TRACTION ENERGY ASIA

WORKING PAPER I – 2020

ASSESSMENT OF THE PALM OIL REPLANTING PROGRAM TO SUPPORT INDONESIA'S GREEN FUEL POLICY

2020

Alin Halimatussadiah
Atiqah A. Siregar
Faizal R. Moeis
Rafika F. Maulia

Traction Energy Asia contacts:

Traction Energy Asia
Plaza Marein Lt. 23
Jl. Jend. Sudirman Kav 76-78
Kuningan, Kecamatan Setiabudi,
Jakarta, 12910, INDONESIA

email: info@tractionenergy.asia
website: https://www.tractionenergy.asia/

WORKING PAPER 1 – 2020

ASSESSMENT OF THE PALM OIL REPLANTING PROGRAM TO SUPPORT INDONESIA'S GREEN FUEL POLICY

2020

Alin Halimatussadiah
Atiqah A. Siregar
Faizal R. Moeis
Rafika F. Maulia

TRACTION ENERGY ASIA

Executive Summary

Indonesia's biodiesel policy underwent a progressive change after the Government achieved its target of implementing the 30% mix (B30) in early 2020, in accordance with the Regulation of the Minister of Energy and Mineral Resources No. 12 of 2015. The Government began collaborating with various parties, such as Institut Teknologi Bandung (ITB) and PT Rekayasa Industri, to conduct research and development on the use of biofuel, referred to as 'green fuel'. As a new and higher quality biofuel, green fuel is expected to replace biodiesel.

Nevertheless, considering that demand for crude palm oil (CPO) as biodiesel feedstock is projected to continue increasing in the future, it is important to observe the impacts of the policy from the economic, environmental, and social perspectives. Therefore, this study aims to:

1. project the demands for biodiesel and green fuel in various scenarios up to 2025;
2. estimate the area needed for replanting palm oil in order to meet the increasing demand;
3. determine the priority of palm oil plantation replanting activities in seven provinces; and
4. estimate the impact of the replanting program on the welfare of farmers and regional economies.

This study shows that the policy on biodiesel and green fuel has the potential to increase the CPO deficit from 34.9 million tonnes (B30 scenario) to 122 million tonnes (B50 and green gasoline scenario) by 2025. The size of the deficit will be greatly influenced by the increasing energy mix target and the assumption that CPO exports will keep increasing in accordance with the business-as-usual scenario, regardless of the current international trade issues.

Since the enactment of Presidential Instruction No. 8 of 2018, the Indonesian Government has been encouraging intensification efforts by increasing the productivity of palm oil plantation through replanting, especially for independent smallholders. By using the dynamic model, the additional land area required for palm oil plantations to meet the projected CPO demand for different policy scenarios by 2025 is estimated to be between 3.8 million to 16.6 million hectares out of the total palm oil plantations currently existing in Indonesia.

With the assumption that 40% of area set for replantation are smallholder plantations, it will be crucial to secure adequate funding, particularly for independent smallholders. The Indonesian Palm Oil Plantation Fund Management Agency (*Badan Pengelola Dana Perkebunan Kelapa Sawit*/BPDP-KS) must prepare at least Rp39 trillion in funding for the implementation of the replanting program in 2020 and 2021 (with B30 scenario).

However, BPDP-KS only needs to spend Rp4.5 trillion annually as the Government only targets 180,000 hectares of plantation to be replanted annually, much smaller than the figure estimated in this study. With this scheme, the output of smallholder plantations will not be able to meet CPO demands in 2025 for all scenarios except B20.

On the other hand, the replanting program is projected to increase plantation yields, thus enabling poverty reduction among palm oil farmers and at the same time creating positive impacts on regional economy. Poverty reduction attributable to palm oil replanting activities in the seven main palm-oil-producing provinces will be as high as 2.09 percentage points, whereas P1 (poverty gap) reduction in these areas will be Rp1,683. Meanwhile, the impact on Gross Regional Domestic Product (*Produk Domestik Regional Bruto*/PDRB) will have different magnitudes, proportional to the stimulant (replanting result) and the palm oil/plantation sector multiplier of each area.

From the explanation above, it can be seen that the support given to the replanting program is especially important to create positive impacts, both for the farmers and for the region. Nevertheless, there are other issues that need to be immediately resolved for the program to achieve its target, such as (1) the cashflow sustainability of BPDP-KS as a public funding agency; (2) improvement of institutional governance for smallholder farmers to minimize information gap of various issues, such as access to formal funding institution, access to high-quality input market, as well as improving the technical and administrative readiness of smallholder farmers.

Table of Contents

List of Figures

List of Tables

List of Appendices

Green Fuel Policy and Welfare of the Palm Oil Farmers

a. Biofuel Policy Dynamics and the Development of Green Fuel in Indonesia

Indonesia's biofuel program is one of the main instruments in the National Energy Policy (*Kebijakan Energi Nasional*/KEN), as stipulated in Government Regulation No. 7/2014. KEN targets the use of renewable energy in the national energy mix at 23% in 2025 and 31% in 2050. The biofuel use target derived from this number is approximately 13.9 million kiloliters (kl) in 2025 and 52.3 million kiloliters (kl) in 2050.

In 2006, Indonesia adopted a national biofuel policy by issuing Presidential Regulation No. 5/2006 on National Energy Policy and Presidential Instruction No. 1/2006 on the provision and use of biofuel, both of which became the first legal umbrella to formally regulate the implementation and development of biofuel. This policy was enforced for the purpose of establishing national energy resilience and independence (Koaksi Indonesia, 2018), where energy resilience is defined as the availability of public access to affordable energy resources and energy independence is defined as the utilization of domestic energy resources.[1]

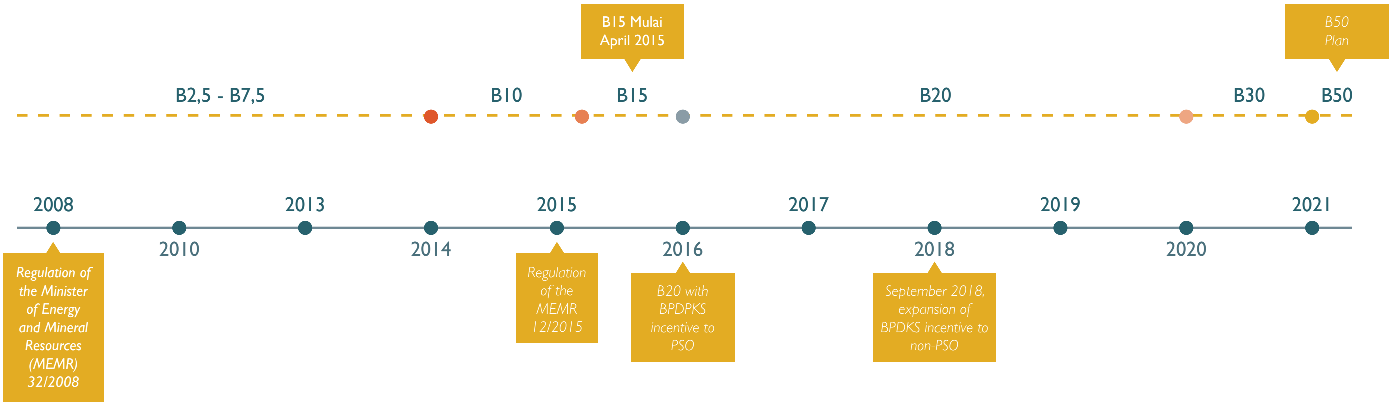
In support of the regulations above, Presidential Decree No. 20/2006 instructed the establishment of the National Biofuel Development Team, which is responsible for monitoring the implementation of the biofuel program and creating the blueprint for biofuel development. According to the blueprint, the objectives of biofuel development are: 1) to reduce poverty and unemployment, 2) to encourage economic activities through the provision of biofuel, and 3) to reduce domestic fossil fuel consumption.

The enactment of several regulations on energy—biofuel in particular—in 2006 was succeeded by the issuance of Law No. 30/2007 on Energy by the House of Representatives (*Dewan Perwakilan Rakyat*/DPR) to strengthen the regulations that prioritize the use of renewable energy. The Energy Law became the highest regulation on energy issued by the Government and acts as the legal umbrella for other energy regulations and policies. It regulates various matters related to energy sector in general, including the mandate to manage energy by virtue of National Energy Policy and National Energy General Plan (*Rencana Umum Energi Nasional*/RUEN). These formal legal instruments reflect the Indonesian Government's serious efforts in the development of renewable energy, which includes biofuel.

The government's commitment to the development of biofuel in Indonesia has become increasingly apparent. In 2008, the Indonesian Government issued the biofuel blending mandate by virtue of Regulation of the Minister of Energy and Mineral Resources No. 32, which requires transportation sector to use biofuel, including biodiesel, with 1% blending rate (99% fossil-based diesel fuel and 1% biodiesel). The blending number will continue to increase to 20% by 2020. During the initial implementation, the blending policy was only implemented in Public Service Obligation (PSO) transportations for easy monitoring and control due to their direct affiliation with the government. As it progresses, the policy is expected to be more widely implemented as to include non-PSO sector and other sectors such as industry and commercial, power plant, and Micro, Small, and Medium Enterprises (MSMEs).

[1] Definition of national energy resilience as defined in Government Regulation 79/2014

Figure 1. Mandatory Biodiesel Use Policy Implementation in Indonesia



Source: Ministry of Energy and Mineral Resources (2019)

As time went by, there was impetus for a much larger biodiesel use, and therefore the implementation of mandatory biodiesel use in Indonesia became more aggressive. As of now, Regulation of the Minister of Energy and Mineral Resources No. 32/2008, which regulates the blending level of biodiesel among other matters, has been amended three times. The last amendment was by virtue of Regulation of the Minister of Energy and Mineral Resources No. 12/2015, enacted in March 2015, which revised the mandatory blending level of biodiesel from 10% to 15% (B15) effective April 2015, and later to 20% (B20) effective January 2016, for PSO and non-PSO transportation sectors, as well as microbusiness, industry, and commercial sector. In addition, a 30% (B30) mandatory blending target was set to be implemented in early 2020.

The current mandatory biodiesel use policy has a wider objective, which is not only to reduce poverty, but to also improve national energy resilience. Its implementation is directed toward the national economy development, both in the financial sector (reducing deficit in balance of payments and optimizing foreign currency reserves) and the real sector (for the development of national palm oil industry through downstream programs). The mandatory biodiesel policy is also expected to be able to stabilize world CPO prices by absorbing excess stock in the market.[2]

Seeing a large potential for palm oil derivative product development and abundant CPO production yields in Indonesia[3]—which may even cause oversupply[4]—the Indonesian Government put the opportunity to good use, especially to anticipate oversupply that may lead to CPO price drop. For this reason, the Government tries to increase the uptake of domestic CPO by accelerating biodiesel blending target increase. After the implementation of B30 in early 2020, the Government planned to to increase the blending target to B40 in 2021, but this has since been postponed to 2022. However, the government appears committed to continuing to increase the blending target even further, to B50 and even higher.[5] This is an aggressive and risky decision, particularly in relation to the environmental impact, as an increase in CPO consumption will not only absorb excess production yields, but also

[2] Presentation of the Ministry of Energy and Mineral Resources, titled "*Bakti untuk Negeri Melalui Bahan Bakar Nabati: Dinamika Kebijakan Biodiesel di Indonesia*". Presented during the Koaksi Indonesia Interactive Discussion, 11 December 2019

[3] Estimated at 48 million tonnes in 2019 (Ministry of Agriculture, 2019)

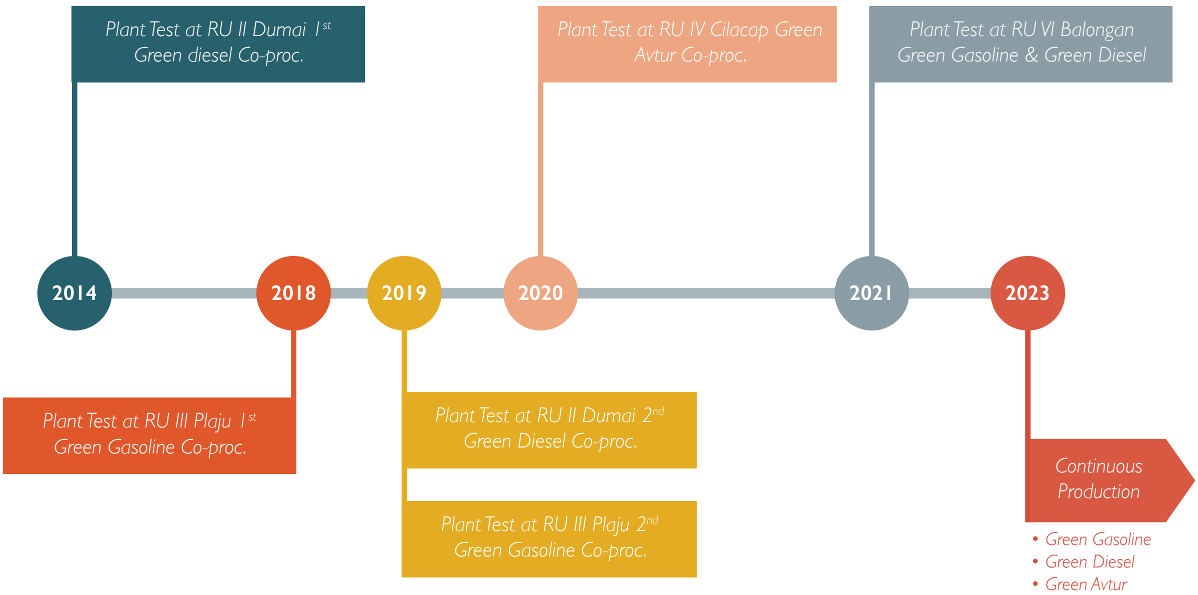
[4] Tirto.id, 2019. *Ketika Indonesia Dihantui Oversupply Produksi Sawit*. Accessed from https://tirto.id/ketika-indonesia-dihantui-oversup- ply-produksi-sawit-efh8

[5] Katadata.co.id, 2019. *Baru Implementasikan B30, Pemerintah Tancap Gas Implementasikan B40 Tahun Depan*. Accessed from https://katadata.co.id/berita/2019/12/23/baru-implementasi-b30-pemerintah-tancap-gas-terapkan-b40-tahun-depan

encourage land expansion. Another factor to be considered is the readiness of the market (i.e. automotive industry) to use fuel with certain biodiesel blending level. In addition to biodiesel, the Indonesian Government has initiated the development of green fuel, a liquid fuel derived from biofuel, such as CPO, that is processed using a certain technology to be more environmentally friendly compared to conventional fuel. The use of CPO for green fuel is expected to increase domestic CPO absorption, of which in 2019, only 21% was used for biodiesel (FAME).[6]

Although currently there is no formal policy that regulates the production and use of green fuel, the initiative to develop green fuel goes back to 2014 with the trial production of green diesel using co-processing technology in Pertamina Dumai refinery. The government has put green fuel development on the agenda and included it in the 2020–2024 National Middle-Term Development Plan (*Rencana Pembangunan Jangka Menengah Nasional*/RPJMN), despite its lack of details on the direction and implementation of the policy. In the future, the government expects green fuel to be mass-produced to complement the use of biodiesel, especially in the transportation sector.

