Chapter 10
Biofuels Development and Indirect Deforestation

Rizky Ramadhan, Akihisa Mori, and Oekan S. Abdoellah

Abstract The Indonesian government launched the B30 program (a mixture of 30% biodiesel and 70% diesel fuel) in 2019 to save foreign exchange, reduce dependence on fossil fuels, and improve environmental quality. Indonesia uses palm oil as the main source for making biodiesel, as proven by an increase in the domestic market demand for biodiesel by as much as 2.69 million tons. This is followed by the increase of the area of palm oil plantations by 4.25 million hectares from 2014 to 2020. In contrast, the rate of deforestation in the three main palm oil-producing islands (Sumatra, Kalimantan, and Papua) tends to decline. These facts raise a hypothesis that the B30 program may trigger indirect deforestation or conversion of nonforest areas to palm oil. To prove this hypothesis, we use the geographic information system (GIS) to detect and analyze land cover by looking at historical data on land-use changes in the Province of Riau and Central Kalimantan, the largest palm oil-producing provinces. The development of biofuels under the moratorium regulation indirectly encourages oil palm companies to open oil palm plantations in areas originally used as cultivation areas. The loss of land for cultivation has encouraged local communities to clear land for cultivation in the forest. This situation is what we call indirect deforestation.

Keywords KCP · Governance · Representation · Palm oil · ISPO · Indonesia

10.1 Introduction

Indonesia's government committed to reducing GHG emissions by 29% from Business as Usual (BAU) by 2030. For this purpose, starting in 2020, the Government of Indonesia issued a mandatory program of biodiesel called B30 (a mixture of 30%

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biodiesel and 70% diesel fuel), making Indonesia the highest implementer of biodiesel in the world. This program claimed to benefit the state by adding foreign exchange of $ 3.4 billion.

As palm oil is a raw material for biodiesel, this program can contribute positively to the regional economy by alleviating rural poverty and promoting local infrastructure development (Janda et al., 2012; Pacheco et al., 2017). On the other hand, the development of oil palm plantations is often associated with deforestation and causes the loss of biodiversity and exacerbates climate change that has already occurred (Cazzolla Gatti & Velichevskaya, 2020; Miettinen et al., 2014; Oon et al., 2019; Vijay et al., 2016).

An increasing number of domestic markets demand for biodiesel by as much as 2.69 million tons, followed by the increase in the area of palm oil plantations by 4.25 million hectares from 2014 to 2020. In contrast, the rate of deforestation in the three main palm oil-producing islands (Sumatra, Kalimantan, and Papua) tends to decline. The government, through the Ministry of Environment and Forestry, prohibits the clearing of oil palm in conservation of forest areas but allows the clearing of oil palm land in other use land (APL) or nonforest areas through Law No. 41 of 1999. This indicates that the government is trying to reduce deforestation in Indonesia. However, the conversion of other land uses to palm oil will cause deforestation through the process of indirect deforestation.

Several studies show that indirect deforestation occurs in the development of soybean commodities (Gollnow et al., 2018; Lima et al., 2011; Song et al., 2021). Studies on indirect deforestation in oil palm development are still limited. However, a study by Ramadhan et al. (2021) shows that on a small scale, indirect deforestation has occurred in the Dusun Tonggong, Parindu, West Kalimantan, Indonesia, due to the development of oil palm commodities in the area. The previous research regarding indirect deforestation in the context of oil palm development has a limited scope of the study, so this chapter tries to see if something similar is happening in the level of provinces in Indonesia, particularly the provinces of Riau and Central Kalimantan. We use a Geographic Information System (GIS) to detect and analyze indirect deforestation by looking at historical data on land-use changes.

10.2 Biofuel Policy

10.2.1 Mandatory Blending Rates of Biodiesel in Indonesia

In 2006, through Presidential Decree No. 5/2006, the Indonesian government made the Ministry of Energy and Mineral Resources the legal body to create the National Energy Management Blueprint. One of the targets is to increase biofuel utilization (higher than 5%). In this year, biodiesel was also used for the first time through the Directorate General of Oil and Gas Decree No. 3675 K/24/DJM/2006 with a maximum limit of 10% FAME (Fatty, Acid, Methyl, and Ester) content.

