JIPAGI
Jurnal Inovasi Pangan dan Gizi
JIPAGI 2(2): 111–126
ISSN 3062-8881

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

The impact of biodiesel policy on the availability of cooking oil: An analysis of sustainable food strategies

Mega Putri Arumdhani[1,*]
[1] *School of Environmental Science, Universitas Indonesia, Central Jakarta, DKI Jakarta 10430, Indonesia.*
*Correspondence: mega.putri32@ui.ac.id

Received Date: January 2, 2025 Revised Date: July 21, 2025 Accepted Date: August 31, 2025

ABSTRACT

Background: Indonesia's biodiesel policy has developed rapidly as a government strategy to reduce reliance on fossil fuels and enhance the domestic added value of palm oil commodities. A growing body of literature suggests that while biodiesel policies can support national energy security and economic growth, they also create potential risks for food security and environmental sustainability. The aim of this study is to analyze the impact of Indonesia's mandatory biodiesel policy on the availability of cooking oil, a staple food commodity, in the context of sustainable food strategies. **Methods**: This research employs a descriptive-qualitative approach using a systematic literature review. Data were collected from published studies, government documents, and statistical reports related to biodiesel policy, crude palm oil allocation, and the food supply chain in Indonesia. The analysis focuses on connecting empirical evidence with the four pillars of food security and principles of environmental and social sustainability. **Findings:** The findings indicate that increased allocation of crude palm oil (CPO) for biodiesel production, primarily incentivized by government subsidies, has decreased the supply available for domestic food consumption. This has led to cooking oil shortages and price surges across several regions in Indonesia. Furthermore, the expansion of oil palm plantations to satisfy biodiesel industry demands has contributed to deforestation, biodiversity loss, and social conflicts involving local communities. **Conclusion**: The principal conclusion from this study underscores the urgency for a holistic and integrative energy policy reformulation that balances the needs of energy independence, food security, environmental sustainability, and social justice. **Novelty/Originality of this article:** This article uniquely integrates the analysis of biodiesel policy impacts on food availability with overarching sustainable development frameworks in Indonesia. The study offers new insights by linking policy analysis with food security pillars and sustainability principles, and provides actionable recommendations for policy enhancements that have not been thoroughly explored in previous research.

KEYWORDS: biodiesel; energy policy; food security; palm oil.

1. Introduction

Palm oil is a strategic commodity for Indonesia, serving not only to meet domestic needs but also as one of the country's main export commodities. Indonesia is the world's largest producer and exporter of palm oil, with production reaching 51.3 million tons in 2023, of which approximately 33 million tons were allocated for export (GAPKI, 2024a). However, in recent years, there has been an imbalance between production, domestic consumption, and government policies that prioritize the use of palm oil for biodiesel, which has implications for the availability of cooking oil in the domestic market. Cooking oil consumption in Indonesia continues to increase in line with population growth and

Cite This Article:
Arumdhani, M. P. (2025). The impact of biodiesel policy on the availability of cooking oil: An analysis of sustainable food strategies. *Jurnal Inovasi Pangan dan Gizi, 2*(2), 111-126. https://doi.org/10.61511/jipagi.v2i2.1876

changing consumption patterns among the population. In 2023, the total demand for cooking oil for national household consumption reached 2.66 million tons per year, marking a 2% increase compared to the previous year. Meanwhile, total domestic palm oil consumption reached 19.03 million tons from January to October 2023, with 8.6 million tons allocated for food, including cooking oil, and 8.46 million tons for biodiesel (GAPKI, 2024b). These data indicate that palm oil consumption for biodiesel is now nearly equal to the amount allocated for food needs, creating pressure on the domestic supply of cooking oil.

The Indonesian government has implemented a mandatory biodiesel policy since 2008, continuously increasing the proportion of biodiesel blended with petroleum diesel. In 2023, the B35 program (a blend of 35% biodiesel with 65% petroleum diesel) was officially introduced, and the government set a target to implement B40 in 2025 report by *Kementerian Energi dan Sumber Daya Mineral Republik Indonesia*/Republic Indonesian Ministry of Energy and Mineral Resources (ESDM, 2024). This policy aims to reduce fossil fuel imports, enhance national energy security, and support the palm oil industry (Coordinating Ministry for Economic Affairs of Indonesia, 2024). In addition, the policy is expected to absorb 13.15 million kiloliters of biodiesel for domestic industry (Coordinating Ministry for Economic Affairs of Indonesia, 2024). The implementation of this policy is also projected to save foreign exchange by USD 10.75 billion and increase the added value of the downstream industry by IDR 16.76 trillion. The B35 policy is further projected to reduce greenhouse gas emissions by 34.9 million tons of CO_2.

However, on the other hand, the increased allocation of palm oil for biodiesel reduces the supply of crude palm oil (CPO) that can be processed into cooking oil, causing shortages and sharp price increases in the domestic market (Tomei & Helliwell, 2016). The cooking oil crisis that occurred in 2022–2023 demonstrated the imbalance in policy between food and energy needs. Domestic cooking oil prices soared to IDR 25,000 per liter due to unstable export and distribution policies (BPS, 2024). The government had implemented the Domestic Market Obligation (DMO) policy to ensure domestic supply of cooking oil, but its implementation.

With the increasing demand for crude palm oil (CPO), the Indonesian government has favored expansion over intensification in palm oil production (Varkkey et al., 2018). In contrast to Malaysia, which by the late 1990s committed to maintaining at least 50% forest cover while supporting plantation expansion in Indonesia, the Indonesian government did not make a similar pledge (Varkkey et al., 2018). As a result, the expansionist policy adopted focused more on market creation and increasing production, with limited incentives for technology-based intensification. This approach has led to extensive land conversion, including forests and peatlands, for oil palm plantations (Varkkey et al., 2018). Research by Xin et al. (2022) estimates that Indonesia will require 313–679 million tons of palm oil products by 2050, necessitating an additional 18.58–45.59 million hectares of plantation land. If this expansion follows historical patterns, around 8%–22% of secondary forests and 21%–54% of peatlands will be lost, further exacerbating carbon emissions, given that each ton of CPO is estimated to produce 1.08 tons of CO_2-equivalent (Farizal et al., 2024).