Figure 2. Green Fuel Development Plan



Source: Pertamina (2019)

Figure 2 shows the green fuel development trial plan of Pertamina as the main party appointed by the Government to carry out the project. In the implementation, Pertamina collaborated with other parties for development, such as Institut Teknologi Bandung (ITB) as the catalyst developer (Katalis Merah Putih), PT Rekayasa Industri, and ENI (eco-fining company from Italy, whose collaboration with Pertamina was terminated due to the anti-CPO policy of the European Union).

It can be seen from the timeline in Figure 2 that green fuel is planned to be ready for mass production in 2023. Meanwhile, the B50 policy implementation scheduled for 2021 by the government will use green fuel blending, i.e. green diesel, as follows: B30 (30% biodiesel) +

[6] The result of author's calculation based on the data from the Ministry of Agriculture (2019) and APROBI (2020)

D20 (20% green diesel). The readiness for commercial production of green diesel must be taken into consideration if the scheme above is implemented.

Box 1. About Biofuel and Green Fuel

Biofuel

Biofuel is a kind of fuel derived from vegetable matter that can be categorized into three major groups: biodiesel, bioethanol, and pure vegetable oil. Biodiesel is a Fatty Acid Methyl Ester (FAME) or Mono Alkyl Ester product of biological raw materials and other biomass. Bioethanol is an ethanol product derived from vegetable raw materials and other biomass. Pure vegetable oil is derived from vegetable raw materials, which was produced mechanically and through fermentation.[7]

The production of bioethanol is declining with the termination of bioethanol blending policy by the Indonesian Government. As a result, bioethanol manufacturers shift their production focus solely to meet industrial demand. Total capacity of Indonesia's ethanol refineries, both active and idle, in 2018 was 408 million liters. However, only 3 out of 14 refineries were still in operation in 2018, with total production capacity of 100,000 kiloliters (USDA, 2018). The main raw material used in Indonesian ethanol refineries is sugar cane.

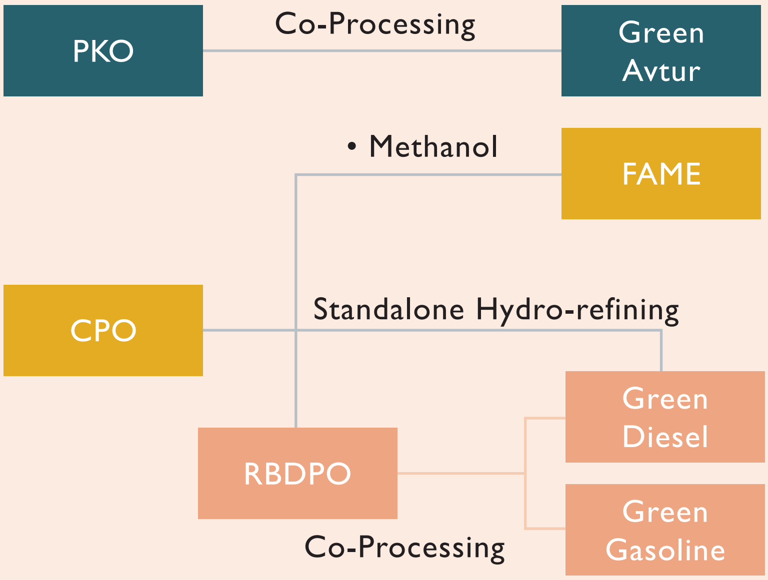
In contrast to bioethanol, the production of biodiesel has continued to increase since the enactment of mandatory biodiesel use in 2008. In 2019 (data only up to November), the production of biodiesel (FAME) was 9.6 million kiloliters, a significant increase from the previous year of 6.1 million kiloliters (APROBI, 2020). Biodiesel production in 2019 absorbed 21% CPO, or equivalent to 9.7 million tonnes. The acceleration of mandatory biodiesel use program was expected to encourage the absorption of domestic CPO for the purpose of anticipating oversupply and anti-CPO policy of the European Union.

Green fuel

Green fuel is in essence a biofuel as it is derived from vegetable raw materials. However, the processing of green fuel is different from biodiesel or bioethanol, as green fuel uses co-processing and hydro-refining standalone technologies. Currently, green fuel planned for production in Indonesia will use CPO (for green diesel and green gasoline) and PKO (for green aviation turbine fuel/avtur) as raw materials. In general, the processing of green fuel can be seen in the following diagram.

[7] Ministry of Energy and Mineral Resources, 2008. Regulation of the Minister of Energy and Mineral Resources No. 32 of 2008 on Provision, Utilization, and Commercialization of Biofuel as Alternative Fuel

Figure 3. Green Fuel Processing



Adopted from: Pertamina (2019)

Co-processing is carried out by mixing RBDPO (a CPO processed product) with fuel (gasoline, diesel). Standalone is a direct product of CPO, produced using a mixture of catalyst and hydrogen. Currently, green fuel trial production is being carried out in two Pertamina refineries: Plaju (for green gasoline, with a daily capacity of 4 MB) and Dumai (for green diesel, with a daily capacity of 3 MB).[8]

b. Biofuel Policy and Its Impact on the Welfare of Farmers

Palm oil farmers play an important role in the production of palm oil Fresh Fruit Bunches (FFB) to be distributed to the processing companies. In general, palm oil farmers in Indonesia can be categorized into two major groups: nucleus farmers and smallholder farmers. The main difference between the two is the ownership of the plantation. Smallholder farmers cultivate palm oil on land owned by themselves, while nucleus farmers work on land owned by palm oil companies. Smallholder farmers can be further categorized into two groups based on their land management model: independent and plasma smallholder farmers. While independent smallholder farmers manage their plantations independently, plasma smallholder farmers are affiliated with certain companies (usually as buyers of their yields) in the management of the plantations.

In general, the competitiveness of smallholder farmers is still low. The average productivity rate of smallholder plantations in 2017 was 3.066 tonnes of CPO/ha, which is below the average national productivity rate of 3.52 tonnes of CPO/ha. The gap becomes even wider when the number is compared to the productivity of private plantations (3.85 tonnes of CPO/ha) and government plantations (4 tonnes of CPO/ha).[9] The low productivity rate of independent smallholders has an impact on the farmers' income.

[8] Presentation of Pertamina titled *"Pengembangan Industri Green Fuels Pertamina"*. Presented in Jakarta, 20 May 2019

[9] Ministry of Agriculture. (2018). Indonesian Plantation Statistics: Palm Oil 2017–2019. Ministry of Agriculture of the Republic of Indonesia: Jakarta.

Hopefully, the biofuel policy can improve the welfare of palm oil farmers as specified in the Indonesian biofuel blueprint. A number of studies show that the biofuel policy, particularly the mandatory biodiesel use, has made positive impacts on the farmers' welfare. A study on Indonesian palm oil industry, conducted as part of a global study under the coordination of Australian National University, concluded that the development of palm oil industry has made a positive impact on the income and standard of living of the involved parties (Barlow, Zen, & Gondowarsito, 2003). According to a study conducted in Sumatra, palm oil plantations are able to absorb a large number of workers and are able to provide a good income for the workers (Tomich et al., 2001).

The development of domestic palm-oil-based biodiesel can increase CPO production, which will subsequently drive regional economic growth, increase the income of farmers in rural areas, and reduce rural poverty (PASPI, 2014 in GAPKI 2017).[10] A study in Riau Province in 2013 shows that investment in the palm oil sector can improve rural settlement development and rural economy (Budidarsono et al., 2013). In several palm oil center locations, it is found that the development of palm oil plantations can increase the income of the communities. In addition, the income of palm oil farmers in palm-oil-producing provinces is higher than the highest Provincial Minimum Wage (*Upah Minimum Provinsi*/UMP) in Indonesia.[11]

Specifically, the effectiveness of biodiesel incentive policy through BPDP-KS, which has been carried out since 2016 to reduce the poverty rate of palm oil farmers, is still debatable. In practice, critics claim that the biodiesel program is only beneficial for the large companies receiving economic incentives. Although the implementation of biodiesel incentive scheme is followed with an increase in CPO price and a stable palm oil price for a certain period of time, the real impact of this program on the stability of CPO price is still debatable (Koaksi Indonesia, 2018; LPEM, 2018). The impact of the biodiesel incentive program cannot be directly felt by the farmers as the transmission or the impact distribution process takes too long. The increase in CPO prices is not always directly proportional to the FFB price received by the farmers due to numerous factors, such as business process and farmers' institutionalization (LPEM, 2018).

[10] GAPKI. (2017). *Kebijakan Mandatori Biodiesel dan Pilihan Instrumen Implementasi yang Sustainable*. Accessed from https://gapki.id/news/1795/kebijakan-mandatori-biodiesel-dan-pilihan-instrumen-implementasi-yang-sustainable

[11] BPDPKS. (2019). *Dampak Sosial Ekonomi Pengusahaan Kelapa Sawit Terhadap Kesejahteraan pekebun*. Accessed from https://www.bpdp.or.id/Dampak-Sosial-Ekonomi-Pengusahaan-Kelapa-Sawit-Terhadap-Kesejahteraan-pekebun

Replanting Program for Development of Upstream Palm Oil Sector and Sustainable Biodiesel

As Indonesia is the world's largest palm oil supplier, the role of independent palm oil farmers is crucial. According to the 2017 data of the Central Statistics Agency (*Badan Pusat Statistik*/BPS), the area managed by smallholders has reached 5.7 million hectares or 46% of the total area of palm oil plantations in Indonesia, contributing 40% to the total CPO production in Indonesia. However, the productivity of smallholder plantations is still very low, which can pose a threat to meeting future demands for palm oil.

Among the problems faced by smallholder plantations is the large gap between productivity level of smallholder plantations and large plantations, both state-owned and private-owned. Even among smallholders, there is a significant gap between independent smallholders and plasma smallholders (supported by nucleus companies). Meanwhile, the implementation of biodiesel policy and the plan to implement green fuel policy in the future will boost the demand for CPO as feedstock.

Since 2018, the government has implemented a moratorium policy on the expansion of palm oil plantations, in accordance with Presidential Instruction No. 8 of 2018 on the Postponement and Evaluation of Palm Oil Plantation Licensing and Productivity Improvement for Palm Oil Plantations. Currently, the focus is intensification by increasing the productivity of palm oil plantations, including reducing the gap between independent smallholders and other producers.

Intensification efforts can be divided into two categories: technology-driven and market-driven intensification. Market-driven intensification will cause a shift from commodities grown (for example rubber) to higher value commodities (for example palm oil). The shift will result in a trade-off, particularly in relation to land use, i.e.: (1) risk of deforestation or land clearing, as happened in Indonesia (Varkkey et al., 2018), since normally smallholder plantations are located in the frontier area within a forest (Nurfitriani et al., 2018); and (2) risk of competing with other commodities (which will impact food security). Meanwhile, technology-driven intensification will also need to be monitored as it will accelerate the deterioration of environmental quality in palm oil plantations, such as soil and water quality. Therefore, any technology-driven intensification effort must be sustainable (Bronkhorst et al., 2017).

Another way to increase the productivity of palm oil plantations is by replanting (Varkkey et al., 2018). Late replanting of palm oil plantations may reduce yield and affect soil quality. The majority of palm oil plantations in Indonesia have entered their old age or have operated for more than 25 years, as they were established between 1980 and1990. According to Daemeter's projection (2015), all smallholder plantations must be replanted by 2040, of which 30% must be replanted by 2025, with an estimated cost of USD 5–6.5 million.

Condition improvements in the upstream sector are largely dependent and influenced by all actors along the supply chain. Currently, independent smallholder farmers have no bargaining power against the other actors in the market, have no access to formal financial institutions, are prone to be manipulated, and have a higher tendency to open new land instead of replanting due to its lower cost.

The success of replanting to increase the productivity of palm oil smallholder plantations is not limited to the smallholder farmers' access to formal financial institutions, but also in the improvement of institutional arrangement and managerial interaction, which could influence the whole business process of the smallholders (Jelsma et al., 2017; Zen et al., 2008). If the smallholders are not able to gain access to better input market, low productivity issues will become a vicious cycle, which eventually leads to unresolved long-term environmental, economic, and social issues. In addition, seed quality, fertilizer quality and usage method, as well as farming practices will also contribute to the success of replanting.

Box 2. Lessons Learned from the Ophir Scheme in West Sumatra

One of the successful pilot projects for independent smallholders is the Ophir Scheme, which is a mentoring scheme provided by a Germany donor institution, GIZ, to cooperatives in West Pasaman Regency, West Sumatra. The purpose of this study is to identify factors that can improve the production efficiency of smallholders and to find the solution to sustainable challenges faced by independent smallholders.