Although in 2006 biofuels were used, the government, for the first time, issued a mandatory to use biodiesel in 2008, through the Ministry of Energy and Mineral Resources Decree No. 32/2008. At this time, the government only allowed the use of B2.5–B.7.5 (a mixture of 2.5% to 7.5% biodiesel to diesel fuel). In 2010, the government established the Directorate General of Renewable Energy and Energy Conservation. One of its directorates is the Directorate of Bioenergy, which handles biodiesel. This Directorate plays an essential role in developing biofuels policy, including the improvement of regulations related to mandatory and biodiesel specifications. This B2.5–B7.5 program lasted until 2013.

The B2.5–B7.5 program in 2014 was followed by B10, which was later increased to B15 in 2015. In 2015, the Ministry of Energy and Mineral Resources Decree No. 12/2015 replaced the Ministry of Energy and Mineral Resources Decree No. 32/2008. This regulation has currently become the reference for implementing mandatory biodiesel in Indonesia.

The B20 mandate, implemented in 2016, is a new history, especially for Indonesia, where Indonesia is the first country to implement B20. Even though it is considered successful in the transportation sector, this mandatory B20 program has not been followed by other sectors. Some of the obstacles faced are price, availability, and distribution, which are still limited. To expand the use of B20 in all sectors, the government issued Presidential Decree No. 66/2018 and implemented it in September 2018. This Presidential Decree succeeded in reducing diesel imports in September by 379,400 tons (see Fig. 10.2). Despite the increase in the following months after the implementation of Presidential Decree No. 66/2018, overall, this program succeeded in reducing diesel imports by 466,902 KL (Public Relation Directorate General of New and Renewable Energies and Energy Conservation, 2019) (see Fig. 10.1).

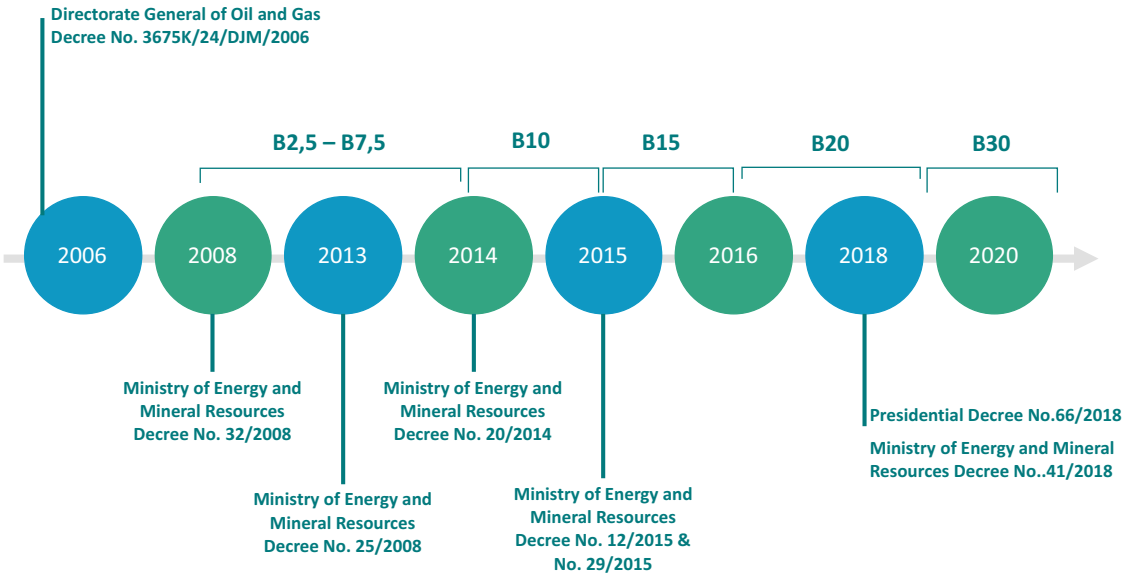

Fig. 10.1 Progressive blending rates in biodiesel policy and implementation in Indonesia. (Source: Ministry of Energy and Mineral Resources, 2021)

