil Leading Provinces in Indonesia

No	Province	CGE	GRDP Before	GRDP After
1	Riau	-0.22%	3.52%	3.51%
2	Central Kalimantan	-0.53%	4.46%	4.44%
3	West Kalimantan	-0.19%	4.90%	4.89%
4	North Sumatra	-0.05%	5.01%	5.01%
5	East Kalimantan	-0.62%	6.17%	6.13%
6	South Sumatra	-0.44%	5.03%	5.01%
7	Jambi	-0.26%	4.51%	4.50%
8	West Sumatra	-0.21%	4.36%	4.35%
9	South Kalimantan	-0.22%	5.05%	5.04%
10	Aceh	-0.23%	4.66%	4.65%

Appendix 19. Incentive, Subsidy and HIP Biodiesel-Solar



Appendix 20. Simulation of Biodiesel Incentive



Source: Author calculation. PSO only (48% of total Biodiesel consumption projection, based on 2025 PSO and Non-PSO allocation)

Appendix 21. Palm Oil and Gas Oil Price Projection

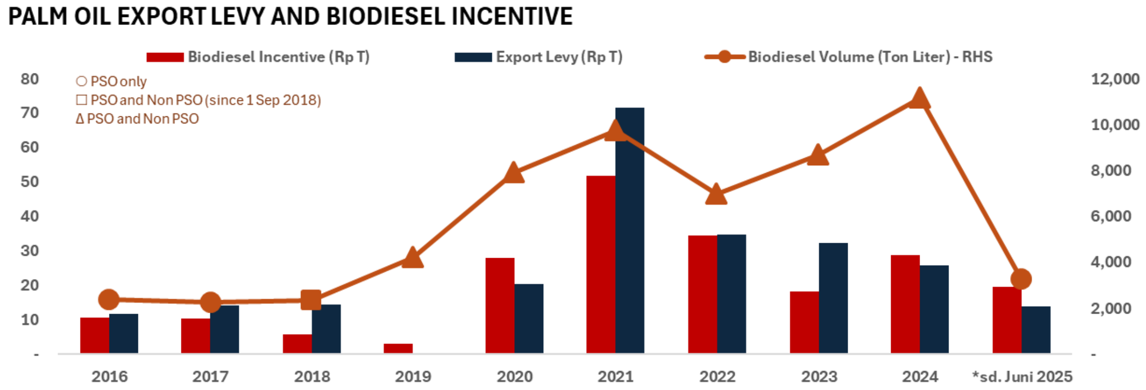
Commodity	2025	2026	2027
Palm Oil	1026	1077	1054
Gas Oil	649	638	720

Appendix 22. CPO Export Levy Rate

Commodity	2023	2024	2025
Palm kernel shell	3	3	3
Palm kernel cake	25	25	25
CPO	55-240	7.5%	10%
RBD Olein	35-204		
RBD Stearin	25-194	4.5%	7.5%
RBD PKO	38-207		
Biodiesel	25-194	3%	4.75%

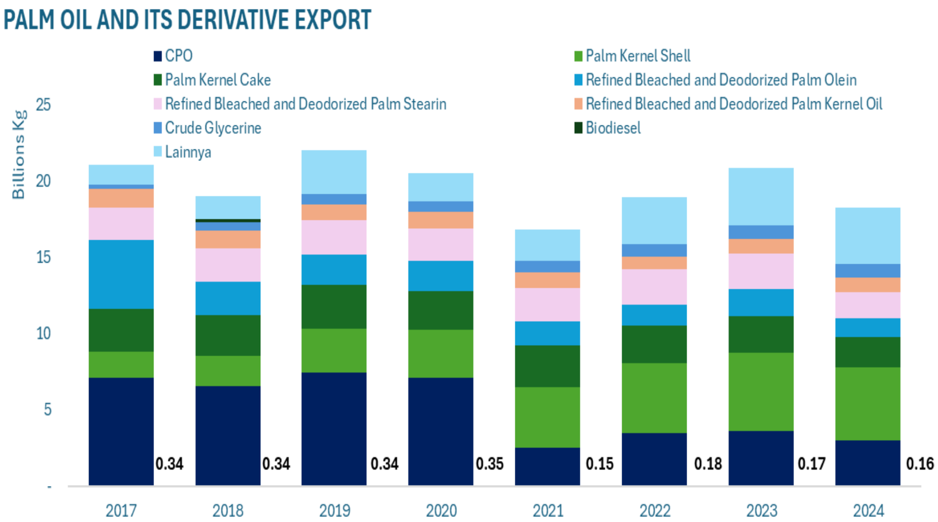
Source: 154/PMK.05/2022, PMK No. 62 tahun 2024, PMK No. 30 thn 2025