This project is developed based on the principles of collective action (Ostrom, 1990; Cox et al, 2010) and by combining the advantages of independent smallholder system (e.g., strong motivation to produce more yields and use of family members as workers) with the advantages of corporate plantation system (e.g., lower transaction cost, clearer hierarchical structures, and better access to market and capitals).

By using this approach, Ophir plantation is able to consistently produce higher yields compared to the national average of more than 25 years, with 8–11 years faster credit repayment rate than the original estimation.

Source: Jelsma et al., 2017

Analysis of Palm Oil Replanting Requirements Based on Various Green Fuel Policy Scenarios

This study analyzes palm oil replanting requirements by using several blending scenarios and green fuel products based on the government's plan. Scenario 1 is the baseline scenario using the blending status at the start of this study (November 2019). Scenario 2 is an advanced scenario using the currently implemented B30 blending (effective December 2019). Scenario 3 is a scenario that takes into consideration the B30 policy and a more progressive policy, i.e. B30D20 (B50), based on industry readiness plan to produce B50 in 2023. Scenario 4 is the scenario planned/presented by the government at the moment, which is similar to Scenario 3, with a faster blending of B30D20 in 2021. Meanwhile, Scenario 5 is similar to Scenario 4 with the additional green gasoline product as planned by Pertamina.[12] Each scenario shows a more progressive green fuel policy.

Table 1. Summary of Green Fuel Scenarios

Scenario	Blending	Blending Start Time	Green Gasoline (A)
Scenario 1	B20	2016	No
Scenario 2	B30	2020	No
Scenario 3	B30D20	2023, B30 2020	No
Scenario 4	B30D20	2021, B30 2020	No
Scenario 5	B30D20	2021, B30 2020	Yes A20, 2021

Source: Author's Illustration

Box 3. CPO and Green Fuel Balances and Assumptions Used

To understand how the CPO deficit is calculated, it is necessary to understand CPO and green fuel balances. CPO balance consists of 3 parts: production, consumption, and CPO surplus/deficit. The production part increases CPO stock, such as production, import, and initial stock of CPO. The consumption part includes export, use of CPO for non-green fuel, and use of CPO for green fuel. If there is a difference between production and consumption, the balance is called CPO surplus (if positive) or CPO deficit (if negative), which becomes the initial stock of CPO for the subsequent period.

CPO production can be derived from two sources: existing land and land replanted by the government.13 From the existing land, CPO production is calculated based on the assumption that the land area is constant at 16,381,959 ha since 2019 due to the moratorium policy.14 Back casting is used to calculate land area for the years prior to 2019, by using the land growth data from BPS (the land growth from 2018 to 2019 uses the average land growth from 2014 to 2018). Starting from 2019, it is constantly assumed that 81.53% of the total area is productive,15 as not all palm oil plantations are productive. Lalu, produktivitas lahan sejak 2019 diasumsikan naik mengikuti tren sebelumnya, sehingga pada tahun 2025 produktivitas CPO diproyeksikan mencapai 3,692 Ton/ha. Produksi CPO dari lahan

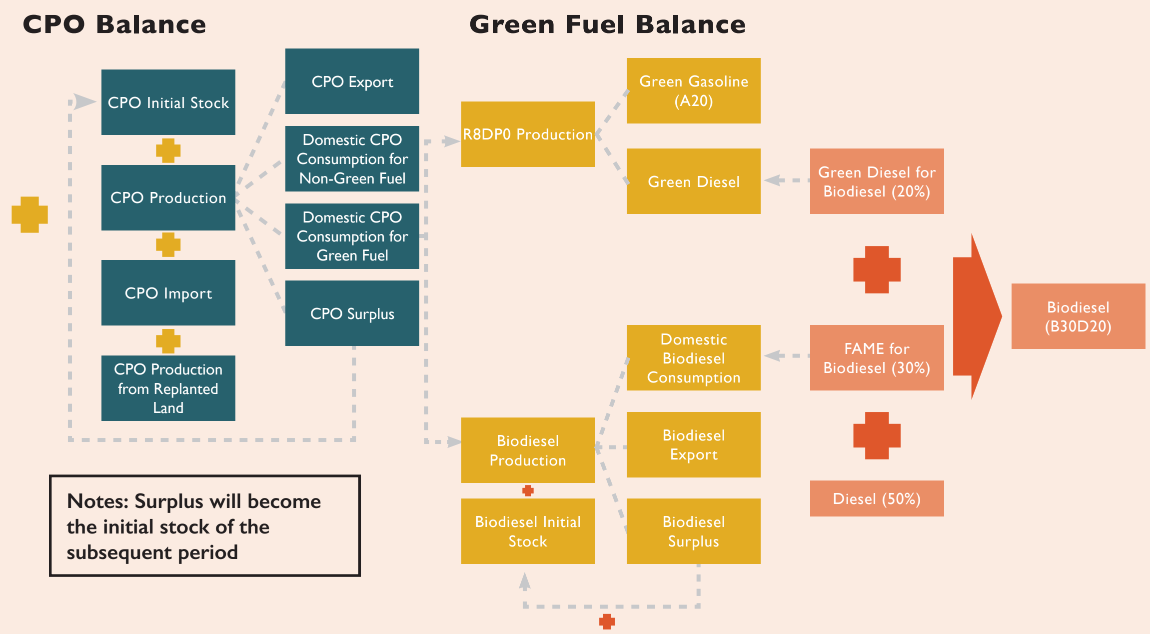
[12] Currently, non-mass production has started in several regions

[13] The government has been replanting palm oil plantations since 2017. Total area replanted from 2017 to 2019 was 130,588 ha, of which 14,634 ha was replanted in 2017, 33,842 ha in 2018, and 82,112 ha in 2019.

[14] In accordance with the Presidential Instruction No. 8 of 2018 on the Postponement and Evaluation of Palm Oil Plantation Licensing and Productivity Improvement for Palm Oil Plantation.

[15] Prior to 2019, the proportion of productive land area to the total palm oil plantation area was calculated using the real data from BPS. 81.53% is the proportion of productive land area to the total palm oil plantation area in 2018 (latest data).

Figure 4. CPO and Green Fuel Balances



Sumber: Author's Illustration

yang Starting from 2019, land productivity is assumed to increase in line with the previous trend, so in 2025, CPO productivity is projected at 3.692 tonnes/ha. CPO production from existing land is calculated by multiplying land area with the percentage of productive land area against total land area and land productivity. Meanwhile, to calculate CPO production from the replanted land, it is assumed that all of the replanted land area will be productive with a productivity of 8 tonnes/ha. However, the land requires a waiting period of 3 years before it is able to produce CPO (e.g. a land replanted in 2017 will only start to produce CPO in 2020). CPO production from the replanted land is calculated by multiplying replanted land area by land productivity after replanting (8 tonnes/ha). The increase of CPO import will follow the previous trend (taken from the year 2006). CPO initial stock for 2014 is 2.1 million tonnes (USDA Report, 2014), whereas for the subsequent periods, CPO initial stock will be equivalent to the accumulation of the previous years' CPO surplus/deficit.

In the consumption part, CPO export and non-green fuel CPO consumption are projected based on the previous trends (starting from 2006). There is a special balance for green fuel CPO consumption to calculate the required CPO (green fuel balance). Green fuel CPO consumption is calculated from its two derivative products, RBDPO[16] and FAME.[17] RBDPO is the raw material for green diesel (mixed to produce B30D20) and green fuel (equivalent to Pertalite).[18] Meanwhile, FAME is comprised of biodiesel production, biodiesel consumption, and biodiesel export. Biodiesel consumption is the biodiesel that will ultimately be mixed with diesel to produce biodiesel/biofuel.

[16] Refined Bleached Deodorized Palm Oil

[17] Fatty Acid Methyl Ester

[18] Conversion rate used in RBDPO products are as follows: CPO (tonnes) to RBDPO (tonnes) = 1:0.77, RBDPO (tonnes) to RBDPO (kl) = 1:1.16, RBDPO to Green diesel = 1:0.85, and RBDPO to Green Gasoline = 1:0.9

Biodiesel consumption is projected using ARIMA method based on the monthly biodiesel consumption data. The projection reflects biodiesel (non-mixed) requirement with B20 blending up to 2025. Next, biodiesel (mixed) requirement can be calculated by dividing biodiesel (non-mixed) by 0.2 (B20 blending). Biodiesel (mixed)[19] is assumed to be constant in the scenarios where biodiesel (non-mixed) requirement will adjust to the blending rate. For example, biodiesel requirement for 2020 is 10 million kl biodiesel (mixed), therefore biodiesel (non-mixed) consumption will be 2 million kl in B20 scenario, 3 million kl in B30 scenario, and so on.

To calculate biodiesel export, the projection is based on the monthly data using ARIMA method that is adjusted to the seasonal index. Biodiesel initial stock in 2014 is 97,000 kl (USDA Annual Report, 2014) and for the subsequent year will be based on the accumulated surplus/deficit of the previous year. Biodiesel surplus prior to 2018 is the initial stock plus biodiesel production minus biodiesel consumption and export. From 2019, 0.59% biodiesel surplus is retained from biodiesel consumption[20] as a reserve for energy resilience. Biodiesel production starting from 2019 is the residue of consumption, export, surplus, and initial stock (which previously used real data). This biodiesel production calculation will become the basis for the calculation of CPO consumption for biodiesel.[21] In general, the assumptions used in this analysis can be seen in Table 2.

Table 2. Assumption Used in the Analysis of CPO and Green Fuel Balances

Assumption	Description
CPO Production	Starting from 2019, palm oil land area is constant (16,381,959 ha), productivity increases based on previous trend
CPO Export, CPO Import, Non-Biodiesel CPO Consumption	Increases based on previous trend
Biodiesel Consumption and Export	Estimated using ARIMA method based on the monthly data from 2014 (January) to 2019 (November)
Biodiesel Surplus	Starting from 2019, 59% of biodiesel consumption (based on previous trend)
Biodiesel Production	Residue of biodiesel consumption, export, surplus, and initial stock
Land Productivity After Replanting	Land productivity after replanting is 8 tonnes/ha
Green Gasoline	10% of Premium and Pertalite users shift to green gasoline and the blending used is 20%

Source: Author's Illustration

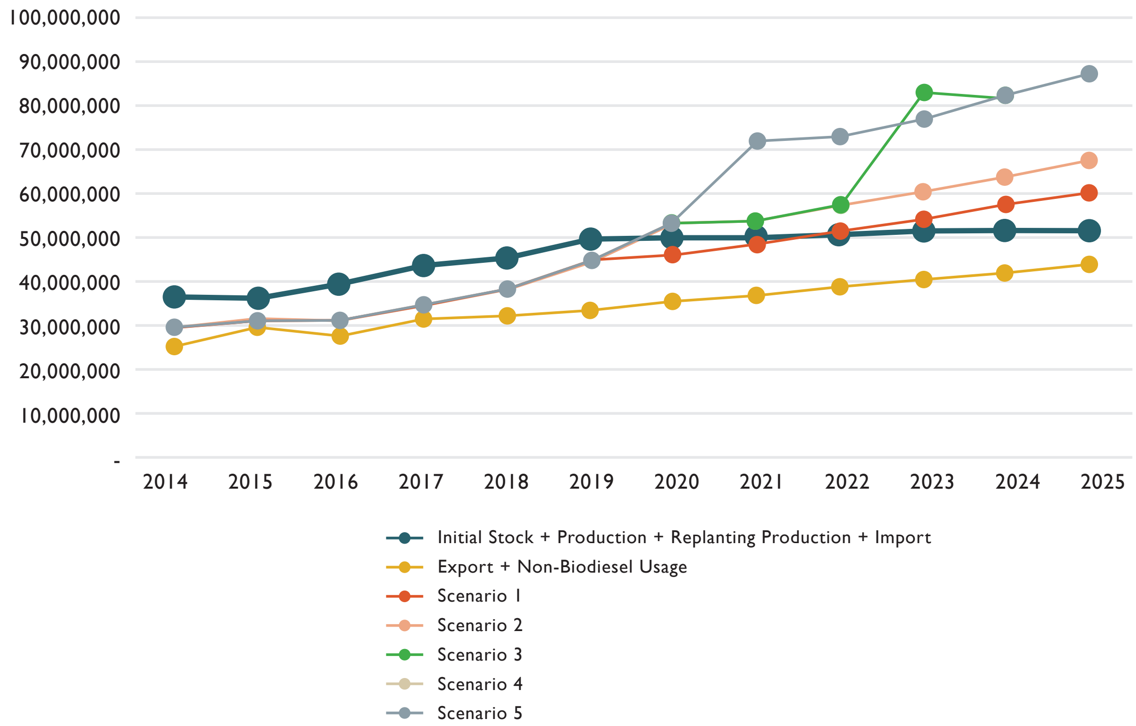
With these various scenarios, the resulting CPO and green fuel balances will be different between scenarios, and the use of CPO as green fuel will become the differentiator of each scenario. The difference is caused by the difference in blending rate (for example B20 vs B30) or due to the emergence of new product (for example green diesel or green gasoline). This variation will influence the speed and volume of CPO deficit in Indonesia.

[19] Number of Biodiesel users (mixed) out of the total diesel users in 2018: 46.58%

[20] 0.59 is the average ratio between surplus and biodiesel consumption in 2014–2018

[21] Conversion rate used for FAME products are as follows: CPO (tonne) to FAME (tonnes) = 1:0.85, FAME (tonnes) to FAME (kl) = 1:1.16

Figure 5. Visualization of CPO Balance



Notes: A scenario consists of CPO export, CPO consumption for non-biodiesel use and green fuel use (biodiesel, green diesel, or green gasoline according to each scenario)
Source: From Various Sources

Figure 5 shows in what year each scenario starts to experience deficit, or when all CPO stock accumulation has been used up. The stock is used up when the scenario line is higher than the red line (initial stock + production + replanting production + import). It can be seen that Scenario 1 starts to experience deficit between 2021 and 2022, whereas Scenarios 2 to 5 start to experience deficit between 2019 and 2020, in which the deficit increases from Scenario 2 to Scenario 5. From this figure, it can be concluded that the more progressive the policy, the faster and larger the resulting deficit.