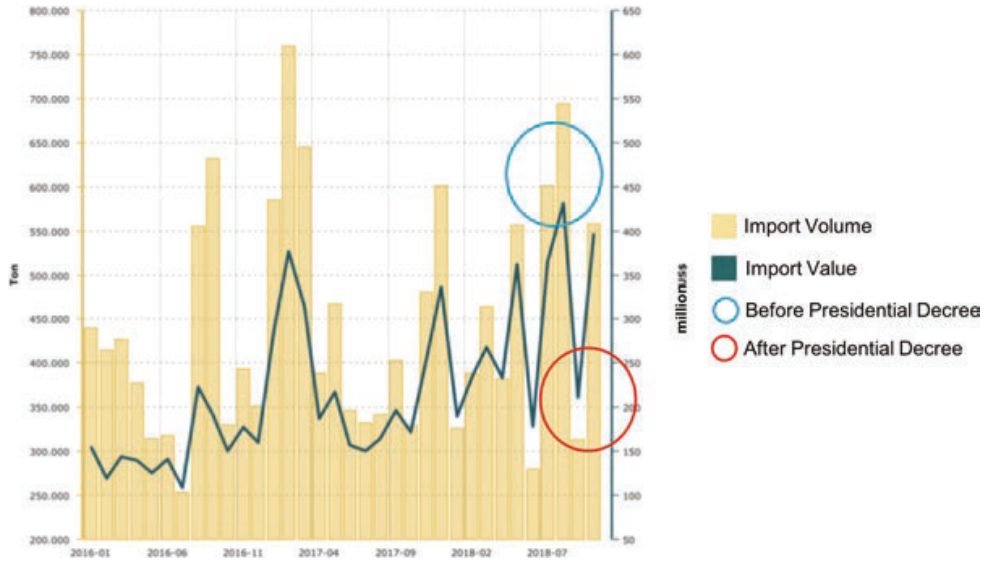

Fig. 10.2 Imported Indonesian diesel after the presidential decree (66/2018). (Source: "*Impor Solar Oktober*," 2018)

The government of Indonesia implemented the mandatory program B30 on January 1, 2020. Until now, this program has been running for more than one and a half years. This program is considered successful. The B30 program up to semester one has saved Indonesia's foreign exchange of 1.7 billion USD.

10.2.2 Environmental Impacts on Biofuels Program

The biofuels program in Indonesia is considered to be acceptable by the public because since 2016 the government has guaranteed through incentives that the price of biofuel is not higher than the price of fuel. This has been proven to increase biofuel sales (Wiratmini, 2019). Data in 2019 shows that domestic demand for biofuels in Indonesia has increased by 2.22 million tons (see Table 10.1). The development of this demand is in line with the increase in palm oil plantation area. Based on the Directorate General of Estate data, there was an increase in the area of palm oil plantations by 0.39 million hectares in 2019 (see Fig. 10.3).

Indonesia uses palm oil as the primary source of biodiesel production. Several parties in Indonesia debate it (Corley, 2009; Kamahara et al., 2010; Khatiwada et al., 2021; Oosterveer, 2020). The development of palm oil plantations is often associated with deforestation and causes the loss of biodiversity and exacerbates climate change that has already occurred.

In principle, the government of Indonesia and all palm oil stakeholders are against any illegal practices of palm oil stakeholders. For this reason, the government implemented a moratorium and Indonesian Sustainable Palm Oil (ISPO) certificate as a policy (Salman and Mori in this volume). Although the effectiveness of the palm oil development moratorium is still in question and becoming a debatable

Table 10.1 Biodiesel production and usages in Indonesia (recreated by the author based on data from Indonesia Biofuel Producers 2020

Year	Production (mill tons)	Domestic (mil tons)	Export (mil tons)	Domestic Growth (mil tons)	Blending rate
2014	3.32	1.55	1.37	0.67	B10
2015	1.39	0.77	0.28	−0.78	B10
2016	3.07	2.52	0.40	1.76	B10
2017	2.87	2.16	0.16	−0.37	B10
2018	5.17	3.15	1.51	0.99	B20
2019	7.04	5.36	1.11	2.22	B20
2020 E	8.47	8.05	0.42	2.69	B30

Source: Indonesian Biofuel Producers 2020, cited from Council of Palm Oil Producing Countries (2021)