In addition to its environmental impacts, Indonesia has also become an epicenter of large-scale species extinction and biodiversity loss due to the expansion of oil palm plantations (Dalheimer et al., 2024). The conversion of natural ecosystems into monoculture plantations reduces habitats for various species, disrupts ecological balance, and increases the risk of extinction. Further degradation of peatlands accelerates greenhouse gas emissions, which contradicts Indonesia's commitments to climate change mitigation (Goh et al., 2016). The main challenge for Indonesia is balancing palm oil production with efforts to protect forests and peatlands, which requires significant policy changes and a stronger commitment to sustainability (Afriyanti et al., 2016; Xin et al., 2022).

The expansion of oil palm plantations has also triggered numerous social conflicts between companies and local communities (Afrizal et al., 2024; Berenschot et al., 2024). According to Berenschot (2024), an analysis of 150 conflict cases revealed that palm oil companies are often confrontational actors, frequently employing specific strategies to

seize and maintain claims over land. These strategies include co-opting local leaders, building connections with local authorities, suppressing community protests, and criminalizing opposition figures. The lack of effective legal mechanisms for resolving land disputes further exacerbates tensions, resulting in the displacement of indigenous communities and human rights violations (Afrizal et al., 2024). Without stronger governance, increased transparency, and equitable land distribution policies, Indonesia's palm oil industry will continue to face escalating environmental and social crises.

By 2025, the Ministry of Environment and Forestry (KLHK, 2023) reports that forest land conversion into oil palm plantations continues to increase deforestation, ecosystem degradation, and social conflicts with indigenous communities who lose access to natural resources (Hidayat et al., 2022). Considering the environmental, social, and economic impacts, this study aims to analyze how biodiesel policy and oil palm plantation expansion affect food security, particularly the availability of cooking oil. Specifically, this study seeks to examine the impact of the mandatory biodiesel policy on the supply of palm oil for food security, evaluate the relationship between cooking oil shortages and the crude palm oil (CPO) distribution mechanisms in Indonesia, and identify the environmental, social, and economic impacts resulting from these policies and their connection to food provision. Based on these analyses, appropriate policy strategies can be formulated to balance food and energy security in the palm oil industry in a sustainable manner.

2. Methods

This study employs a descriptive-qualitative approach to gain an in-depth understanding of the relationship between biodiesel policy and the availability of cooking oil, as well as its impacts on food security and the environment. This approach allows for a comprehensive analysis of the various aspects involved in the implementation of biodiesel policy. The descriptive-qualitative method is commonly used in energy policy research to explore complex social and economic impacts.

Data were collected through a comprehensive literature review using the keywords “food security”, “crude palm oil”, and “biodiesel” in international journal databases such as Scopus, SpringerLink, and ScienceDirect. This search strategy aimed to identify previous relevant studies that have been published in reputable journals. Literature review enables researchers to integrate findings from diverse studies and provides a more holistic understanding of the research topic. The analysis was conducted by reviewing and comparing previous research findings on the impact of biodiesel policy on the availability of cooking oil, food security, and the environment. This approach allows for the identification of patterns, trends, and gaps in the existing literature, thereby providing a strong basis for drawing valid conclusions. In this way, this study is expected to make a significant contribution to understanding the social and environmental implications of biodiesel policy in Indonesia.

3. Results and Discussion

3.1 Dynamics of palm oil production and consumption in Indonesia

According to data released by the Agricultural Data and Information System Center – Ministry of Agriculture of the Republic of Indonesia (2024), the total area of oil palm plantations in Indonesia reached 16.83 million hectares in 2023. Of this total, private large plantations (*Perkebunan Besar Swasta*/PBS) managed approximately 8.42 million hectares (50.07%), smallholder plantations (*Perkebunan Rakyat*/PR) about 6.29 million hectares (37.37%), and state-owned large plantations (*Perkebunan Besar Negara*/PBN) around 545.71 thousand hectares (3.24%). In addition, there is an area still in the process of confirmation amounting to 1.40 million hectares (8.31%).

According to the Central Bureau of Statistics (BPS, 2024), in 2023, oil palm plantations in Indonesia were widely distributed across 26 provinces, covering the entire regions of Sumatra and Kalimantan, as well as several provinces on other islands such as West Java, Banten, Central Sulawesi, South Sulawesi, Southeast Sulawesi, West Sulawesi, Gorontalo, Maluku, North Maluku, Papua, and West Papua. This widespread distribution reflects the importance of palm oil as one of the leading sectors in the national economy. Among all these provinces, Riau province holds the position as the largest palm oil producer, with a plantation area reaching 3.40 million hectares or approximately 21.36% of the total oil palm plantation area in Indonesia. Riau's contribution to national production is highly significant, with total crude palm oil (CPO) production reaching 9.22 million tons in the same year.

In 2023, Indonesia's crude palm oil (CPO) production increased to 47.08 million tons. Riau Province contributed the largest share, producing 9.22 million tons, which accounted for 19.59% of the national total. The next largest producer was Central Kalimantan Province, producing 8.47 million tons or approximately 17.98% of total production. In terms of management status, the production structure in 2023 remained largely unchanged compared to previous years, with production dominated by private large plantations, which accounted for 28.66 million tons or around 60.88%. This was followed by smallholder plantations with 16.22 million tons (34.46%), while the remaining 2.20 million tons (4.67%) were contributed by state-owned large plantations, as illustrated in (Fig. 1).

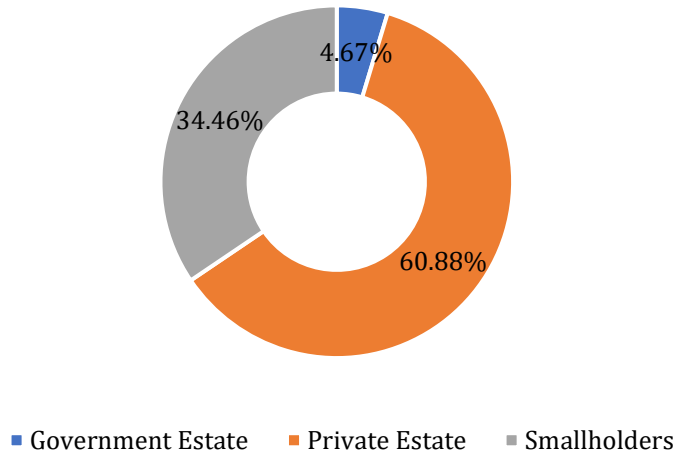

Fig. 1. Indonesian palm oil production by management status 2023 (BPS, 2024)

Private large plantations still dominate crude palm oil production, accounting for 60.88% of Indonesia's total palm oil output. This situation merits particular attention, as large-scale plantations can restrict free markets and open competition, especially for smallholders or small-scale farmers. In line with the research conducted by Cramb & McCarthy (2018), the dominance of large plantation companies in the palm oil industry has not only persisted since the colonial era but has continued into the current era of globalization. Although globalization is often associated with market liberalization, in reality, large companies actively encourage government intervention to secure access to cheap land and low-wage labor. The expansion efforts of small-scale farmers are frequently viewed as a threat to corporate interests, thereby impeding the potential for inclusive rural development. Furthermore, Cramb & McCarthy (2018) also emphasize that one of the main economic issues surrounding the palm oil boom is how to balance small-scale and large-scale agriculture, subsistence and commercial needs, as well as the roles of the state and the private sector. In this context, dependence on an industry model dominated by major corporations can increase economic and social risks, especially when faced with global market fluctuations or instability in the prices of vegetable oil and biofuels.