Table 3. Summary of CPO Balance

Scenario	*Blending*	Blending Start Time	Stock Accumulation Deficit Start Time	Deficit Accumulation by 2025 (tonnes of CPO)
Scenario 1	B20	2016	No Deficit	N/A
Scenario 2	B30	2020	2023	34,914,453
Scenario 3	B30D20	2023, B30 2020	2023	92,988,380
Scenario 4	B30D20	2021, B30 2020	2021	119,122,471
Scenario 5	B30D20 & A20	2021, B30 2020	2021	122,689,037

Source: Author's Calculation in 2020

From Table 3, the starting year of stock accumulation deficit and the size of the deficit can be seen. In Scenario 1, there is no CPO deficit until 2025, whereas in 2024 stock accumulation is at 3,432,654 tonnes. In Scenario 2, stock accumulation deficit starts in 2023 with accumulated deficit of 34,914,453 tonnes in 2025. In Scenario 3, stock accumulation deficit starts in 2023 with accumulated deficit of 92,988,380 tonnes in 2025. In Scenario 4, stock accumulation deficit starts in 2021 with accumulated deficit of 119,122,471 tonnes in 2025. In Scenario 5, stock accumulation deficit starts in 2021 with accumulated deficit of 122,689,037 tonnes in 2025. From Scenarios 3 and 5, we can see that at the starting year of B30D20 blending, the CPO stock accumulation will immediately experience a deficit due to higher blending rate and higher CPO requirement to produce 1 liter of green diesel (compared to 1 liter of biodiesel). The more progressive the policy, the faster the deficit and the larger stock accumulation deficit.

Dynamic CPO Balance

There are several ways to cover the deficit, such as land expansion or land intensification (replanting). This study focuses on the replanting method to be aligned with the applicable palm oil moratorium policy. In contrast to land expansion (in which production increase from the newly opened land will be immediately accumulated as CPO surplus), replanting mechanism is more complex as the land to be replanted is usually an existing land and will not be productive until three years. The three-year non-productive period will affect CPO production and this should be taken into consideration. The impact of this condition is that the land needed for replanting will be larger than if land expansion is carried out to cover the deficit in 2025. It is assumed that the CPO stock accumulation deficit is 0 in 2025. With dynamic analysis, this study is able to calculate the total land area that needs to be replanted to cover the CPO stock accumulation deficit, by taking into consideration the non-productive period after replanting.

Below are the assumptions used in the dynamic analysis:

1. The replanting land is the land that is less productive (land with a productivity rate of ≤ 2 tonnes/ha).
2. Replanted lands need a 3-year period before they start producing.
3. Productivity rate of replanted lands is assumed to be 8 tonnes/ha.
4. As the calculation is limited up to 2025, replanting can only be done in 2020 and 2021. If replanting is carried out after 2020 and 2021, the land will not be able to produce surplus yields (the amount of CPO produced by replanted lands is higher than the number of CPO lost during the 3-year period) until 2025, which will increase the deficit. This is a key assumption to take into consideration.
5. Total land area to be replanted in 2020 is equal to 2021.
6. Total land area of smallholder plantations to be replanted is 40% of the total estimated land area that needs replanting.[22].

The 4th assumption is a key assumption in this study. As the analysis is only limited up to 2025, replanting will produce surplus only if carried out in 2020 and 2021. However, in reality, the surplus can also be targeted for the subsequent years (after 2025). It means that replanting can be phased in the year after 2021. However, the total land area required for replanting calculated in this study can still be used, but with a more even distribution among the years. The following are the steps required to conduct the dynamic analysis:

[22] 40% is the contribution of smallholder palm oil plantations to total CPO production in Indonesia

1. In 2020, CPO production will be deducted by 2 x land area replanted in Phase 1 until 2022;
2. In 2021, CPO production will be deducted (again) by 2 x land area replanted in Phase 2 until 2023;
3. From 2023, CPO production will increase by 8 x land area replanted in Phase 1– 2 x land area replanted in Phase 1 each year;
4. From 2024, CPO production will increase (again) by 8 x land area replanted in Phase 2– 2 x land area replanted in Phase 2 each year;
5. CPO balance calculation should accommodate Steps 1 to 4;
6. And then, using solver equilibrium, calculate total land area to be replanted so that CPO deficit in 2025 will be 0; and
7. The total land area is multiplied by 40% to get the total land area of smallholder plantations to be replanted.

Table 4. Calculation of Total Replanting Land Area Using Dynamic Analysis Method

Scenario	Total Replanting Land Area (ha)	% Total Replanting Land Area to Total Land Area in 2019	Smallholder Plantation Land Area to be Replanted (ha)[23]
Scenario 1	0	0	0
Scenario 2	3,879,384	24	1,551,753
Scenario 3	10,332,042	63	4,132,817
Scenario 4	13,235,830	81	5,294,332
Scenario 5	13,632,115	83	5,452,846

Source: Author's Calculation in 2020

From Table 4, we could see that Scenario 2 needs 3,879,384 ha of replanting land, or 24% of the total land area in 2019. Scenario 3 needs 10,332,042 ha of replanting land, or 63% of the total land area in 2019. Scenario 4 needs 13,235,830 ha of replanting land, or 81% of the total land area in 2019. Scenario 5 needs 13,632,115 ha of replanting land, or 83% of the total land area in 2019. In the scenarios with B30D20 blending, land requirement is more than 50% of the total land area in 2019, which creates a large amount of deficit.

Subsequently, Scenario 2 will require the replanting of 1,551,753 ha smallholder plantation land, 4,132,817 ha in Scenario 3, 5,294,332 ha in Scenario 4, and 5,452,846 ha in Scenario 5. The current replanting program carried out has only covered 10% of the land area needed to meet the requirement of Scenario 2. The government must encourage more replanting in the future in order to be able to implement a more progressive green fuel policy.

An important issue in this dynamic analysis is the reduction of CPO production during replanting process. Although the deficit analysis is able to calculate land requirements so that CPO stock accumulation deficit in 2025 will be 0, in the period of 2020–2024, CPO stock accumulation deficit will keep recurring in Scenarios 2 to 5. The government must find ways to cover for this CPO stock accumulation deficit before replanting is able to produce surplus, such as through CPO import, etc.

[23] Smallholder plantation land area to be replanted is 40% of total replanting land area

Palm Oil Plantation Replanting Priority

Smallholder palm oil plantation replanting program is one of the government's flagship programs. Adequate indicators are required to determine the areas, including which ones to prioritize for the replanting program. In this study, priority areas are determined based on productivity rate and the number of poor palm oil farmers in the regency/city. Productivity rate is ordered from low to high based on the 2017 palm oil statistics (Directorate General of Plantation, 2018), whereas the number of poor palm oil farmers is calculated using proxy data due to limited data availability. The P0 number from the National Economy Social Survey (*Survei Sosio-Ekonomi Nasional*/Susenas) is then multiplied by the number of palm oil farmers in the 2017 palm oil statistics. The regencies/cities included in the priority areas are from 7 provinces with a total of 64 regencies/cities, which cover approximately 73% of the total smallholder plantations in Indonesia (Directorate General of Plantation, 2018). The 7 provinces, which are also included in the 10 priority provinces for the improvement of program and policy for palm oil smallholders (Daemeter, 2015), are North Sumatra, Riau, Jambi, South Sumatra, West Kalimantan, Central Kalimantan, and East Kalimantan.

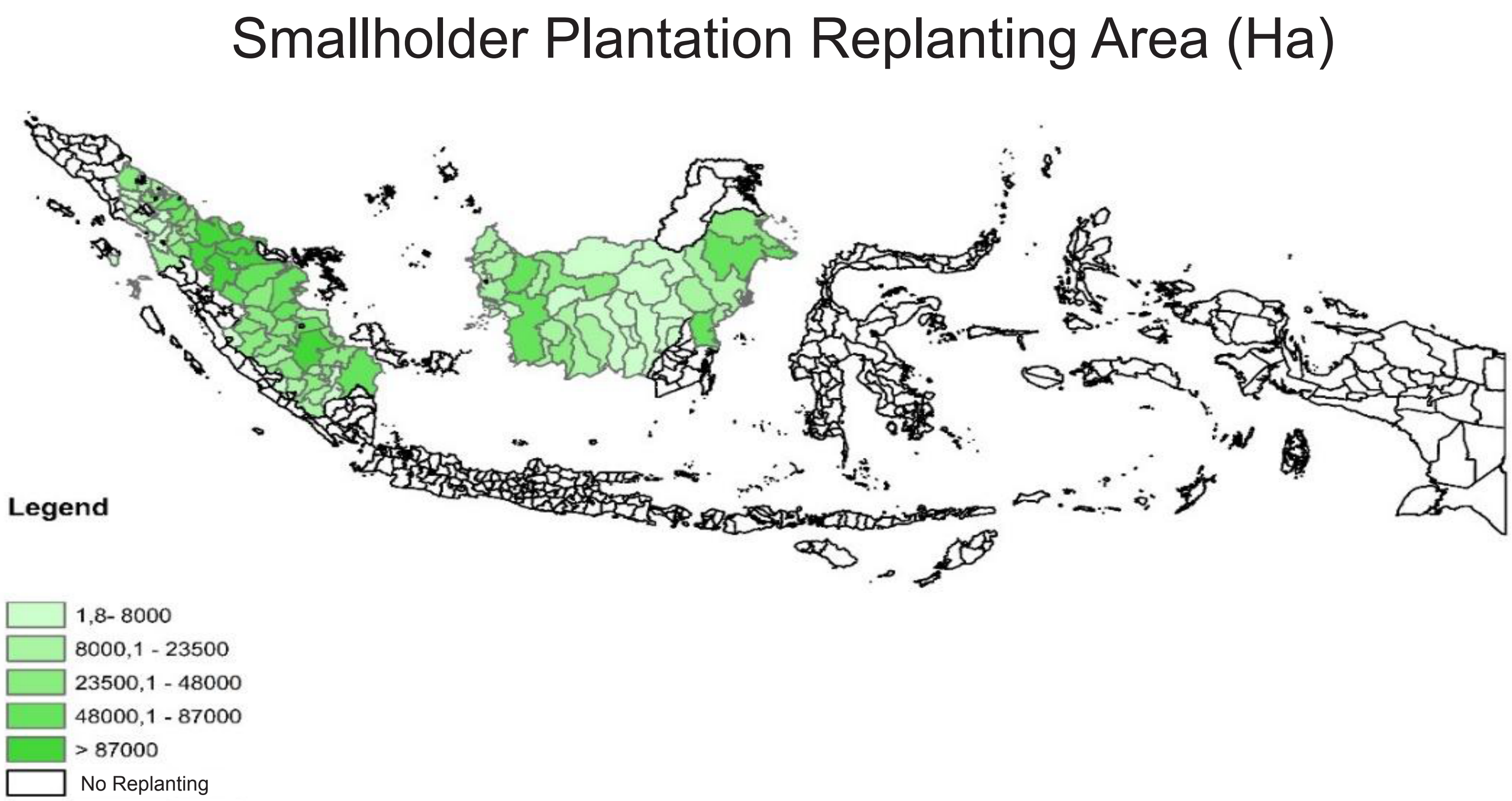
As previously mentioned, replanting target has to be achieved within two years (2020–2021) in order to meet the requirements in 2025. Referring to the total replanting land area calculated using the dynamic analysis method in Table 4, the minimum target for replanting land is 775,877 ha per year. This target is not achievable considering the financial capacity of BPDP-KS as funder and the readiness of palm oil institutions and smallholders. Therefore, the areas for replanting are prioritized based on the target set by the government, which is 180,000 ha per year.[24] However, it must be noted that the target for CPO fulfillment from smallholder plantations in Scenarios 2 to 5 will not be achieved with this replanting plan.

The calculation in Table 4 shows that the projected requirement in Scenario 1 can be fulfilled, and therefore the replanting of smallholder plantation land is not needed. Meanwhile, Scenario 2 requires replanting land area of 1.5 million ha, and Scenarios 3 to 5 require a larger size of land compared to the estimated size of smallholder plantation land available for replanting. The gap can be closed by taking into consideration smallholder plantations in other provinces or production increase in state-owned and private large plantations. Also necessary to be taken into consideration is the risk of land expansion, particularly by independent smallholders, as they tend to grow more sporadically and thus more difficult to monitor.

[24] See: https://ekonomi.bisnis.com/read/20190918/99/1150013/pemerintah-revisi-target-peremajaan-kebun-sawit

Figure 6. Distribution of Smallholder Plantation Replanting Areas in Each Regency/City (ha)

According to the previous land calculation, only 40% of the total land area requirement will be fulfilled by replanting smallholder plantation land. Meanwhile, out of the total area of smallholder plantations in the 7 provinces, it is assumed only 60% will be replanted. Therefore, total area that can be replanted is 2,515,374 ha, with distribution as seen in Figure 6.