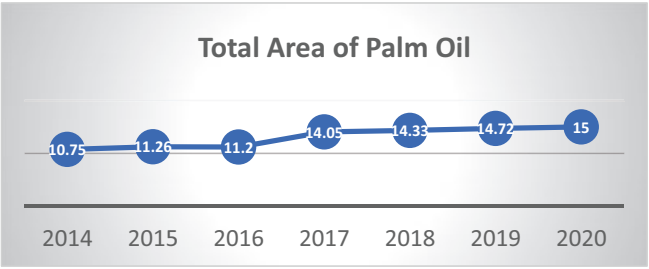

Fig. 10.3 Total area of palm oil plantation (recreated by the author based on data from Directorate General of Estate Crops). (Source: Directorate General of Estate Crops, 2019)

issue, this regulation affects the rate of deforestation in Indonesia (see Fig. 10.4). From this figure, the rate of deforestation declined, and the government claimed that the decline of the deforestation rate is due to the success of the implementation of the moratorium program (Austin et al., 2019). However, the other argument claims that the decline of the deforestation rate during the last 2 years is due to the La Nina years, wet conditions resulting in a less flammable landscape (Gaveau et al., 2022).

In addition, many mentioned that the potential massive deforestation is still there (Andrianto et al., 2019; Gaveau, 2018; The Gecko Project, 2018). This is particularly true in the Papua and West Papua provinces, where a million forestlands have been allocated or licensed to oil palm companies for the development of oil palm plantations in the future (Gaveau, 2018). Based on the data in Fig. 10.5, the deforestation rate in Papua provinces tends to increase, despite the existence of the moratorium (see Fig. 10.5).

10.2.3 Indirect Deforestation

Indirect deforestation occurs when one commodity in one location displaces the previous commodity to the frontier forest area (Rausch & Gibbs, 2016). Oil palm plantations can claim that their plantations are deforestation-free because they are