According to Indonesian Palm Oil Entrepreneurs Association/*Gabungan Pengusaha Kelapa Sawit Indonesia* (GAPKI), of the total crude palm oil production in Indonesia, domestic consumption reached 23.13 million tons, with 10.65 million tons used for biodiesel, 10.3 million tons for food consumption, and 2.27 million tons for the oleochemical industry (GAPKI, 2024c). This data shows that 46% of Indonesia's palm oil consumption is allocated for biodiesel production. In addition to meeting domestic needs, Indonesian palm oil is also used for export, as Indonesia is one of the largest global palm oil suppliers. According to the Central Bureau of Statistics (2024), in 2023, the total volume of palm oil and related products exported to various countries was 26.13 million tons. This means that 55% of Indonesia's total produced palm oil is exported to meet palm oil demand in other countries such as India, Italy, Malaysia, the Netherlands, Kenya, and several others. The majority of Indonesia's palm oil production is exported, while the remainder is marketed domestically. In 2023, these five countries were the largest importers of Indonesian palm oil, accounting for 97.64% of Indonesia's total palm oil exports, with India as the largest importer, receiving 86.71% of the total export volume (Agricultural Data and Information System Center, 2024).

Based on the available data, there was a deficit in meeting the national demand for palm oil in 2023. This situation can be attributed to the high volume of palm oil exports to fulfill global demand, in addition to the fact that domestic crude palm oil consumption is largely dominated by its use for biodiesel production as a renewable energy source in Indonesia. As a result, only 44.5% of the total national crude palm oil consumption is used to meet food needs.

3.2 Biodiesel policy and its impact on food security in Indonesia

Research on biodiesel in Indonesia has been ongoing since the 1950s, as noted by the ESDM (2021), indicating that the discourse on the utilization of renewable energy based on vegetable oils is not new. The various studies conducted by national researchers in those early decades served as an important foundation for the development of biodiesel technology in Indonesia. Over time, the results of this research were implemented as pilot projects in several regions, which later became the basis for the formulation of biodiesel-based energy policies. This long journey ultimately culminated in the establishment of the national mandatory biodiesel policy, which has been gradually implemented from B2.5 blends to the current B35, and is even planned to reach B40. This policy is not only part of the national energy transition strategy but also reflects Indonesia's commitment to reducing dependence on fossil fuels and increasing the added value of palm oil commodities domestically.

The mandatory biodiesel policy in Indonesia has undergone significant gradual development since its initial implementation in 2006. This process began with the issuance of the Directorate General of Oil and Gas Decree No. 3675K/24/DJM/2006, which regulated the specifications of domestic diesel fuel to allow for up to 10% Fatty Acid Methyl Ester (FAME) content. This policy was strengthened by ESDM Regulation No. 32 of 2008, which mandated the provision, utilization, and trade of biofuels as an alternative fuel. During this initial phase, Indonesia began blending biodiesel in the range of B2.5 to B7.5.

Over time, this policy has been continuously updated through several subsequent regulations, such as ESDM Regulation No. 25/2013 and No. 20/2014, which increased the blending ratio and expanded the range of users. The year 2015 marked a significant milestone with the issuance of Regulation No. 12/2015, which shifted the financing scheme from the state budget to the Palm Oil Plantation Fund Management Agency, while also setting the blending ratio at B15. The financing mechanism was further strengthened through Regulation No. 29/2016, which regulated the provision of biodiesel within the Palm Oil Plantation Fund Management Agency funding framework. Subsequently, in 2018, the government comprehensively implemented the B20 policy, including for the non-Public Service Obligation (non-PSO) sector, through Presidential Regulation No. 66 of 2018 and

ESDM Regulation No. 41 of 2018. An overview of the development roadmap for biodiesel policy in Indonesia can be seen in (Fig. 2).

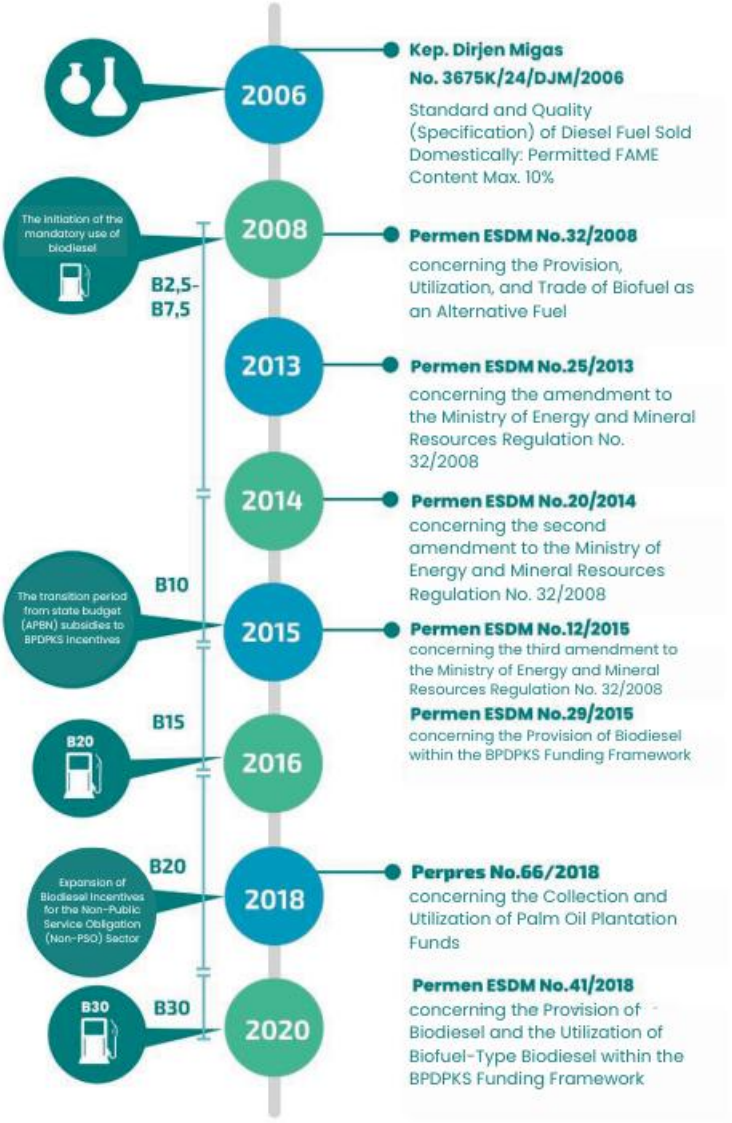

Fig. 2. Roadmap of biodiesel policy development in Indonesia (ESDM, 2021)