Source: Author's Calculation in 2020

Table 5. Priority Replanting Areas for Scenario 2 in 2020

Priority	Regency	Province	Replanting Area*	Replanting Area Accumulation per year*
1	Landak Regency	West Kalimantan	16,125,00	16,125,00
2	Penajam Paser Utara Regency	East Kalimantan	14,303,40	30,428,40
3	Kayong Utara Regency	West Kalimantan	2,458,20	32,886,60
4	Pulang Pisau Regency	Central Kalimantan	1,833,00	34,719,60
5	Kubu Raya Regency	West Kalimantan	9,304,20	44,023,80
6	Barito Utara Regency	Central Kalimantan	2,086,80	46,110,60
7	Tanjung Jabung Timur Regency	Jambi	23,268,00	69,378,60
8	Lamandau Regency	Central Kalimantan	17,886,00	87,264,60
9	Sarolangun Regency	Jambi	24,482,40	111,747,00
10	Paser Regency	East Kalimantan	55,014,60	166,761,60
11	Melawi Regency	West Kalimantan	3,988,20	170,749,80
12	Sanggau Regency	West Kalimantan	9,250,20	180,000,00

** in ha*

Source: Author's Calculation in 2020

Public and Private Funding Requirements for Replanting Program

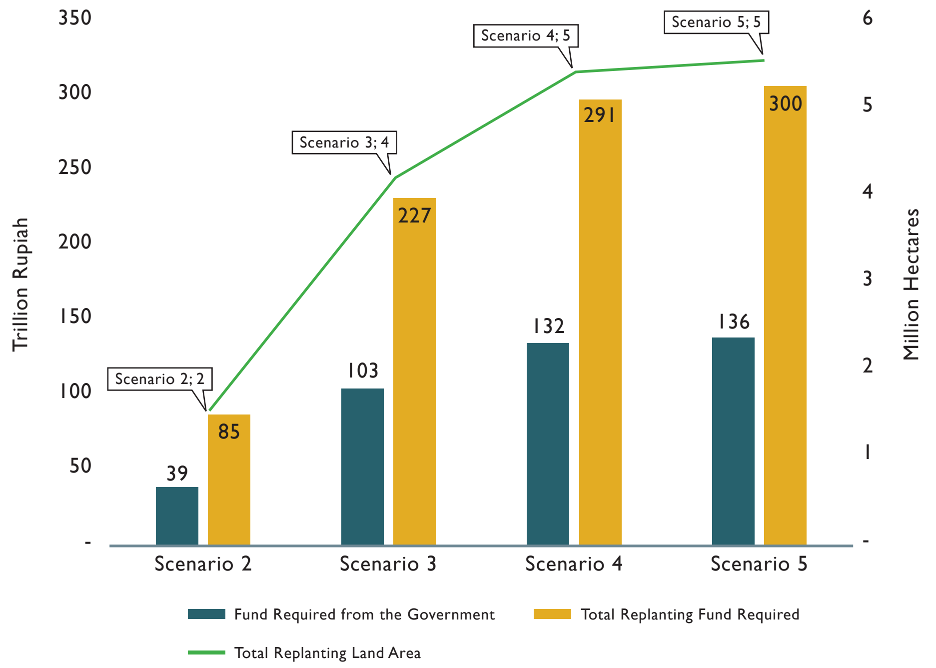
The urgency for palm oil plantation replanting, especially for independent smallholders, has encouraged a greater effort in allocating public and private funds in order to meet future demands for CPO. Funds required for the replanting program vary between regions, range from Rp45 million to Rp60 million per hectare. In this study, it is assumed that the replanting fund required is Rp55 million per hectare.

Funds needed for replanting can be sourced from both public and private/personal fund. Public fund is the fund acquired, managed, and distributed by BPDP-KS for various programs, including palm oil plantation replanting program. Private fund is the remaining fund required for replanting program that has to be acquired from other sources, such as personal funds/ farmers' savings or loans from financial institutions, such as bank or micro-lending institution.

As previously explained, land requirement is calculated using the dynamic analysis method. By using this method, estimation of replanting land required will be higher, thus requiring more fund. Estimation for fund requirement differs according to the estimation of land required for each palm oil projection in each scenario. Only Scenario 1 that does not require replanting as the projected requirement for CPO in 2025 can still be fulfilled using the business-as-usual CPO production scheme.

With an assumption that the total area of smallholder plantations is 180,000 ha per year, the total fund required each year is Rp9.9 trillion, of which Rp4.5 trillion per year is sourced from BPDP-KS and the rest from other sources. This assumption and scenario are lighter on BPDP-KS financial burden, but it will require more time (years) to complete the replanting of the total land area as the annual target is lower compared to the result of dynamic analysis. With this assumption, replanting must be carried out from 2020 to 2033. However, it is apparent that this scheme will not be able to meet the demand for CPO from smallholder plantations in 2025 in Scenarios 3, 4, and 5.

Figure 7. Replanting Fund Estimates



Source: Author's Calculation in 2020

Another thing to consider is the sustainability of revenue and expenditure or cash flow from BPDP-KS. The revenue of BPDP-KS is influenced by international CPO prices. Regulation of the Minister of Finance No. 23/PMK.05/2019 on the Second Amendment to Regulation of the Minister of Finance No. 81/PMK.05/2018 on BLU BPDP-KS Service Rate in the Ministry of Finance stipulates a different export tariff for CPO and each category of its derivatives. For example, a company is obliged to pay US$25 for every tonne of CPO exported if the CPO market price is between US$570–US$619 per tonne. This regulation was supposed to be effective starting 1 June 2019, but the levy implementation was postponed to 1 January 2020.[25] Therefore, there was no income for BPDP-KS since the first quarter of 2019.

According to the Financial Statement of BPDP-KS Year 2016 and 2017, the current largest expenditure is the biodiesel incentive, which comprises 90% of the total distributed fund. With the development of bio-hydrocarbon fuel or green fuel as one of the national strategic projects listed in the 2020–2024 National Mid-Term Development Plan (RPJMN),[26] the sustainability of expenditure also needs to be taken into consideration. The amount of fund provided by BPDP-KS for the replanting of palm oil independent smallholder plantations is Rp25 million per ha, with a maximum land area of 4 ha per smallholder. If smallholders require Rp55 million per ha for replanting, they will need to obtain the remaining Rp30 million per ha from other funding sources.

In terms of private funding, several financial institutions have provided loans to the smallholders, for example state-owned national banks (e.g., Bank Mandiri, BRI, BNI), local banks (e.g., Bank Sumsel Babel), microfinance institutions (e.g., Micro Capital Service Unit [*Unit Layanan Modal Mikro*/UlaMM]) (Sahara et al., 2017). Other institutions that offer loans

[25] Umah, A., 2019. *Pemerintah Tunda Pungutan Ekspor Sawit Sampai 1 Januari 2020*. Accessed from https://www.cnbcindonesia.com/news/20190924164207-4-101896/pemerintah-tunda-pungutan-ekspor-sawit-sampai-1-januari-2020

[26] BPDP-KS, 2020. Press Release: *BPDPKS Siap Melaksanakan Program Green Fuel Sesuai RPJMN 2020-2024*. Accessed from: https://www.bpdp.or.id/press-release-bpdpks-siap-melaksanakan-program-green-fuel-sesuai-rpjmn-2020-2024

to the smallholders are saving and loan cooperatives, informal institutions (e.g., collecting traders), and companies with their respective programs (e.g., Golden-Agri Resource of PT SMART Tbk and Asian Agri Independent Smallholder Partnership Arrangement of Asian Agri) (Johnston et al., 2020).

Regarding access to formal funding sources, the challenges faced by independent smallholder farmers are among others difficulties in meeting the requirements for obtaining land certificates that can be used as collateral for loans; they are more unlikely to keep a good record of their finances as compared to plasma smallholders; their cultivation practices are less standardized and thus could pose a greater risk for potential yields after replanting; and most of them do not have accounts at the lending banks. Another risk is related to price, where prices received by independent smallholder farmers tend to be unstandardized (as there is no formal contract between the smallholder farmers and collecting traders) compared to those received by plasma smallholder farmers who have contracts with cooperatives or companies that use standard prices set by the local Plantation Office. This could impact the cash flow of independent smallholder farmers and affect their ability to repay loans, especially during the first three years of replanting period, as funding is not only used to cover replanting expenditures, but also to cover the living cost of the farmers if they have no other source of income.

With this in mind, it is understandable that financial institutions are not interested in providing funds for the replanting of independent smallholder land as there are too much at stake, including their reputation. Therefore, this issue must be solved from the upstream level or at the level of the independent smallholder farmers (Shibao & Selamat, 2018).

Another scheme that can be done to close the fund gap is by encouraging farmers to save some of their sales income for a period of time so that it can be used when the land needs to be replanted. This will help farmers to better manage their finances and reduce their likelihood to take up loans. This managerial ability will also be a good financial record for them if at any point they need to borrow money from a financial institution. However, this mechanism requires a good institutional system in order to run optimally.

Impacts of Replanting Program on the Welfare of Independent Smallholder Farmers

One of the impacts of replanting is improvement of palm oil farmers' welfare (BPDPKS, 2019) as the replanted land will have higher quality Fresh Fruit Bunches (FFB) yields as compared to its previous harvests (Shibao & Selamat, 2018; Johnston et al., 2020). With an increase in CPO prices, this improvement in yields can increase farmers' income.

Box 4. Data and Method for Calculating the Impacts of Replanting on Poverty Level

To calculate the impact of replanting on poverty level, the data used is from National Socioeconomic Survey (*Survei Sosio-Ekonomi Nasional*/Susenas) 2018, Village Potential (*Potensi Desa*/Podes) 2018, and BPS Poverty Line 2018. Susenas data is used as the basis for poverty calculation (based on expenditure per capita) and to identify individual business field. Poverty line used in the calculation is the provincial poverty line, which is divided into urban and rural poverty lines. Podes data is used to identify the main commodity of a village.

A significant assumption used in this analysis is regarding the identification of palm oil farmers in Susenas data, since there is no accurate way to identify whether a respondent is a palm oil farmer. Susenas classified its respondents based on 22 sectors, of which plantation sector was the deepest sector information that can be obtained. Therefore, Podes data is used to gain information about the commodity produced by a village to be combined with Susenas data at the village level. Assumption used to identify palm oil farmers in Susenas data is: if someone has an occupation in the plantation sector, the main sector of their village is farming, and the major commodity of their village is palm oil, it is concluded that the respondent is a palm oil farmer.

To calculate the impact of replanting on poverty level, 2 poverty indicators are used: poverty headcount (P0) and poverty gap (P1). P0 is an indicator that shows the proportion of poor residents to total number of residents (poverty size), while P1 is an indicator that shows the difference between poor residents' expenditure to relative poverty line and poverty line (poverty depth). Both indicators can be calculated using the general formula as follows:

$$P_\alpha = \frac{1}{N}\sum_{i=1}^{q} \left[\frac{z - y_i}{z}\right]^\alpha$$

P = poverty indicator	α = 0 or 1 (0 for P0 and 1 for P1)
N = number of residents	q = number of residents below poverty line
z = poverty line	y_i = poor individual per capita expenditure

After obtaining the baseline of P0 and P1 indicators for palm oil farmers, per capita expenditure shock is calculated by increasing per capita expenditure of palm oil farmers by 1.2 times (Shibao & Selamat, 2018) for farmers in regencies/cities undergoing replanting program in each scenario. P0 and P1 are then re-calculated based on per capita expenditure shock of the existing poverty line.

From the baseline calculation in Table 6, it can be seen that the P0 of the palm oil farmers is relatively lower compared to the national P0 (9.41). In this case, 5.25% of palm oil farmers are poor, and the lowest poverty level is in Keerom Regency, Simeulue Regency, and Barito Kuala Regency. The poverty gap calculation shows that palm oil farmers have a lower baseline compared to the national P1 (1.71). In this case, in average, per capita expenditure of poor palm oil farmers is 0.89% below poverty line. In general, the average per capita expenditure of palm oil farmers is Rp1,083,905. From the baseline condition, it can be seen that the economic condition of palm oil farmers is relatively better compared to that of Indonesian people in general.

Table 6. Summary of Replanting Impacts on the Poverty Level of Palm Oil Farmers

	Initial Condition	Scenario 2	Scenario 3 - 5
P0 (%)	5.25	3.64	3.16
Number of impacted farmers		30,251	39,270
Impacted individuals (ART)		102,831	136,895
P1 (%)	0.89	0.63	0.51
Absolute Gap (Rupiah)	4,033	2,860	2,350

Source: Author's Calculation in 2020

Out of the 5 scenarios, only the impact for Scenario 1 is not calculated as there is no CPO deficit and therefore, there is no need for replanting program in Scenario 1. For Scenarios 3–5, it is assumed that the impact is the same as all three scenarios require more than the total area of smallholder plantation land available for replanting (2,515,374 ha). In Scenario 2, replanting is carried out to 37.01% of the total area of smallholder plantation land available for replanting, and the poverty level is reduced by 1.61 percentage point (from 5.25 to 3.64). It means that 30,251 palm oil farmers will be able to get out of poverty. The largest poverty reduction occurs in Penajam Paser Utara Regency (East Kalimantan) and Rokan Hilir Regency (Riau). P1 also decreases by 0.26 percentage point (from 0.89 to 0.63). This is equivalent to the decrease in the distance between poor palm oil farmers' expenditure and poverty line, which is Rp1,173.00.

In Scenarios 3–5, areas which carry out replanting at 100% experience a poverty reduction of 2.09 percentage point (5.25 to 3.16). It means that 39,270 palm oil farmers and their 136,895 family members will be able to get out of poverty. The largest poverty reduction occurs in Penajam Paser Utara Regency (East Kalimantan) and Banyuasin Regency (South Sumatra). In addition to P0, P1 decreases by 0.38 percentage point (from 0.89 to 0.51). This is equivalent to the decrease in the distance between poor palm oil farmers' expenditure and poverty line, which is Rp1,683.00.

By looking at the conditions above, the most significant poverty reduction occurs in Scenario 2, when replanting is carried out at 61.69% of the total plantation land available for replanting. Poverty level after that point can only be reduced by a maximum of 4.8 percentage point. This is due to the fact that the initial replanting areas are priority areas with high poverty rate and low productivity, and therefore, the impact of replanting is greater in those priority areas.

Impact of Replanting Program on the Regional Economy

Box 5. Calculation Method

The input-output model is a standard method that can be used to measure the impact of change on the final demand for a product produced by a certain industry/sector in the economy. This model is based on an input-output table (I-O table) presented as a matrix. This table describes the goods and service transactions between production sectors in the economy. The row in the I-O table shows manufacturers' output distribution in the economy, whereas the column shows input composition required by a sector to produce the output. In addition, the I-O table shows information on the final demand, which covers household consumption, export-import, and government's expenditure (Amir & Nazara, 2005).