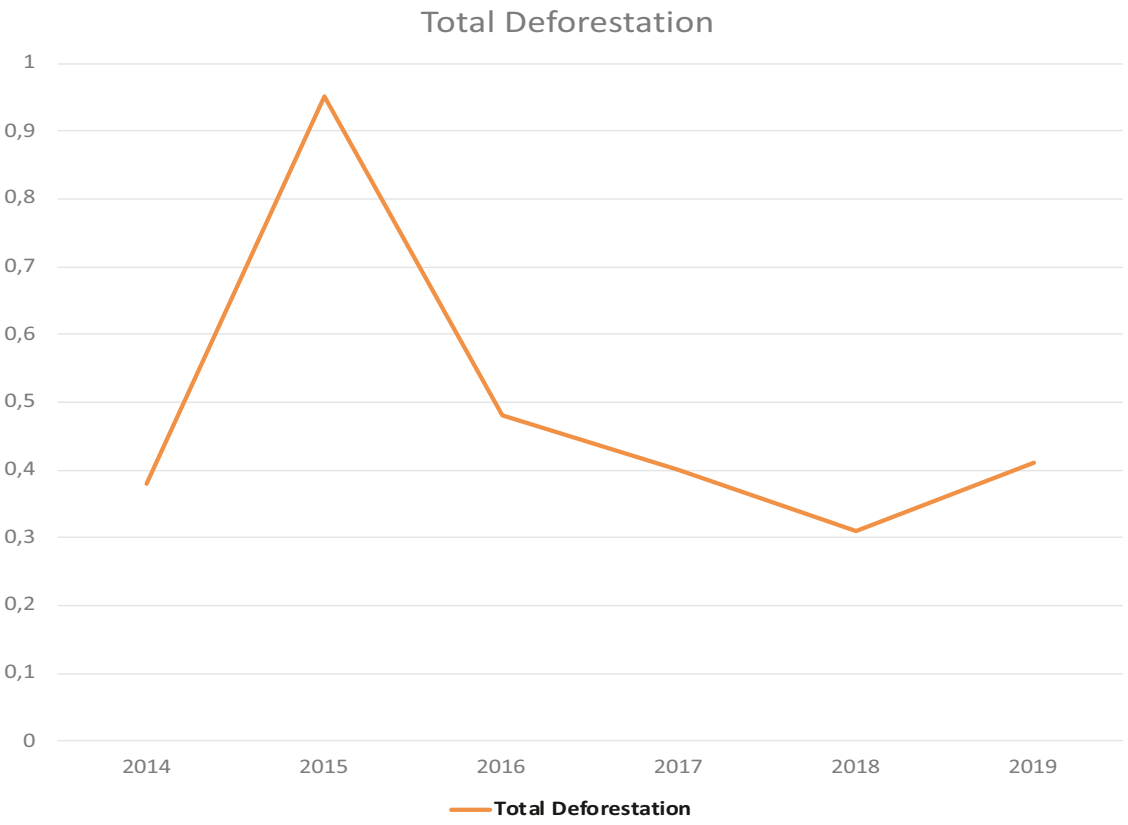

Fig. 10.4 Total deforestation in Indonesia. (Source: BPS, 2019)

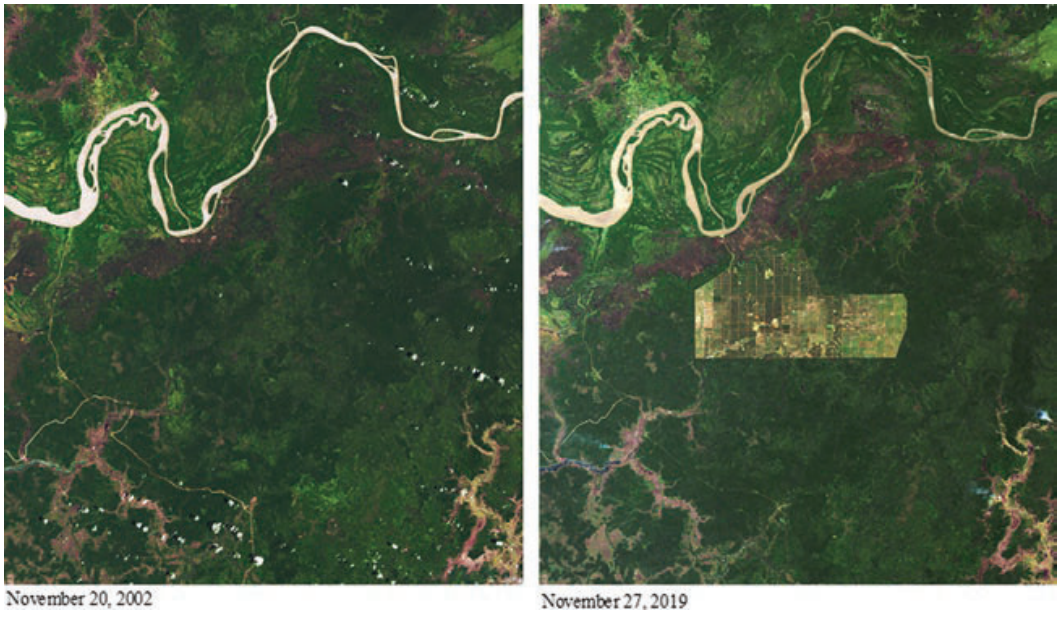

Fig. 10.5 Deforestation in Papua. (Source: NASA Earth Observatory, 2021)

built on nonforest lands such as vacant fields or land. Palm oil plantations may use land that the local people should use to cultivate their daily needs. It is not uncommon for the cultivation of biofuels to replace previous agricultural activities.