The policy reached its peak in 2020 with the nationwide launch of the B30 mandate. This implementation made Indonesia the first country in the world to apply a 30% biodiesel blend in diesel fuel. In general, this policy aims to strengthen national energy security, reduce dependence on fossil fuel imports, and increase the added value of crude palm oil (CPO) domestically (ESDM, 2021). Although this policy has been successful from an energy and economic perspective, the discourse regarding its impact on the food sector and environmental sustainability remains a significant debate in the context of sustainable development.

The Indonesian government is committed to further expanding the use of renewable energy through plans to increase the mandatory biodiesel blend from 35% (B35) to 40% (B40), which is targeted for nationwide implementation in 2025. This step is part of the country's energy transition strategy and greenhouse gas emission reduction efforts, while also aiming to enhance the added value of domestic palm oil, strengthen national energy security, and reduce dependence on fossil fuel imports (ESDM, 2024; Christina, 2025). This indicates that Indonesia will continue to increase domestic palm oil consumption as a raw

material for biodiesel, in line with the rising blend percentage mandated through current and forthcoming government policies.

Food security is a multidimensional, complex, and highly dynamic concept that has been defined in various ways by international organizations, academics, and policymakers. Among the numerous definitions available, one of the most widely used and broadly accepted is the definition adopted at the 1996 World Food Summit, which was later refined by the Food and Agriculture Organization (FAO) in 2001. According to this definition, food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active, healthy, and productive life in a sustainable manner. This concept emphasizes not only the quantitative availability of food, but also includes the dimensions of food quality, sustainability of food systems, and resilience to external disturbances or shocks.

This definition highlights four main pillars that form the foundation of food security: availability, access, utilization, and stability. The first pillar, availability, refers to the extent to which food is physically present in a region, which may result from local production, interregional or international imports, as well as food reserves managed by the government or community organizations. The second pillar, access, emphasizes the ability of individuals or households to obtain available food equitably and fairly, which is heavily influenced by factors such as income, food prices, market infrastructure, and logistics distribution. Good access is not only about the presence of food in the market, but also whether people can actually afford to purchase it, both economically and socially.

The third pillar is utilization, which refers to how available food can be used in a healthy and nutritious manner by individuals. This includes how food is cooked, processed, and how nutrients are absorbed by the body, all of which are greatly influenced by factors such as sanitation conditions, access to clean water, nutrition knowledge, and overall health status. The fourth pillar, stability, pertains to the temporal aspect of food security, meaning that the previous three pillars must be sustained consistently over the long term. Stability is especially important in the context of climate change, economic crises, conflict, and natural disasters, which can disrupt the food system in both the short and long term.

The use of food crops as energy sources, such as in biofuel production, has significant potential to affect the structurally established food systems within society. Such changes can have considerable impacts on various aspects of food security, which, according to the Food and Agriculture Organization (FAO), is comprised of four main pillars: availability, access, utilization, and stability (FAO, 2014). The first pillar, availability, refers to the supply of food through production, distribution, and exchange. In this context, biofuel production that utilizes food crops such as corn, soybeans, or palm oil can divert agricultural outputs from human consumption to energy use, thus directly reducing food availability (Sorda et al., 2010).

The second pillar, access, pertains to the ability of individuals or households to obtain sufficient and nutritious food. When demand for food crops for bioenergy increases, food prices have the potential to rise, thereby decreasing people's capacity—especially among vulnerable groups—to purchase the food they need (Searchinger et al., 2008). The third pillar, utilization, refers to the way food is consumed and utilized by the human body, including cooking practices, nutritional content, and sanitation. Although biofuel production does not directly affect utilization, drastic changes in availability and access can influence consumption patterns and the overall nutritional status of the population (Pinstrup-Andersen, 2009).

Finally, the pillar of stability emphasizes the importance of maintaining the continuity and consistency of the other three pillars over the long term. Fluctuations in food prices caused by energy markets or dependence on biofuel commodities can result in instability within the food system, thereby undermining food security in the long run, especially in a global context that is increasingly vulnerable to climate and economic crises (de Schutter, 2009; FAO, 2014). Therefore, it is crucial to carefully assess and design bioenergy policies to avoid compromising the key dimensions of existing food security.

The introduction of using food crops as energy sources inevitably leads to changes in the established food system. Food security is commonly defined as a condition in which all people, at all times, have physical, economic, and social access to sufficient, safe, and nutritious food that meets their dietary needs and preferences for an active and healthy life. Its core components include food safety, affordability, and availability.

The Indonesian government actively provides subsidies to the biodiesel industry as part of a national strategy to strengthen energy security and reduce dependence on imported fossil fuels. This policy is implemented through mandatory biodiesel schemes, such as the B30 and B35 programs, which require the blending of biodiesel made from crude palm oil (CPO) into transportation fuels. The implementation of these policies is fully supported by the Palm Oil Plantation Fund Management Agency (BPDPKS), which utilizes export levy funds to cover the price gap between biodiesel and conventional diesel fuel, thereby ensuring the competitiveness and sustainability of the domestic biodiesel sector.

The impact of these subsidies is evident in the allocation preferences of major CPO producers, who tend to prioritize sales to the energy sector (biodiesel) or for export due to guaranteed pricing and financial incentives, rather than supplying the domestic food sector. This situation reinforces the trend of shifting CPO use away from household consumption needs, such as cooking oil, toward energy and international industrial needs. As a result, fluctuations in domestic CPO supply and pricing can trigger food price volatility, as seen in the national cooking oil crisis in 2022, which was driven by imbalances in supply and distribution.