Transactions between sectors in the table can be written as the following mathematical formula:

$$X_i = \sum A_{ij} + \sum F_i$$

where X_i is the output of sector i, F_i is the final demand for product of sector i, and A_{ij} is the output of sector i used as input for sector j (intermediary input).

In matrix notation, the above equation can be modified as:

$$X = AX + F$$

where X is the output vector of all sectors, A is the intermediary input coefficient matrix, and F is the final demand vector. The equation can be modified into:

$$X = [I - A]^{-1}F$$

where $[I - A]^{-1}$ is the Leontief inverse matrix and is applied as the output multiplier.

The I-O table used in this analysis is the provincial I-O table (seven main palm-oil-producing provinces) in 2010, which is the domestic transactions on the basis of BPS manufacturer's price. The number of sectors follow the availability in the I-O table of each province (112, 54, 42, 35, and 10 sectors). Replanting impact is analyzed by giving a stimulant/shock to each province. The shock is the additional FFB value (Rp) that will be generated if the provinces carry out the replanting program (FFB yields estimation after replanting minus initial FFB, multiplied by FFB price of each province). Shock is applied to palm oil/plantation crop sector at a different value for each province depending on the total replanted land area of the province in the first year.

Linkage Analysis

Linkage between each sector and its upstream and downstream sectors can be analyzed using backward linkage and forward linkage concepts. Backward linkage is defined as the magnitude of input demand increase of one sector due to the increase in output of a particular sector. Forward linkage is defined as the increase of available input for other sectors due to the increase in output of a particular sector.

Direct linkage can be derived from the sum value of each column (direct backward linkage) and row (direct forward linkage) in the technical coefficient matrix. Indirect linkage impact can be derived by calculating total linkage value from Leontief inverse matrix. Total backward linkage and total forward linkage values can be calculated by adding up each column and row of the Leontief inverse matrix.

a. Result Analysis: Impact of Replanting Stimulus on Regional Output

Table 7. Summary of Replanting Stimulus Impact on Gross Regional Domestic Product (Produk Domestik Regional Bruto/PDRB) Calculation

Province	Total Initial Output*	Stimulant Size*, **	Additional Output*	Percentage of Additional Output	Output Multiplier
Riau	593,167,145	954,235	1,422,156	0.24%	1.4904
South Sumatra	266,132,326	842,059	1,073,797	0.40%	1.2752
North Sumatra	115,398,411	2,555,218	3,210,999	2.78%	1.2566
Jambi	98,864,829	1,937,125	2,491,159	2.52%	1.2860
Central Kalimantan	40,576,766	714,713	843,835	2.08%	1.1807
West Kalimantan	114,387,250	1,600,346	2,064,342	1.80%	1.2899
East Kalimantan	559,394,274	2,505,826	3,667,176	0.66%	1.4635

Source: Author's Calculation in 2020

b. Intersectoral Linkage Analysis

Table 8. List of Priority Backward Linkage (BL) and Forward Linkage (FL) for Palm Oil/Plantation Sector in Each Province

Riau		South Sumatra		North Sumatra		Jambi		Central Kalimantan		West Kalimantan		East Kalimantan	
BL	FL	BL	FL	BL	FL	BL	FL	BL	FL	BL	FL	BL	FL
Trading	Food Oil, Vegetable and Animal Fats	Petro-chemical Industry	Palm Oil Industry	Food, Bev-erage, and Tobacco	Gold Min-eral Mining	Trading	Palm Oil Industry	Processing Industry	Processing Industry	Construc-tion	Oil Palm Industry	Petro-chemical Industry	Palm Oil Industry
Bank	Noodles, Macaroni, and the like	Petroleum Refinery	Rubber and Rubber Products Industry	Oil and Gas Industry	Non-Gold Mineral Mining	Land Transpor-tation	Rubber and Rubber Products Industry	Agriculture, Farming, Forestry, and Fish-eries	Construc-tion	Large Re-tail Trading	Food and Beverage Provision	Construc-tion	Other Industries
Petroleum	Bread, Biscuit, and the like	Oil, Gas, and Geo-thermal Mining	Hotel and Restaurant	Paper and Printed Materials	Food, Bev-erage, and Tobacco	Financial Institutions & Agri-cultural Services	Food and Beverage Industry	Transpor-tation and Communi-cation	Other Services	Land Transpor-tation	Farming and Hunt-ing Service	Trading	Food and Beverage Industry
Construc-tion	Other Food	Trading	Food and Beverage Industry	Transport Equipment, Machine, and Tools	Electricity	Hotel and Restaurant	Hotel and Restaurant	Trading, Hotel, and Restaurant	Transpor-tation and Communi-cation	Informa-tion and Communi-cation	Large Re-tail Trading	Oil, Gas, and Geo-thermal Mining	Farming and Its Products
Fertilizer	Restaurant Services	Other Services	Farming and Its Products	Non-Alumi-num Base Metals	Food Crops	Construc-tion	Other Services	Mining and Excavation	Mining and Excavation	Bank	Land Transpor-tation	Financial Institutions and Ag-ricultural Services	Hotel and Restaurant

Sumber: Analisis Penulis pada tahun 2020

Conclusion

The implementation of biofuel policy is one of the key agendas to support the achievement of 23% renewable energy mix target by 2025. The implementation of increasingly ambitious mandatory biodiesel policies and the development of green fuel also encourages various parties to examine the risks and impacts that could arise from these policies.

Biodiesel and green fuel policies have the potential to create a CPO deficit at least until 2025, with an accumulated value between 34.9 million tonnes (Scenario B30) and 122 million tonnes (Scenario B50 + green gasoline). Concerns about CPO oversupply may not occur in line with the increasing target of biodiesel blending and the start of green fuel production. This condition occurs with the assumption that CPO export will continue to experience growth regardless of the current international trading issues. There may be a decline in export due to the anti-palm oil policy of the European Union, however, the emergence of new market shares also needs to be accommodated.

One of the programs that can be carried out to ensure the availability of CPO stock to support biofuel policies, particularly green fuel, is the replanting program, especially for smallholders. The amount of replanting land required for various biodiesel and green fuel policy scenarios is estimated between 3.8 million ha to 16.6 million ha depending on the policy scenario implemented.

In addition to ensuring CPO stock availability, the replanting program is projected to increase plantation yields and thereby reduce the poverty level of palm oil farmers. Poverty reduction due to replanting palm oil plantations in the seven main palm-oil-producing provinces reaches 2.09 percentage point, whereas the P1 (poverty gap) reduction in these areas is Rp1,683.

In terms of readiness for funding the replanting program, BPDP-KS needs to prepare a significant amount of fund to carry it out. From the results of dynamic modeling, BPDP-KS has to prepare at least Rp39 trillion to carry out the replanting program in 2020 and 2021 (Scenario B30). The government's target of 180.000 ha/year will be able to reduce the need for funds from BPDP-KS to Rp4.5 trillion per year. However, this scheme is clearly unable to meet the land area required for Scenario B50 and above. Other funding issues faced in replanting are: 1) stability of income from BPDP-KS to meet replanting funding requirements; and 2) role of private sector (banks/other financial institutions) to fill the funding gap required for replanting.

The success of the replanting program will have a positive impact on the GRDP of the provinces who are implementing the program with different magnitudes, proportional to the stimulant value (replanting yields) provided and output multiplier of the palm oil/plantation sector in each region. This positive impact is the result of an increase in FFB production due to increased land productivity after replanting the plantation.

Bibliography

Bronkhorst, E., Cavallo, E., van Dorth tot Medler, M., Klinghammer, S., Smit, H. H., Gijsenbergh, A., & van der Laan, C. (2017). Current practices and innovations in smallholder palm oil finance in Indonesia and Malaysia: Long-term financing solutions to promote sustainable supply chains (Vol. 177). CIFOR.

Byerlee, D., Stevenson, J., & Villoria, N. (2014). Does intensification slow crop land expansion or encourage deforestation?. Global food security, 3(2), 92-98.

Daemeter Consulting. (2015). Indonesian Oil Palm Smallholder Farmers: A Typology of Organizational Models, Needs, and Investment Opportunities. Daemeter Consulting: Bogor, Indonesia.

Direktorat Jenderal Perkebunan Kementerian Pertanian. (2018). Statistik Perkebunan Indonesia: Kelapa Sawit (2017-2019). Kementerian Pertanian Republik Indonesia: Jakarta.

Jelsma, I., Slingerland, M., Giller, K. E., & Bijman, J. (2017). Collective action in a smallholder oil palm production system in Indonesia: The key to sustainable and inclusive smallholder palm oil?. Journal of rural studies, 54, 198-210.

Johnston, D., Smit, H. H., Bronkhorst, E., van Dorth tot Medler, M. M., Adjaffon, I., & Cavallo, E. (2020). Innovative Replanting Financing Models for Oil Palm Smallholder Farmers in Indonesia. Potential for Upscaling, Improving Livelihoods and Supporting Deforestation-Free Supply Chains. Tropical Forest Alliance.

Nurfatriani, F., Sari, G. K., & Komarudin, H. (2018). Optimalisasi dana sawit dan pengaturan instrumen fiskal penggunaan lahan hutan untuk perkebunan dalam upaya mengurangi deforestasi (Vol. 238). CIFOR.

Sahara S, Haryadi H, dan Kusumowardhani N. (2017). Smallholder finance in the palm oil sector: Barriers and potential to support the uptake of sustainable practices. Occasional Paper 174. Bogor, Indonesia.

Shibao, P., & Selamat F.. (2018). Financing Indonesia's Independent Smallholders. Working Paper. Singapore Institute of International Affairs: Singapore.

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, 148-159.

Zen, Z., McCarthy, J. F., & Gillespie, P. (2008). Linking pro-poor policy and oil palm cultivation. Policy Brief, 5.

Zen, Z., Barlow, C., Gondowarsito, R., & McCarthy, J. F. (2016). Interventions to promote smallholder oil palm and socio-economic improvement in Indonesia. The Oil Palm Complex: Smallholders, Agribusiness and the State in Indonesia and Malaysia. NUS, Singapore, 78-108.

Appendices

Appendix 1. ARIMA Regression of Biodiesel Distribution

	(1)
VARIABLE	DomBDDistribution
L.ar	0,294
	(0,232)
L.ma	-0,597***
	(0,192)
Constant	7.565
	(5.675)
Observations	70
chi2	34,41

Standard error in parentheses, *** p <0.01, ** p <0.05, * p <0.1

Source: Author's Estimate

Appendix 2. ARIMA Regression of Biodiesel Export

	(1)
VARIABLE	BDExport
L.ar	0,760***
	(0,166)
L.ma	-0,132
	(0,175)
L2.ma	0,156
	(0,170)
Constant	77.402**
	(31.367)
Observations	71
chi2	56,76

Standard error in parentheses, *** p <0.01, ** p <0.05, * p <0.1

Source: Author's Estimate

Appendix 3. Scenario 1 Biodiesel and CPO Balances

Biodiesel Balance					
Year	Initial Stock	Production	Consumption	Export	Final Stock
2014	97000	3962232	1778683	1629263	651286
2015	651286	1652801	944970	328574	1030543
2016	1030543	3656361	3308475	428868	949561
2017	949561	3416416	2571568	187385	1607024
2018	1607024	6167837	3750066	1785489	2239306
2019	2239306	11305278	7632753	1384412	4527419
2020	4527419	10382380	8631658	1158214	5119927
2021	5119927	11450185	9630185	1227718	5712209
2022	5712209	12807558	10810327	1297221	6412219
2023	6412219	13767948	11808908	1366725	7004534
2024	7004534	15125284	12989047	1436229	7704541
2025	7704541	16230319	14078418	1505733	8350709

CPO Balance								
Year	Stock	CPO Production	Production by Replanting *(Prior)*	CPO Import	CPO Export	Non-Biofuel Consumption	Biodiesel	Final Stock
2014	2100000	35534135	0	299	22892224	3546945	4018491	7176774
2015	7176774	34556116	0	7572	26467564	4200398	1676269	9396232
2016	9396232	38516772	0	2658	22761814	5531771	3708277	15913800
2017	15913800	42410336	0	2518	27353337	5149902	3464925	22358490
2018	22358490	44415441	0	806	27898875	5188760	6255413	27431690
2019	27431690	48381509	0	8180	29290831	5467002	11465799	29597746
2020	29597746	48535464	117072	7233	30677202	5745245	10529797	31305271
2021	31305271	48689419	387808	6286	32063572	6023487	11612764	30688962
2022	30688962	48843375	1044704	5339	33449943	6301730	12989409	27841297
2023	27841297	48997330	1044704	4392	34836313	6579972	13963436	22508002
2024	22508002	49151285	1044704	3445	36222683	6858215	15340044	14286493
2025	14286493	49305240	1044704	2497	37609054	7136457	16460769	3432654

Source: Author's Calculation

Appendix 4. Scenario 2 Biodiesel and CPO Balances

Biodiesel Balance					
Year	**Initial Stock**	**Production**	**Consumption**	**Export**	**Final Stock**
2014	97000	3962232	1778683	1629263	651286
2015	651286	1652801	944970	328574	1030543
2016	1030543	3656361	3308475	389791	988637
2017	988637	3416416	2571568	187385	1646100
2018	1646100	6167837	3750066	1485188	2578683
2019	2578683	10965901	7632753	1384412	4527419
2020	4527419	17258173	12947488	1158214	7679890
2021	7679890	16561419	14445277	1227718	8568314
2022	8568314	18562726	16215490	1297221	9618328
2023	9618328	19968559	17713361	1366725	10506800
2024	10506800	21969811	19483571	1436229	11556812
2025	11556812	23592611	21117627	1505733	12526064