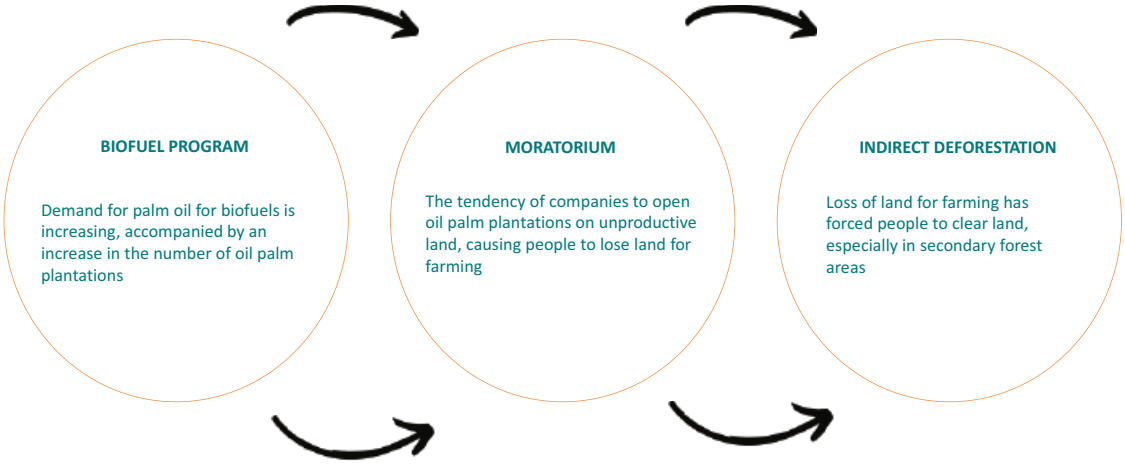

Fig. 10.6 Biofuel program and indirect deforestation

In this case, small-scale farmers who lack access to land and working capital are likely to relocate their cultivation areas to forest areas (Castiblanco et al., 2015; Jensen et al., 2019; Mukherjee & Sovacool, 2014; Saikkonen et al., 2014; Saswattecha et al., 2016; Silalertruksa & Gheewala, 2012). Indirect deforestation caused by displacement or loss of community farming land is difficult to prevent because people need new areas to maintain their livelihoods (Azhar et al., 2021).

Biofuel programs based on vegetable oil raised environmental impacts and indirect deforestation issues (see Fig. 10.6). When the demand for palm oil for biofuels is increasing, it is likely to be followed by an increase in the area of oil palm plantations.

10.3 GIS Analysis of Indirect Deforestation

10.3.1 Methodology

An understanding of indirect deforestation in the development of biofuels in Indonesia is needed to prevent unintended consequences from deforestation prevention policies. This information can help policymakers be more careful and provide a broader picture of deforestation prevention programs. The challenge of this issue is the difficulty in detecting or measuring indirect deforestation (Breetz, 2017; Jafari et al., 2017; Mukherjee & Sovacool, 2014). To overcome this, we use the geographic information system (GIS) to detect and analyze land cover by looking at historical data on land-use changes in Riau and Central Kalimantan as the largest palm oil producers. We examined 890,654 points for Central Kalimantan and 1,038,607 points for the Province of Riau, which was selected based on the image's clarity through satellite imagery.

Table 10.2 Area and palm oil production

Province	Total	
	Areal (Ha)	Production (Ton)
Riau	2.741.621	9.513.208
West Kalimantan	2.017.456	5.235.299
Central Kalimantan	1.922.083	7.664.841

Source: Statistical of National Leading Estate Crops Commodity, 2019–2021

10.3.2 Case Selection

Riau and Central Kalimantan provinces have great potential in developing biodiesel production. The largest area of palm oil plantation is in Riau Province, 2.7 million hectares in 2019, with a CPO production of 9.5 million tons. Central Kalimantan ranks third for the land area with 1.9 million hectares, but CPO production is the second largest after Riau Province, with 7.6 million tons (see Table 10.2). With this land area and total production, Riau and Central Kalimantan provinces have become the largest biodiesel suppliers in Indonesia.

The development of oil palm plantations as biodiesel raw material in the Riau and Central Kalimantan Province and the palm oil moratorium can make local people lose land for farming. People who lose their land tend to clear forests to establish farmland (Azhar et al., 2021). This tendency helps us identify indirect deforestation in Riau and Central Kalimantan Provinces.

10.4 Results

10.4.1 Indirect Deforestation in Riau (Fig. 10.7)

Based on calculations from GIS, the total change in forest area converted directly to oil palm from 1990 to 2020 is 1,502,192 ha, while the total area of forest opened by indirect deforestation activities is 277,126 ha (see Table 10.3). The data shows that 84% of forest cover loss in Riau from 1990 to 2020 was caused by direct deforestation activities from oil palm plantations, and only 16% caused by indirect deforestation (see Fig. 10.8).