The potential for food price increases as a result of rising demand for biofuel feedstocks has become a major concern in global economic discourse, particularly within the context of the "food versus fuel" debate over the past two decades. This issue has been highlighted in a literature review by Serra & Zilberman (2013), which analyzed 33 scientific publications on the relationship between food and energy prices. Their findings indicate that 20 of these publications confirm a long-term relationship between energy or biofuel prices and the prices of major feedstocks, providing evidence of structural interdependence between the sectors. In the context of Indonesia, this issue is especially relevant as crude palm oil (CPO) producers tend to allocate their production towards exports or the domestic biodiesel sector, a trend strongly driven by government subsidies and incentives in support of the national mandatory biodiesel policy. Such policies indirectly affect the distribution of CPO for domestic food needs, potentially leading to price pressures on derivative products such as cooking oil.

Research conducted by Papilo et al. (2022), which systematically reviewed the policies, sustainability, and implications of palm oil-based bioenergy in Indonesia and Malaysia, found that government subsidies for biodiesel enhance its competitiveness. These subsidies keep the selling price of biodiesel competitive despite its higher production costs compared to conventional diesel, which encourages CPO producers to sell to domestic biodiesel producers, as the market becomes more stable and is guaranteed by the state.

Another study by Mayandi & Suharjito (2024), using a dynamic systems modeling approach, sought to understand the complex interactions between CPO production, domestic demand for food, export needs, and biodiesel production by considering variables such as annual CPO production rates, biodiesel production capacity, domestic demand for palm oil for food, CPO export volumes, and government policies regarding subsidies and mandatory biodiesel. The simulation results indicate that an increase in biodiesel production, driven by mandatory policies and government subsidies, can reduce the availability of CPO for export and domestic food needs. Increased allocation of CPO for biodiesel leads to a decrease in the volume of CPO available for export, which could potentially affect national foreign exchange earnings. Furthermore, the rising use of CPO for biodiesel can reduce the supply available for the domestic food industry, potentially resulting in higher prices of cooking oil and its derivative products.

Indonesia experienced significant cooking oil shortages throughout 2022 and into early 2023, which drew considerable attention both nationally and internationally due to their

serious impact on the economy and community welfare, especially among vulnerable groups (Bukit et al., 2022; Pratiwi et al., 2023). Various factors were identified as causes of these shortages, one of which was addressed in the study by Bukit et al. (2022), who highlighted the ineffectiveness of the Domestic Market Obligation (DMO) and Domestic Price Obligation (DPO) policies. This is supported by an analysis from the Head of the Center for Industry, Trade, and Investment at INDEF (Institute for Development of Economics and Finance), who pointed out that the ineffectiveness of the DMO and DPO policies was due to difficulties in reallocating palm oil raw materials from the biodiesel sector, which receives significant subsidies from the Palm Oil Plantation Fund Management Agency (BPDPKS), to the cooking oil production sector. According to him, the price disparity between the international and domestic markets, which is offset by BPDPKS subsidies, made biodiesel products economically more attractive than cooking oil.

Similarly, the Executive Director of the Indonesian Vegetable Oil Industry Association (GIMNI), Sahat Sinaga, stated that the policy was not fully effective because many CPO exporters and its derivative product exporters did not fully comply with the DMO and DPO regulations established by the Ministry of Trade to ensure domestic supply stability (Bukit et al., 2022). The situation of shortages and rising cooking oil prices is directly related to food security issues, particularly violating the access pillar (accessibility). This pillar emphasizes the ability of individuals or households to obtain food both physically and economically, so when prices soar due to scarcity, food access for low-income communities becomes severely disrupted, placing food security in a vulnerable state (FAO, 2014).

3.3 Social, economic, and environmental impacts of biodiesel policy in Indonesia

The implementation of the mandatory biodiesel policy in Indonesia has generated a range of social impacts, both positive and negative. On the positive side, this policy has created new job opportunities, particularly in the palm oil agribusiness sector and the biodiesel processing industry, which indirectly contribute to improving the welfare of some local communities and strengthening regional economies (Mukherjee & Sovacool, 2014). However, the negative social impacts of this policy are also significant. One prominent negative impact is land conflict, where the expansion of oil palm plantations to meet biodiesel production requirements often clashes with customary lands or those of local communities. Such conflicts have led to the loss of indigenous peoples' access to their natural resources, local ecosystem degradation, and the emergence of prolonged social disputes (Berenschot et al., 2024; McCarthy, 2018).

The expansion of palm oil plantations in Indonesia has also been accompanied by a rise in social conflicts between plantation companies and local communities or indigenous peoples (Afrizal et al., 2024; Berenschot et al., 2024). According to research by Berenschot et al. (2024), which provides an in-depth analysis of 150 palm oil plantation-related conflicts in Indonesia, companies often act proactively and strategically in maintaining their land claims. Strategies include co-opting influential local leaders, building strategic relationships with government authorities to gain legal or administrative support, suppressing community protest movements, and criminalizing community leaders who oppose company claims. This situation is exacerbated by the limited effectiveness of existing legal mechanisms for resolving land disputes fairly, ultimately leading to increased social tensions, the displacement of indigenous communities, and systematic human rights violations (Afrizal et al., 2024).

In addition, another social impact is the disruption of domestic food security, particularly concerning shortages and increases in cooking oil prices. Because allocating crude palm oil (CPO) to biodiesel production is more profitable, the supply of raw materials for the domestic cooking oil industry becomes limited, resulting in price spikes that burden society, especially low-income groups who are highly dependent on cooking oil as a staple food necessity (Bukit et al., 2022; Pratiwi et al., 2023).

The implementation of the mandatory biodiesel policy in Indonesia has demonstrated complex and multifaceted economic impacts. One of the main actors in the development of this industry is the Indonesian Biofuel Producers Association/*Asosiasi Produsen Biofuel Indonesia* (APROBI), which was established to unite various biodiesel industry companies, strengthen domestic business positions, and serve as a strategic partner for both central and regional governments to increase competitiveness in national and international markets (APROBI, 2006). Various scientific studies confirm that biodiesel policy provides economic benefits for Indonesia, including reducing fossil fuel imports, thereby saving foreign exchange, and increasing added value in the domestic industry (Wirawan et al., 2024).

According to research by Sahara et al. (2022), the application of a computable general equilibrium (CGE) model shows that the implementation of a 30% biodiesel policy (B30) can increase real Gross Domestic Product (GDP) by 0.058%, reflecting significant economic growth from the biodiesel sector. The same study also found that two policy scenarios—B30 mandate and the impact of European Union trade restrictions—generally have a positive effect on macroeconomic variables, including increases in real GDP and real wages. However, both policies also trigger short-term inflationary effects and may reduce the production of certain agricultural commodities, such as sugarcane, fruits, vegetables, and soybeans, ultimately leading to higher food prices.