Appendix 23. Palm Oil Export Levy and Biodiesel Incentive



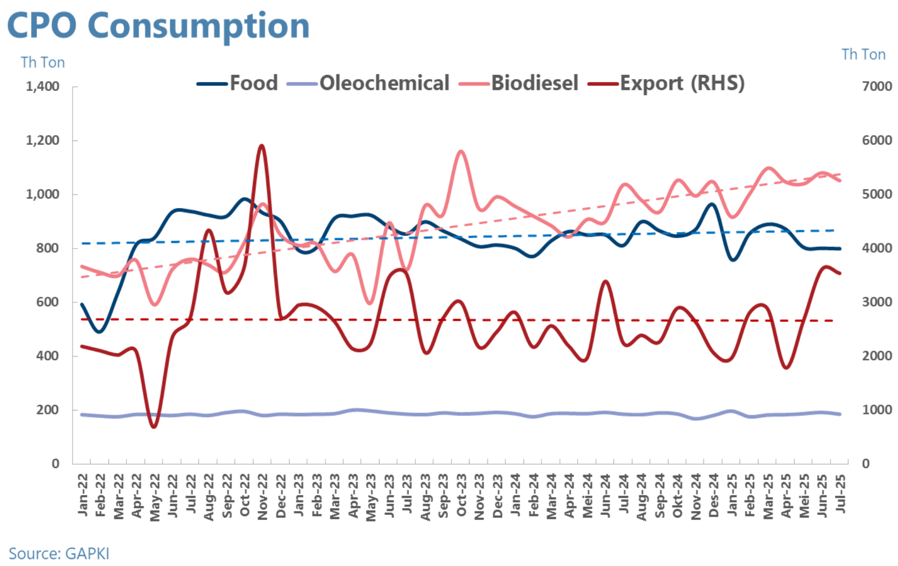
Source: Annual Report- BPDP

Appendix 24. Palm Oil and Its Derivative Export

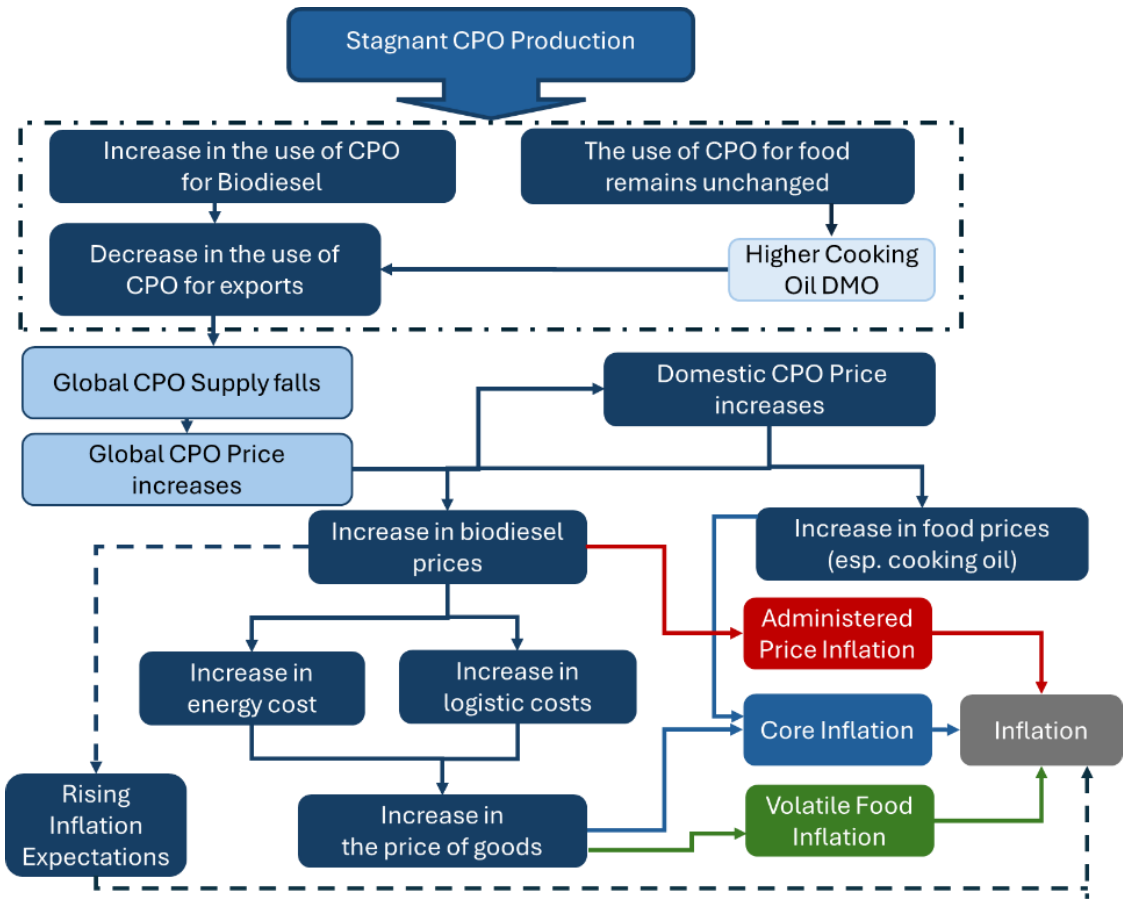


Source: Bea Cukai. Figures in black represent the share of CPO export volume to the total palm oil and derivative exports..