CPO Balance								
Year	**Stock**	**CPO Production**	**Production by Replanting (*Prior*)**	**CPO Import**	**CPO Export**	**Non-Biofuel Consumption**	**Biodiesel**	**Final Stock**
2014	2100000	35534135	0	299	22892224	3546945	4018491	7176774
2015	7176774	34556116	0	7572	26467564	4200398	1676269	9396232
2016	9396232	38516772	0	2658	22761814	5531771	3708277	15913800
2017	15913800	42410336	0	2518	27353337	5149902	3464925	22358490
2018	22358490	44415441	0	806	27898875	5188760	6255413	27431690
2019	27431690	48381509	0	8180	29290831	5467002	11121603	29941942
2020	29941942	48535464	117072	7233	30677202	5745245	17503218	24676047
2021	24676047	48689419	387808	6286	32063572	6023487	16796571	18875931
2022	18875931	48843375	1044704	5339	33449943	6301730	18826294	10191382
2023	10191382	48997330	1044704	4392	34836313	6579972	20252088	-1430566
2024	-1430566	49151285	1044704	3445	36222683	6858215	22281756	-16593786
2025	-16593786	49305240	1044704	2497	37609054	7136457	23927598	-34914453

Source: Author’s Calculation

Appendix 5. Scenario 1 Biodiesel and CPO Balances

Biodiesel Balance					
Year	Initial Stock	Production	Consumption	Export	Final Stock
2014	97000	3962232	1778683	1629263	651286
2015	651286	1652801	944970	328574	1030543
2016	1030543	3656361	3308475	389791	988637
2017	988637	3416416	2571568	187385	1646100
2018	1646100	6167837	3750066	1485188	2578683
2019	2578683	10965901	7632753	1384412	4527419
2020	4527419	17258173	12947488	1158214	7679890
2021	7679890	16561419	14445277	1227718	8568314
2022	8568314	18562726	16215490	1297221	9618328
2023	9618328	38782000	29522269	1366725	17511334
2024	17511334	35658866	32472618	1436229	19261353
2025	19261353	38317197	35196045	1505733	20876773

CPO Balance									
Year	Stock	CPO Production	Production by Replanting (*Prior*)	CPO Import	CPO Export	Non- Biofuel Consumption	Biodiesel	Green Diesel	Final Stock
2014	2100000	35534135	0	299	22892224	3546945	4018491	0	7176774
2015	7176774	34556116	0	7572	26467564	4200398	1676269	0	9396232
2016	9396232	38516772	0	2658	22761814	5531771	3708277	0	15913800
2017	15913800	42410336	0	2518	27353337	5149902	3464925	0	22358490
2018	22358490	44415441	0	806	27898875	5188760	6255413	0	27431690
2019	27431690	48381509	0	8180	29290831	5467002	11121603	0	29941942
2020	29941942	48535464	117072	7233	30677202	5745245	17503218	0	24676047
2021	24676047	48689419	387808	6286	32063572	6023487	16796571	0	18875931
2022	18875931	48843375	1044704	5339	33449943	6301730	18826294	0	10191382
2023	10191382	48997330	1044704	4392	34836313	6579972	26805420	15553999	-23537897
2024	-23537897	49151285	1044704	3445	36222683	6858215	22485390	17108410	-56013162
2025	-56013162	49305240	1044704	2497	37609054	7136457	24038883	18543265	-92988380

Source: Author's Calculation

Appendix 6. Scenario 2 Biodiesel and CPO Balances

Biodiesel Balance					
Year	Initial Stock	Production	Consumption	Export	Final Stock
2014	97000	3962232	1778683	1629263	651286
2015	651286	1652801	944970	328574	1030543
2016	1030543	3656361	3308475	389791	988637
2017	988637	3416416	2571568	187385	1646100
2018	1646100	6167837	3750066	1485188	2578683
2019	2578683	10965901	7632753	1384412	4527419
2020	4527419	17258173	12947488	1158214	7679890
2021	7679890	31903813	24075462	1227718	14280523
2022	14280523	30073062	27025817	1297221	16030547
2023	16030547	32369781	29522269	1366725	17511334
2024	17511334	35658866	32472618	1436229	19261353
2025	19261353	38317197	35196045	1505733	20876773

CPO Balance									
Year	Stock	CPO Production	Production by Replanting (*Prior*)	CPO Import	CPO Export	Non- Biofuel Consumption	Biodiesel	Green Diesel	Final Stock
2014	2100000	35534135	0	299	22892224	3546945	4018491	0	7176774
2015	7176774	34556116	0	7572	26467564	4200398	1676269	0	9396232
2016	9396232	38516772	0	2658	22761814	5531771	3708277	0	15913800
2017	15913800	42410336	0	2518	27353337	5149902	3464925	0	22358490
2018	22358490	44415441	0	806	27898875	5188760	6255413	0	27431690
2019	27431690	48381509	0	8180	29290831	5467002	11121603	0	29941942
2020	29941942	48535464	117072	7233	30677202	5745245	17503218	0	24676047
2021	24676047	48689419	387808	6286	32063572	6023487	22136891	12684314	851297
2022	851297	48843375	1044704	5339	33449943	6301730	19109242	14238728	-22354928
2023	-22354928	48997330	1044704	4392	34836313	6579972	20393201	15553999	-49671989
2024	-49671989	49151285	1044704	3445	36222683	6858215	22485390	17108410	-82147253
2025	-82147253	49305240	1044704	2497	37609054	7136457	24038883	18543265	-119122471

Source: Author's Calculation

Appendix 7. Scenario 1 Biodiesel and CPO Balances

Biodiesel Balance					
Year	**Initial Stock**	**Production**	**Consumption**	**Export**	**Final Stock**
2014	97000	3962232	1778683	1629263	651286
2015	651286	1652801	944970	328574	1030543
2016	1030543	3656361	3308475	389791	988637
2017	988637	3416416	2571568	187385	1646100
2018	1646100	6167837	3750066	1485188	2578683
2019	2578683	10965901	7632753	1384412	4527419
2020	4527419	17258173	12947488	1158214	7679890
2021	7679890	31903813	24075462	1227718	14280523
2022	14280523	30073062	27025817	1297221	16030547
2023	16030547	32369781	29522269	1366725	17511334
2024	17511334	35658866	32472618	1436229	19261353
2025	19261353	38317197	35196045	1505733	20876773

CPO Balance										
Year	**Stock**	**CPO Production**	**Production by Replanting (*Prior*)**	**CPO Import**	**CPO Export**	**Non-Biofuel Consump-tion**	**Biodiesel**	***Green diesel***	***Green Gasoline***	**Final Stock**
2014	2100000	35534135	0	299	22892224	3546945	4018491	0	0	7176774
2015	7176774	34556116	0	7572	26467564	4200398	1676269	0	0	9396232
2016	9396232	38516772	0	2658	22761814	5531771	3708277	0	0	15913800
2017	15913800	42410336	0	2518	27353337	5149902	3464925	0	0	22358490
2018	22358490	44415441	0	806	27898875	5188760	6255413	0	0	27431690
2019	27431690	48381509	0	8180	29290831	5467002	11121603	0	0	29941942
2020	29941942	48535464	117072	7233	30677202	5745245	17503218	0	0	24676047
2021	24676047	48689419	387808	6286	32063572	6023487	22136891	12684314	705848	145449
2022	145449	48843375	1044704	5339	33449943	6301730	19109242	14238728	709580	-23770356
2023	-23770356	48997330	1044704	4392	34836313	6579972	20393201	15553999	713313	-51800730
2024	-51800730	49151285	1044704	3445	36222683	6858215	22485390	17108410	717046	-84993040
2025	-84993040	49305240	1044704	2497	37609054	7136457	24038883	18543265	720779	-122689037

Source: Author’s Calculation

Appendix 8. Scenario 4 Dynamic CPO Balance

Year	Adjusted Initial Stock	Stock	CPO Production	Production by Replanting (*Prior*)	CPO Import	CPO Export
2014		2100000	35534135	0	299	22892224
2015		7176774	34556116	0	7572	26467564
2016		9396232	38516772	0	2658	22761814
2017		15913800	42410336	0	2518	27353337
2018		22358490	44415441	0	806	27898875
2019		27431690	48381509	0	8180	29290831
2020		29941942	48535464	117072	7233	30677202
2021	20796664		48689419	387808	6286	32063572
2022	7237780		48843375	1044704	5339	33449943
2023	-9205537		48997330	1044704	4392	34836313
2024	-13068717		49151285	1044704	3445	36222683
2025	-4955635		49305240	1044704	2497	37609054

Year	Non-Biofuel Consumption	Biodiesel	Reduced Production in Replanting Land	Added Production in Replanting Land	Final Stock	Adjusted Final Stock
2014	3546945	4018491			7176774	
2015	4200398	1676269			9396232	
2016	5531771	3708277			15913800	
2017	5149902	3464925			22358490	
2018	5188760	6255413			27431690	
2019	5467002	11121603			29941942	
2020	5745245	17503218	3879384			20796664
2021	6023487	16796571	7758767			7237780
2022	6301730	18826294	7758767			-9205537
2023	6579972	20252088	3879384	11638151		-13068717
2024	6858215	22281756		23276302		-4955635
2025	7136457	23927598		23276302		0

Source: Author's Calculation

Appendix 9. Scenario 5 Dynamic CPO Balance

Year	Adjusted Initial Stock	Stock	CPO Production	Production by Replanting (*Prior*)	CPO Import	CPO Export
2014		2100000	35534135	0	299	22892224
2015		7176774	34556116	0	7572	26467564
2016		9396232	38516772	0	2658	22761814
2017		15913800	42410336	0	2518	27353337
2018		22358490	44415441	0	806	27898875
2019		27431690	48381509	0	8180	29290831
2020		29941942	48535464	117072	7233	30677202
2021	14344005		48689419	387808	6286	32063572
2022	-12120196		48843375	1044704	5339	33449943
2023	-41468829		48997330	1044704	4392	34836313
2024	-54534024		49151285	1044704	3445	36222683
2025	-25017036		49305240	1044704	2497	37609054

Year	Non-Biofuel Consumption	Biodiesel	*Green diesel*	Reduced Production in Replanting Land	Added Production in Replanting Land	Final Stock	Adjusted Final Stock
2014	3546945	4018491	0			7176774	
2015	4200398	1676269	0			9396232	
2016	5531771	3708277	0			15913800	
2017	5149902	3464925	0			22358490	
2018	5188760	6255413	0			27431690	
2019	5467002	11121603	0			29941942	
2020	5745245	17503218	0	10332042			14344005
2021	6023487	16796571	0	20664084			-12120196
2022	6301730	18826294	0	20664084			-41468829
2023	6579972	26805420	15553999	10332042	30996127		-54534024
2024	6858215	22485390	17108410		61992253		-25017036
2025	7136457	24038883	18543265		61992253		0

Source: Author's Calculation

Appendix 10. Scenario 4 Dynamic CPO Balance

Year	Adjusted Initial Stock	Stock	CPO Production	Production by Replanting (*Prior*)	CPO Import	CPO Export
2014		2100000	35534135	0	299	22892224
2015		7176774	34556116	0	7572	26467564
2016		9396232	38516772	0	2658	22761814
2017		15913800	42410336	0	2518	27353337
2018		22358490	44415441	0	806	27898875
2019		27431690	48381509	0	8180	29290831
2020		29941942	48535464	117072	7233	30677202
2021	11440217		48689419	387808	6286	32063572
2022	-38856194		48843375	1044704	5339	33449943
2023	-88534078		48997330	1044704	4392	34836313
2024	-89379479		49151285	1044704	3445	36222683
2025	-42439763		49305240	1044704	2497	37609054

Year	Non-Biofuel Consumption	Biodiesel	*Green diesel*	Reduced Production in Replanting Land	Added Production in Replanting Land	Final Stock	Adjusted Final Stock
2014	3546945	4018491	0			7176774	
2015	4200398	1676269	0			9396232	
2016	5531771	3708277	0			15913800	
2017	5149902	3464925	0			22358490	
2018	5188760	6255413	0			27431690	
2019	5467002	11121603	0			29941942	
2020	5745245	17503218	0	13235830			11440217
2021	6023487	22136891	12684314	26471660			-38856194
2022	6301730	19109242	14238728	26471660			-88534078
2023	6579972	20393201	15553999	13235830	39707490		-89379479
2024	6858215	22485390	17108410		79414981		-42439763
2025	7136457	24038883	18543265		79414981		0

Source: Author's Calculation

Appendix 11. Scenario 5 Dynamic CPO Balance

Year	Adjusted Initial Stock	Stock	CPO Production	Production by Replanting (*Prior*)	CPO Import	CPO Export
2014		2100000	35534135	0	299	22892224
2015		7176774	34556116	0	7572	26467564
2016		9396232	38516772	0	2658	22761814
2017		15913800	42410336	0	2518	27353337
2018		22358490	44415441	0	806	27898875
2019		27431690	48381509	0	8180	29290831
2020		29941942	48535464	117072	7233	30677202
2021	11043932		48689419	387808	6286	32063572
2022	-40750897		48843375	1044704	5339	33449943
2023	-91930932		48997330	1044704	4392	34836313
2024	-92697075		49151285	1044704	3445	36222683
2025	-44096695		49305240	1044704	2497	37609054

Year	Non-Biofuel Consumption	Biodiesel	*Green diesel*	*Green Gasoline*	Reduced Production in Replanting Land	Added Production in Replanting Land	Final Stock	Adjusted Final Stock
2014	3546945	4018491	0	0			7176774	
2015	4200398	1676269	0	0			9396232	
2016	5531771	3708277	0	0			15913800	
2017	5149902	3464925	0	0			22358490	
2018	5188760	6255413	0	0			27431690	
2019	5467002	11121603	0	0			29941942	
2020	5745245	17503218	0	0	13632115			11043932
2021	6023487	22136891	12684314	705848	27264230			-40750897
2022	6301730	19109242	14238728	709580	27264230			-91930932
2023	6579972	20393201	15553999	713313	13632115	40896346		-92697075
2024	6858215	22485390	17108410	717046		81792691		-44096695
2025	7136457	24038883	18543265	720779		81792691		0