The implications of these policies underline that the B30 mandate and the European Union export ban do not automatically improve the fuel trade balance. These findings are consistent with other research, such as Wirawan et al. (2024), which highlights that while biodiesel can drive economic development and reduce greenhouse gas emissions, the use of food-based raw materials like palm oil for renewable energy raises concerns about the stability of food security.

Sustainability issues in Indonesia's palm oil industry have become increasingly complex as global demand for palm oil products rises and national policies promote production expansion. Recent studies have examined the environmental, social, and spatial aspects of palm oil production, involving both smallholder farmers and large companies. These studies provide important insights into the impacts of land expansion-based development strategies, limited intensification, and the ecological effects of operational practices and replanting in the sector. Using multidisciplinary approaches—including spatial analysis, carbon emission projections, and assessments of local community perceptions—these studies reinforce the urgent need to formulate more sustainable palm oil policies.

Based on the findings of Varkkey et al. (2018), it can be concluded that Indonesia's approach to developing its palm oil sector tends to prioritize land expansion over intensification. Although there have been increases in productivity and profitability within the sector, the Indonesian government has yet to demonstrate a strong commitment to limiting land expansion, as has been done by Malaysia. The absence of a clear national policy targeting forest cover preservation has driven an expansionist strategy focused on meeting production targets and expanding markets, but this approach has not been sufficiently supported by incentives to promote efficiency improvements through technological innovation or agricultural intensification. This situation gives rise to several challenges, including accelerated deforestation, conversion of peatlands, and tenure conflicts with local communities. If this pattern continues without a shift toward more sustainable policies, Indonesia risks long-term natural resource degradation and declining environmental integrity. Therefore, the study’s findings underscore the importance of reforming national policies to not only pursue economic growth and increased production volumes, but also to strengthen land governance, environmental commitments, and incentives for sustainable intensification.

The research conducted by Xin et al. (2022) provides a comprehensive assessment of local responses to land use changes and associated environmental impacts in Indonesia resulting from the dynamics of the global palm oil market. The findings indicate that

approximately 313 to 679 million tons of palm oil products (fresh fruit bunch equivalent) from Indonesia will be required by 2050. This amount implies the need for opening up new land areas totaling around 18.58 to 45.59 million hectares. It is estimated that 8% to 22% of secondary forests and 21% to 54% of peatlands would be lost due to oil palm plantation expansion if this expansion follows historical patterns. However, if expansion is redirected from natural forests and peatlands to degraded lands with low environmental value, CO_2 emissions could be reduced by approximately 87 to 142 million tons per year. Nevertheless, this approach would have consequences in the form of increased transportation costs and infrastructure accessibility challenges.

Farizal et al. (2024) conducted research to estimate the carbon footprint of a palm oil company's operations in 2030. In this study, they developed a new methodology that combines the Organizational Lifecycle Assessment (O-LCA) approach, Simple Linear Regression (SLR), and Double Exponential Smoothing (DES). The O-LCA method was used to identify emission sources and calculate the amount of emissions produced, while SLR and DES methods were employed to project future trends of these emission sources. The results indicated that the carbon footprint in 2030 is estimated to reach 62,758,433.56 kilograms of carbon dioxide equivalent (CO_2eq), with an average of each ton of crude palm oil (CPO) producing around 1.08 tons of CO_2eq.

The study also revealed that the three largest emission sources came from palm oil mill effluent (POME), fertilizer use, and transportation activities. Based on calculations using the IPCC method and referencing the commercial database published by Ecoinvent, it was found that each kilogram of biodiesel produced generates an average of 0.487 kilograms of carbon dioxide equivalent (CO_2-eq) within the Global Warming Potential (GWP) impact category. When converted to tons, this means that each ton of biodiesel contributes 0.487 tons of CO_2-eq emissions. This value reflects the contribution of greenhouse gas emissions from biodiesel production processes to global warming and serves as a key indicator in evaluating the sustainability of biofuel life cycles. Although biodiesel is often considered a more environmentally friendly alternative compared to fossil fuels such as diesel, these results demonstrate that biodiesel still has measurable emission impacts that should be thoroughly considered in environmental analyses.

The research conducted by Azhar et al. (2023) makes an important contribution to understanding the differences in the spatial characteristics of oil palm replanting by smallholders and large-scale companies, as well as the potential environmental impacts, particularly on avian biodiversity. Utilizing landscape metrics such as land size, shape of planting areas, and distance from the center of the land to its boundary, this study assessed how the spatial structure of an area can affect habitat quality and the movement of wildlife within oil palm production landscapes. The findings showed that landscape metrics in large-scale industrial plantations tend to be higher compared to smallholder plantations. This can be interpreted to mean that large-scale replanting practices have a broader impact on landscape transformation, which can potentially disrupt wildlife movement, including that of local birds, and lead to declines in population or changes in their distribution patterns. In addition to the spatial analysis, the participation of 52 local bird observers in this study enriched the data by providing social-ecological perspectives. This underscores that the impacts of replanting on biodiversity should not only be measured through technical spatial approaches but also understood through the perceptions and direct experiences of local communities who interact with these landscapes.

Overall, this body of research highlights that the expansionist approach, which has long dominated Indonesia's palm oil industry, has created a variety of environmental challenges. Accordingly, there is an urgent need to shift the focus from land expansion toward sustainable intensification, and to strengthen environmental and social governance—both through spatial planning that is sensitive to biodiversity and by promoting transparency in emissions and ecological impacts. This inclusive and data-driven approach is essential to ensure that the growth of Indonesia's palm oil industry does not come at the expense of environmental conservation and the well-being of local communities.

3.4 Strategies for achieving a more sustainable balance between food and energy security

Food and energy are closely interconnected, especially in the context of the transition towards renewable energy, where various food commodities such as palm oil, corn, and sugarcane serve as primary raw materials for bioenergy production. This dependency creates complex dynamics, as increasing demand for renewable energy has the potential to compete with food needs, both in terms of resource availability and price stability. Consequently, unique challenges arise in achieving sustainable food and energy security.