Appendix 25. CPO Consumption in Indonesia



Appendix 26. Transmission Mechanism of Biodiesel Policy to Inflation



Appendix 27. CPO Price Impact on Inflation

Component	Old Price	New Price	Elasticity	Weight	Inflation (%)	Contribution to CPI (ppt)	New Price	Inflation (%)	Contribution to CPI (ppt)	Share commodities to diesel*
Diesel Price Increase						B50			B60	
Direct Impact										
Diesel					**0.84**	**0.0012**		**1.67**	**0.0024**	**1.00**
Subsidiez Diesel	6,800	6,857		0.14	0.81	0.0012	6,914	1.62	0.0023	0.97
Dexlite	13,931	14,048		0.14	0.02	0.0000	14,164	0.04	0.0001	0.02
Pertamina Dexlite	14,264	14,383		0.14	0.01	0.0000	14,503	0.02	0.0000	0.01
Indirect Impact										
Transportation Tariff						**0.0025**			**0.0049**	
Intercity Transportation			0.35	0.21	0.27	0.0006		0.55	0.0011	
Inner-city Transportation			0.73	0.28	0.57	0.0016		1.15	0.0032	
ASDP			0.26	0.02	0.21	0.0000		0.41	0.0001	
Sea Transportation			0.21	0.05	0.17	0.0001		0.34	0.0002	
Train			0.16	0.13	0.13	0.0002		0.25	0.0003	
Core			0.05	65.06	0.04	**0.0256**		0.08	**0.0512**	
Volatile Food			0.02	15.76	0.02	**0.0030**		0.04	**0.0061**	
Cooking Oil Price Increase										
Cooking Oil	21,170	21,297		1.32	0.6	0.0079	21,425	1.20	0.0159	
Total Impact						**0.0402**			**0.0805**	

Component		B50	B60
CPO requirement B40 (KL)	a	15,600	15,600
CPO requirement B50/B60 (KL)	b	20,000	24,400
Additional CPO for B50/B60 = Decrease in CPO export and its derivatives (KL)	c = b-a	4,400	8,800
CPO exports and derivatives 2025 (predicted) (KL)	d	34,000	34,000

Component		B50	B60
Exports of CPO and its derivatives in B50/B60 (KL)	e = d-c	29,600	25,200
% CPO export growth	f =(e/d1)*100	-12.94	-25.88
Elasticity of CPO price with respect to CPO (and its derivatives) volume for export	h	-0.17	-0.17
CPO price increase (%)	i = f*h	2.23	4.47
Elasticity of cooking oil prices with respect to CPO prices	j	0.27	0.27
Increase in cooking oil prices (%)	k = j*i	0.6	1.2
Elasticity of diesel prices with respect to CPO prices	l	0.37	0.37
Increase in diesel prices (%)	m = l*i	0.84	1.67

Note:

- Elasticity of CPO export to CPO Price

log(CPO price) = 2.8*** – 0.17*** log(vol CPO for export) + 0.85*** log(CPO price (-1))

- Elasticty of CPO price to cooking oil price

log(cooking oil price) = 1.6*** + 0.27*** log(CPO Price) – 0.04 log(vol. CPO for food) + 0.61*** log(cooking oil price (-1)) - 0.00 dummy

- Elasticity of CPO Price to solar price

log(solar price) = -0.58 + 0.37* log(CPO price) + 0.9*** log(vol CPO for biodiesel) + 0.35*** dummy

*** Significant at p-value ≤0.01; ** Significant at 0.01< p-value ≤0.05, *** Significant at 0.05<p-value≤0.1

- Assumption: subsidized solar is subsidized biodiesel, and the price of subsidized solar changes
- Using OLS estimates for the elasticity coefficients of fuel price increases on transportation commodity tariffs in the AP, the prices of core-inflation commodities, and VF inflation

*using a proxy of fuel sales for the first semester of 2024

Appendix 28. B0-B50 Simulation Results on Environmental / Sustainability Perspective

Blend Level	Emission Reduction (% in gCO_2e/MJ)	Biodiesel Needed (M kl)	CPO Required (M tons)	Land Needed (ha)	Peat Needed to Offset (ha)
B0	0.00%	0.00	0.00	-	-
B5	3.22%	1.79	2.10	525.000	50.31
B10	6.44%	3.57	4.20	1.050.000	100.63
B15	9.66%	5.36	6.30	1.575.000	150.94
B20	12.88%	7.14	8.40	2.100.000	201.25
B25	16.10%	8.93	10.50	2.625.000	251.56
B30	19.32%	10.71	12.60	3.150.000	301.88
B35	22.54%	12.50	14.70	3.675.000	352.19
B40	25.76%	14.28	16.80	4.200.000	402.50
B45	28.98%	16.07	18.90	4.725.000	452.81
B50	32.20%	17.85	21.00	5.250.000	503.13
B60	38.64%	21.42	25.20	6.300.000	603.75
B70	45.08%	24.99	29.40	7.350.000	704.38