Source: Author's Calculation

Appendix 12. Annual Smallholder Plantation Land and Funds Requirements

Scenario and Year	Replanting Land Requirement (ha)	Replanting Year	Funds Requirement (Million Rupiah)		
			Total	Public/Government Funds	Private Funds
B20					
2025	-		-	-	-
B30	**1,551,753**				
2023	775,877	2020	42,673,221	19,396,919	23,276,302
2024	775,877	2021	42,673,221	19,396,919	23,276,302
B30 + B30D20 (2023)	**4,132,817**				
2023	2,066,408	2020	113,652,464	51,660,211	61,992,253
2024	2,066,408	2021	113,652,464	51,660,211	61,992,253
B30 + B30D20 (2021)	**5,294,332**				
2023	2,647,166	2020	145,594,131	66,179,151	79,414,981
2024	2,647,166	2021	145,594,131	66,179,151	79,414,981
B30 + B30D20 + Greenfuel (2023)	**5,452,846**				
2023	2,726,423	2020	149,953,267	68,160,576	81,792,691
2024	2,726,423	2021	149,953,267	68,160,576	81,792,691

Source: Author's Calculation

Appendix 13. Matrix of Productivity and Number of Poor Farmers in Cities/Regencies of Priority Replanting Areas

		PRODUCTIVITY									
		TINGGI			LAND SIZE	TOTAL POOR FARM-ERS	NA			LAND SIZE	TOTAL POOR FARM-ERS
POOR FARMERS	LOW	6405	Berau Regency	East Kalimantan	25,421	-					
		1212	Deli Serdang Regency	North Sumatra	10,344	-					
		1207	Labuhan Batu Regency	North Sumatra	29,443	-					
		1605	Musi Rawas Regency	South Sumatra	44,726	-					
		1471	Pekanbaru City	Riau	5,420						
		1206	Toba Samosir Regency	North Sumatra	512	-					
	MODERATE	1203	South Tapanuli Regency	North Sumatra	3,011	958					
		1408	Bengkalis Regency	Riau	112,119	858					
		6404	East Kutai Regency	East Kalimantan	76,688	853					
		1606	Musi Banyuasin Regency	South Sumatra	98,838	669					
		1473	Dumai Regency	Riau	32,150	391					
		1404	Pelalawan Regency	Riau	65,797	316					
		1220	North Padang Lawas City	North Sumatra	16,966	276					
		1221	Padang Lawas Regency	North Sumatra	25,085	220					
		1604	Lahat Regency	South Sumatra	11,623	219					
		1202	Mandailing Natal Regency	North Sumatra	14,463	187					
	HIGH	1507	West Tanjung Jabung Regency	Jambi	66,393	1.283					
		1222	South Labuhan Batu Regency	North Sumatra	36,997	1.363					
		1504	Batanghari Regency	Jambi	36,618	1.031					
		1213	Langkat Regency	North Sumatra	38,114	4.583					
		1602	Ogan Komering Ilir Regency	South Sumatra	54,010	1.431					
		1502	Merangin Regency	Jambi	47,809	1.933					
		1409	Rokan Hilir Regency	Riau	124,273	10.557					
		1403	Indragiri Hilir Regency	Riau	80,501	1.307					
		1405	Siak Regency	Riau	123,874	1.540					
		1209	Simalungun Regency	North Sumatra	24,791	3.713					
		1603	Muara Enim Regency	South Sumatra	26,303	2.065					
		1407	Rokan Hulu Regency	Riau	147,119	2.638					
		1402	Indragiri Hulu Regency	Riau	33,058	2.009					
		1208	Asahan Regency	North Sumatra	68,673	1.098					
		1607	Banyuasin Regency	South Sumatra	40,028	3.400					
	N/A	1205	North Tapanuli Regency	North Sumatra	13		6411	Mahakam Hulu Regency	East Kalimantan	83	
		6104	Mempawah Regency	West Kalimantan	2,130		6213	Murung Raya Regency	Central Kalimantan	2	
		1211	Karo Regency	North Sumatra	1,241						
		1204	Central Tapanuli Regency	North Sumatra	1,794						
		1210	Dairi Regency	North Sumatra	125						
		1214	South Nias Regency	North Sumatra	219						
		1608	East OKU Regency	South Sumatra	11,981						

		PRODUKTIVITAS								
		RENDAH			SEDANG			TINGGI		
POOR FARMERS	LOW	1612	Pali (Penukal Abab Lematang Ilir) Regency	South Sumatra	6106	Ketapang Regency	West Kalimantan	1507	West Tanjung Jabung Regency	Jambi
		1609	South OKU Regency	South Sumatra	6102	Bengkayang Regency	West Kalimantan	1205	North Tapanuli Regency	North Sumatra
		6204	South Barito Regency	Central Kalimantan	6208	Seruyan Regency	Central Kalimantan	1222	South Labuhan Batu Regency	North Sumatra
		6474	Bontang City	East Kalimantan	6108	Kapuas Hulu Regency	West Kalimantan	6405	Berau Regency	East Kalimantan
		1501	Kerinci Regency	Jambi	1503	Sarolangun Regency	Jambi	1504	Batanghari Regency	Jambi
		6271	Palangka Raya City	Central Kalimantan	6105	Sanggau Regency	West Kalimantan	6104	Mempawah Regency	West Kalimantan
		1611	Empat Lawang Regency	South Sumatra	1505	Muaro Jambi Regency	Jambi	1408	Bengkalis Regency	Riau
		1232	Padang Sidimpuan Regency	North Sumatra	6109	Sekadau Regency	West Kalimantan	1212	Deli Serdang Regency	North Sumatra
	MODERATE	1673	Lubuk Linggau Regency	South Sumatra	6402	West Kutai Regency	East Kalimantan	1213	Langkat Regency	North Sumatra
		6211	Gunung Mas Regency	Central Kalimantan	6401	Paser Regency	East Kalimantan	6404	East Kutai Regency	East Kalimantan
		6212	East Barito Regency	Central Kalimantan	6107	Sintang Regency	West Kalimantan	1220	North Padang Lawas City	North Sumatra
		1613	Muratara (North Musi Rawas) Regency	South Sumatra	1219	Batubara Regency	North Sumatra	1602	Ogan Komering Ilir Regency	South Sumatra
		6201	West Kotawaringin Regency	Central Kalimantan	1508	Tebo Regency	Jambi	1207	Labuhan Batu Regency	North Sumatra
		1216	West Pak Pak Regency	North Sumatra	1674	Prabumulih Regency	South Sumatra	1605	Musi Rawas Regency	South Sumatra
		6111	North Kayong Regency	West Kalimantan	6403	Kutai Kertanegara Regency	East Kalimantan	1211	Karo Regency	North Sumatra
		6471	Balikpapan City	East Kalimantan	1601	Ogan Komering Ulu Regency	South Sumatra	1473	Dumai Regency	Riau
		1215	Humbang Hasundutan Regency	North Sumatra	1223	North Labuhan Batu Regency	North Sumatra	1203	South Tapanuli Regency	North Sumatra
		6210	Pulang Pisau Regency	Central Kalimantan	1406	Kampar Regency	Riau	1502	Merangin Regency	Jambi
	HIGH	6172	Singkawang Regency	West Kalimantan	6110	Melawi Regency	West Kalimantan	1409	Rokan Hilir Regency	Riau
		6209	Katingan Regency	Central Kalimantan	1610	Ogan Ilir Regency	South Sumatra	1202	Mandailing Natal Regency	North Sumatra
		6206	Sukamara Regency	Central Kalimantan	1218	Serdang Bedagai Regency	North Sumatra	1403	Indragiri Hilir Regency	Riau
		6203	Kapuas Regency	Central Kalimantan	1509	Bungo Regency	Jambi	1204	Central Tapanuli Regency	North Sumatra
		6202	East Kotawaringin Regency	Central Kalimantan	1671	Palembang City	South Sumatra	1405	Siak Regency	Riau
		6112	Kubu Raya Regency	West Kalimantan	1401	Kuantan Sengingi Regency	Riau	1209	Simalungun Regency	North Sumatra
		6205	North Barito Regency	Central Kalimantan				1603	Muara Enim Regency	South Sumatra
		6409	North Penajam Paser Regency	East Kalimantan				1210	Dairi Regency	Sumatera Utara
		1506	East Tanjung Jabung Regency	Jambi				1471	Pekanbaru City	Riau
		6472	Samarinda City	East Kalimantan				1604	Lahat Regency	South Sumatra
		6207	Lamandau Regency	Central Kalimantan				1206	Toba Samosir Regency	North Sumatra
		6101	Sambas Regency	West Kalimantan				1208	Asahan Regency	North Sumatra
		6103	Landak Regency	West Kalimantan				1221	Padang Lawas Regency	North Sumatra
		6106	Ketapang Regency	West Kalimantan				1407	Rokan Hulu Regency	Riau
		6102	Bengkayang Regency	West Kalimantan				1402	Indragiri Hulu Regency	Riau
	N/A	6208	Seruyan Regency	Central Kalimantan				1214	South Nias Regency	North Sumatra
		6108	Kapuas Hulu Regency	West Kalimantan				1404	Pelalawan Regency	Riau
		1503	Sarolangun Regency	Jambi				1607	Banyuasin Regency	South Sumatra
								1608	East OKU Regency	South Sumatra
								1606	Musi Banyuasin Regency	South Sumatra

		POOR FARMERS											
		LOW			MODERATE			HIGH			NA		
POOR FARMERS	LOW	1471	Pekanbaru City	Riau	1203	South Tapanuli Regency	North Sumatra	1409	Rokan Hilir Regency	Riau	1612	Pali (Penukal Abab Lematang Ilir) Regency	South Sumatra
		6211	Gunung Mas Regency	Central Kalimantan	6109	Sekadau Regency	West Kalimantan	6105	Sanggau Regency	West Kalimantan	1609	South OKU Regency	South Sumatra
		1613	Muratara (North Musi Rawas) Regency	South Sumatra	6107	Sintang Regency	West Kalimantan	1213	Langkat Regency	North Sumatra	6204	South Barito Regency	Central Kalimantan
		6201	West Kotawaringin Regency	Central Kalimantan	1408	Bengkalis Regency	Riau	1209	Simalungun Regency	North Sumatra	6474	Bontang City	East Kalimantan
		1216	West Pak Pak Regency	North Sumatra	6404	East Kutai Regency	East Kalimantan	1607	Banyuasin Regency	South Sumatra	1501	Kerinci Regency	Jambi
		6206	Sukamara Regency	Central Kalimantan	1505	Muaro Jambi Regency	Jambi	1406	Kampar Regency	Riau	6271	Palangka Raya City	Central Kalimantan
		6203	Kapuas Regency	Central Kalimantan	6210	Pulang Pisau Regency	Central Kalimantan	1407	Rokan Hulu Regency	Riau	1611	Empat Lawang Regency	South Sumatra
		6202	East Kotawaringin Regency	Central Kalimantan	6110	Melawi Regency	West Kalimantan	1223	North Labuhan Batu Regency	North Sumatra	1232	Padang Sidimpuan Regency	North Sumatra
	MODERATE	6101	Sambas Regency	West Kalimantan	6401	Paser Regency	East Kalimantan	1603	Muara Enim Regency	South Sumatra	1673	Lubuk Linggau Regency	South Sumatra
		6402	West Kutai Regency	East Kalimantan	1506	East Tanjung Jabung Regency	Jambi	1218	Serdang Bedagai Regency	North Sumatra	6212	East Barito Regency	Central Kalimantan
		1601	Ogan Komering Ulu Regency	South Sumatra	1606	Musi Banyuasin Regency	South Sumatra	1402	Indragiri Hulu Regency	Riau	6471	Balikpapan City	East Kalimantan
		1610	Ogan Ilir Regency	South Sumatra	6102	Bengkayang Regency	West Kalimantan	1502	Merangin Regency	Jambi	1215	Humbang Hasundutan Regency	North Sumatra
		1401	Kuantan Sengingi Regency	Riau	1219	Batubara Regency	North Sumatra	1405	Siak Regency	Riau	6172	Singkawang Regency	West Kalimantan
		6405	Berau Regency	East Kalimantan	1473	Dumai Regency	Riau	1602	Ogan Komering Ilir Regency	South Sumatra	6209	Katingan Regency	Central Kalimantan
		1212	Deli Serdang Regency	North Sumatra	6106	Ketapang Regency	West Kalimantan	1222	South Labuhan Batu Regency	North Sumatra	6472	Samarinda City	East Kalimantan
		1207	Labuhan Batu Regency	North Sumatra	1508	Tebo Regency	Jambi	1403	Indragiri Hilir Regency	Riau	6108	Kapuas Hulu Regency	West Kalimantan
		1605	Musi Rawas Regency	North Sumatra	1404	Pelalawan Regency	Riau	1507	West Tanjung Jabung Regency	Jambi	1672	Prabumulih Regency	South Sumatra
		1206	Toba Samosir Regency	North Sumatra	6111	North Kayong Regency	West Kalimantan	6103	Landak Regency	West Kalimantan	1671	Palembang City	South Sumatra
	HIGH				1220	North Padang Lawas City	North Sumatra	1208	Asahan Regency	North Sumatra	1205	North Tapanuli Regency	North Sumatra
					1221	Padang Lawas Regency	North Sumatra	6409	North Penajam Paser Regency	East Kalimantan	6104	Mempawah Regency	West Kalimantan
					1604	Lahat Regency	South Sumatra	6403	Kutai Kertanegara Regency	East Kalimantan	1211	Karo Regency	Sumatera Utara
					6112	Kubu Raya Regency	West Kalimantan	1504	Batanghari Regency	Jambi	1204	Central Tapanuli Regency	North Sumatra
					1202	Mandailing Natal Regency	North Sumatra				1210	Dairi Regency	North Sumatra
					1503	Sarolangun Regency	Jambi				1214	South Nias Regency	North Sumatra
					6205	North Barito Regency	Central Kalimantan				1608	East OKU Regency	South Sumatra
					6208	Seruyan Regency	Central Kalimantan				1410	Kepulauan Meranti Regency	Riau
					6207	Lamandau Regency	Central Kalimantan				1572	Sungai Penuh City	Jambi
					1509	Bungo Regency	Jambi						

TRACTION
ENERGY ASIA