The study by Bigerna et al. (2022), titled "Convergence of Ecological Footprint and Sustainable Policy Options: A New Multivariate Environmental Kuznets Curve Analysis," makes an important contribution to understanding the relationship between economic growth, resource consumption, and sustainable development policies. This research employs a modified multivariate Environmental Kuznets Curve (EKC) approach to analyze how various factors, such as per capita income, energy consumption, and urbanization, interact with the ecological footprint as an indicator of environmental pressure. Using panel data from a number of countries, the study found that countries with stricter environmental policies tend to experience a decline in their ecological footprint after reaching a particular threshold in national income. On the other hand, in countries with weaker environmental policies, economic growth and urbanization exacerbate environmental impacts. The research also demonstrates that integrating economic and environmental policies is crucial for achieving a balance between development and natural resource conservation. The implications of this study are highly relevant for the formulation of sustainable development policies. The authors recommend that the ecological footprint indicator be used more broadly as a tool for policy evaluation, particularly in developing countries. The multivariate approach also illustrates that policy effectiveness cannot be measured from a single perspective, but must simultaneously consider the interconnections among social, economic, and environmental dimensions.

Policies to be implemented must take into account various cross-sectoral aspects, given that food, water, and energy are now the three main pillars that are interconnected within the resource nexus framework. These three sectors can no longer be separated, as they influence one another and form complex interdependencies within socio-ecological systems. In this context, the food security principles adopted by the Roundtable on Sustainable Biomaterials (RSB) serve as a concrete example of how biomass-based energy policies must be carefully designed so as not to compromise people's rights to food.

The RSB explicitly states that biomass production for energy purposes must not compromise local communities' access to adequate, nutritious, and affordable food. Therefore, every bioenergy project is required to conduct a thorough and participatory risk assessment to identify potential impacts on food availability and accessibility. This assessment includes an analysis of changes in local food production systems, price fluctuations, and the loss of access to land and natural resources. In addition, it is crucial to actively involve affected communities, especially indigenous groups, through mechanisms such as Free, Prior and Informed Consent (FPIC). If there are indications that food security may be compromised, project developers are obliged to implement mitigation measures such as diversifying food sources, enhancing local agricultural capacity, or providing fair compensation.

Furthermore, the *Rencana Strategi Bisnis*/Business Strategy Plan (RSB) also sets strict criteria regarding the types of biomass feedstocks considered eligible for use—specifically, only feedstocks that do not directly compete with food and are not sourced from land with high conservation value. Examples of allowable feedstocks include agricultural waste and residues (such as straw, bagasse, husks), processing industry waste (such as used cooking oil, distillers' grains), non-food crops that grow on marginal land, products resulting from the restoration of degraded land, and organic solid waste from commercial or urban sectors. Thus, the food security principles and sustainable feedstock criteria established by the RSB

can serve as important references in formulating energy and bioeconomy policies that are not only technically efficient but also socially equitable and ecologically responsible.

4. Conclusions

This study reveals that although the mandatory biodiesel policy in Indonesia provides benefits in strengthening energy security and driving national economic growth, it also brings serious consequences for food security and environmental sustainability. The large allocation of palm oil to the energy sector, coupled with government incentives and subsidies, has resulted in a decline in the availability of palm oil for domestic food consumption, contributing to shortages and surges in cooking oil prices. The dominance of large corporations in the production and distribution of palm oil further increases the vulnerability of the food system, particularly with regard to accessibility for vulnerable groups. In addition, uncontrolled plantation expansion has led to ecosystem degradation, greenhouse gas emissions, and social conflicts with indigenous communities.

Given the interconnections between food, energy, and the environment, future policies should adopt the precautionary principle and a cross-sectoral approach. Alternative strategies such as sustainable intensification, strengthened land governance, and the implementation of standard criteria for the selection of energy feedstocks—with explicit consideration of their impact on food security—must be prioritized in formulating policies that are fair, inclusive, and environmentally responsible to ensure a balance between food and energy security in the future.

Acknowledgement
The author express their sincere gratitude to the esteemed reviewers and editors for their valuable time, insightful comments, and constructive suggestions, which have greatly contributed to the improvement of this manuscript.

Author Contribution
Each author is expected to make substantial contributions to the design or design of the The authors contributed fully to the writing of this scientific article, from the planning stage to the final editing.

Funding
This research received no external funding.

Ethical Review Board Statement
Not available.

Informed Consent Statement
Not available.

Data Availability Statement
Not available.

Conflicts of Interest
The author declare no conflict of interest.

References

Afriyanti, D., Kroeze, C., & Saad, A. (2016). Indonesia palm oil production without deforestation and peat conversion by 2050. *Science of the Total Environment, 557–558*, 562–570. https://doi.org/10.1016/j.scitotenv.2016.03.032

Afrizal, Putra, E. V., & Elida, L. (2024). Palm oil expansion, insecure land rights, and land-use conflict: A case of palm oil centre of Riau, Indonesia. *Land Use Policy, 146*(August), 107325. https://doi.org/10.1016/j.landusepol.2024.107325

BPS. (2024). *Analisis Kinerja Perdagangan Komoditas Kelapa Sawit*. Badan Pusat Statistik. https://satudata.pertanian.go.id/assets/docs/publikasi/1F_Analisis_Kinerja_Perdagangan_Kelapa_Sawit_2024_-_publish.pdf

Berenschot, W., Dhiaulhaq, A., Hospes, O., Afrizal, & Pranajaya, D. (2024). Corporate contentious politics: Palm oil companies and land conflicts in Indonesia. *Politica Geography, 114*(June), 103166. https://doi.org/10.1016/j.polgeo.2024.103166

Bigerna, S., Bollino, C. A., & Polinori, P. (2022). Convergence of ecological footprint and sustainable policy options. *Journal of Policy Modeling, 44*(3), 564–577. https://doi.org/10.1016/j.jpolmod.2022.07.001

Bukit, A. N., Hasanah, U., Na'im, K., & Elyani, E. (2022). Kenaikan harga minyak goreng dalam perspektif hukum persaingan usaha dan ekonomi. *Jurnal Justisia: Jurnal Ilmu Hukum, Perundang-Undangan Dan Pranata Sosial, 7*(1), 61. https://doi.org/10.22373/justisia.v7i1.13212

Christina, B. (2025). *Indonesia Expects To Reach Full Implementation Of B40 Biodiesel In March*. reuters.com. https://www.reuters.com/sustainability/climate-energy/indonesia-expects-reach-full-implementation-b40-biodiesel-march-2025-02-14/

Cramb, R., & McCarthy, J. F. (Eds.). (2016). The oil palm complex: smallholders, agribusiness and the state in Indonesia and Malaysia. *NUS Press.* https://doi.org/10.2307/j.ctv1xz0km

Dalheimer, B., Parikoglou, I., Brambach, F., Yanita, M., Kreft, H., & Brümmer, B. (2024). On the palm oil-biodiversity trade-off: Environmental performance of smallholder producers. *Journal of Environmental Economics and Management, 125*(March). https://doi.org/10.1016/j.jeem.2024.102975

De Schutter, O. (2009). The Right to Food and the political economy of hunger. *FAO Conference*. https://api.semanticscholar.org/CorpusID:211225672

ESDM. (2021). *Biodiesel, Jejak Panjang Sebuah Perjuangan.* Esdm.go.id. https://www.esdm.go.id/assets/media/content/content-buku-biodiesel-jejak-panjang-perjuangan-.pdf

ESDM (2024). *Menteri ESDM: B40 Bisa Jalan Tahun Depan.* Esdm.go.id. https://www.esdm.go.id/id/media-center/arsip-berita/menteri-esdm-b40-bisa-jalan-tahun-depan

FAO. (2014). *Committee on World Food Security (CFS) global strategic framework for food security & nutrition (GSF)*. https://www.fao.org/3/mb060e/mb060e.pdf

Farizal, F., Amanda, T., Dachyar, M., & Noor, Z. Z. (2024). 2030 oil palm plantation carbon footprint estimation using O-LCA and forecasting. *Journal of Cleaner Production*, *463*, 142646. https://doi.org/10.1016/j.jclepro.2024.142646

GAPKI. (2024b). *Ketum GAPKI: Konsumsi Sawit Indonesia Capai 25 Juta Ton, Terbesar Sedunia!*. Gapki.id. https://gapki.id/news/2024/01/17/ketum-gapki-konsumsi-sawit-indonesia-capai-25-juta-ton-terbesar-sedunia/

GAPKI. (2024a). *Kinerja Industri Minyak Sawit Tahun 2023 & Prospek Tahun 2024.* Gapki.id. https://gapki.id/news/2024/02/27/kinerja-industri-minyak-sawit-tahun-2023-prospek-tahun-2024/#:~:text=Kinerja

GAPKI. (2024c). *Sawit Jadi Tulang Punggung Ekonomi Indonesia! Begitu Kata Wamentan Sudaryono.* Gapki.id. https://gapki.id/news/2024/11/07/sawit-jadi-tulang-punggung-ekonomi-indonesia-begitu-kata-wamentan-sudaryono/?utm_source=chatgpt.com

Goh, C. S., Wicke, B., Verstegen, J., Faaij, A., & Junginger, M. (2016). Linking carbon stock change from land-use change to consumption of agricultural products: A review with Indonesian palm oil as a case study. *Journal of Environmental Management, 184*, 340–352. https://doi.org/10.1016/j.jenvman.2016.08.055

Mayandi, Z., & Suharjito. (2024). Palm oil-based biodiesel industry sustainability model using dynamic systems to balance food, energy, and export allocations. *Smart Agricultural Technology, 7*(February). https://doi.org/10.1016/j.atech.2024.100421

Mukherjee, I., & Sovacool, B. K. (2014). Palm oil-based biofuels and sustainability in southeast Asia: A review of Indonesia, Malaysia, and Thailand. *Renewable and Sustainable Energy Reviews, 37*, 1–12. https://doi.org/https://doi.org/10.1016/j.rser.2014.05.001

Papilo, P., Marimin, M., Hambali, E., Machfud, M., Yani, M., Asrol, M., Evanila, E., Prasetya, H., & Mahmud, J. (2022). Palm oil-based bioenergy sustainability and policy in Indonesia and Malaysia: A systematic review and future agendas. *Heliyon, 8*(10), e10919. https://doi.org/10.1016/j.heliyon.2022.e10919

Pinstrup-Andersen, P. (2009). Food security: definition and measurement. *Food Security, 1*(1), 5–7. https://doi.org/10.1007/s12571-008-0002-y

Pratiwi, D. S., Arkusi, F., & Wardani, K. H. J. (2023). Analisis faktor – faktor yang menyebabkan kelangkaan minyak goreng Indonesia tahun 2022. *Jurnal Economina, 2*(12), 3688–3696. https://doi.org/10.55681/economina.v2i12.1061

Sahara, Dermawan, A., Amaliah, S., Irawan, T., & Dilla, S. (2022). Economic impacts of biodiesel policy in Indonesia: a computable general equilibrium approach. *Journal of Economic Structures, 11*(1). https://doi.org/10.1186/s40008-022-00281-9

Searchinger, T., Heimlich, R., Houghton, R. A., Dong, F., Elobeid, A., Fabiosa, J., Tokgoz, S., Hayes, D., & Yu, T. H. (2008). Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from land-use change. *Science, 319*(5867), 1238–1240. https://doi.org/10.1126/science.1151861

Serra, T., & Zilberman, D. (2013). Biofuel-related price transmission literature: A review. *Energy Economics, 37*, 141–151. https://doi.org/https://doi.org/10.1016/j.eneco.2013.02.014

Sorda, G., Banse, M., & Kemfert, C. (2010). An overview of biofuel policies across the world. *Energy Policy, 38*(11), 6977–6988. https://doi.org/https://doi.org/10.1016/j.enpol.2010.06.066

Tomei, J., & Helliwell, R. (2016). Food versus fuel? Going beyond biofuels. *Land Use Policy, 56*, 320–326. https://doi.org/10.1016/j.landusepol.2015.11.015

Varkkey, H., Tyson, A., & Choiruzzad, S. A. B. (2018). Palm oil intensification and expansion in Indonesia and Malaysia: Environmental and socio-political factors influencing policy. *Forest Policy and Economics, 92*(April), 148–159. https://doi.org/10.1016/j.forpol.2018.05.002

Wirawan, S. S., Solikhah, M. D., Setiapraja, H., & Sugiyono, A. (2024). Biodiesel implementation in Indonesia: Experiences and future perspectives. *Renewable and Sustainable Energy Reviews, 189*(September 2023). https://doi.org/10.1016/j.rser.2023.113911

Xin, Y., Sun, L., & Hansen, M. C. (2022). Oil palm reconciliation in Indonesia: Balancing rising demand and environmental conservation towards 2050. *Journal of Cleaner Production, 380*(P2), 135087. https://doi.org/10.1016/j.jclepro.2022.135087

Biographies of Author

Mega Putri Arumdhani, School of Environmental Science, Universitas Indonesia, Central Jakarta, DKI Jakarta 10430, Indonesia.

- Email: mega.putri32@ui.ac.id
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A