10.4.2 Indirect Deforestation in Central Kalimantan (Fig. 10.9)

Based on the GIS calculation, the total area of forest open as a direct result of oil palm plantations in the Central Kalimantan region is 459.524 ha. In comparison, that caused by indirect deforestation is 384.596 ha (see Table 10.4). Also, 54% of

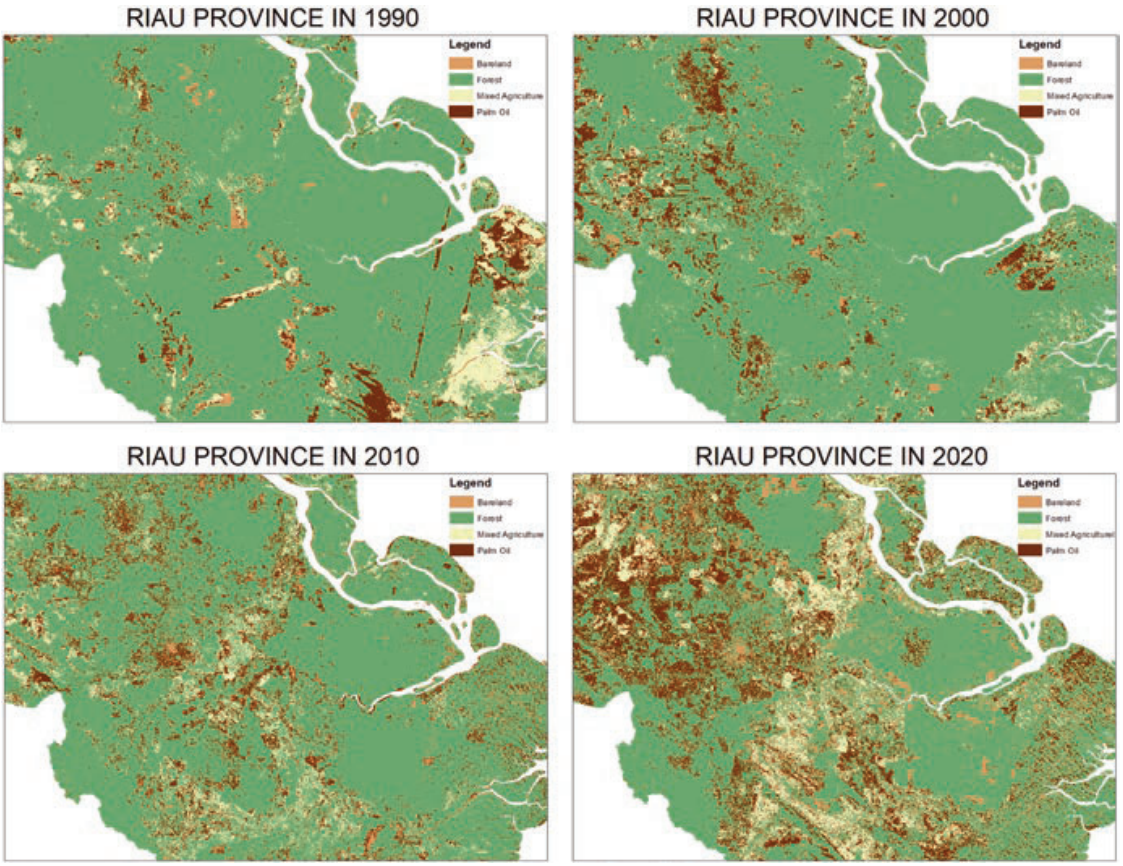

Fig. 10.7 Land use change in Riau (1990–2000). The picture shows that palm oil has existed in the Riau area since 1990. It has grown rapidly from 2010 to 2020. (Source: Data Processing from USGS satellite imagery)

Table 10.3 Total area by land-use change activity in Riau Province

Land use change	Area (Ha)
Direct by palm oil	1502192,747
Indirect deforestation	277126,6219
Total area	**1779319,369**

Source: Data Processing

land cover loss in Central Kalimantan is due to direct land conversion from forest to oil palm plantations, and 46% of forest cover loss in Central Kalimantan is caused by indirect deforestation (see Fig. 10.10).

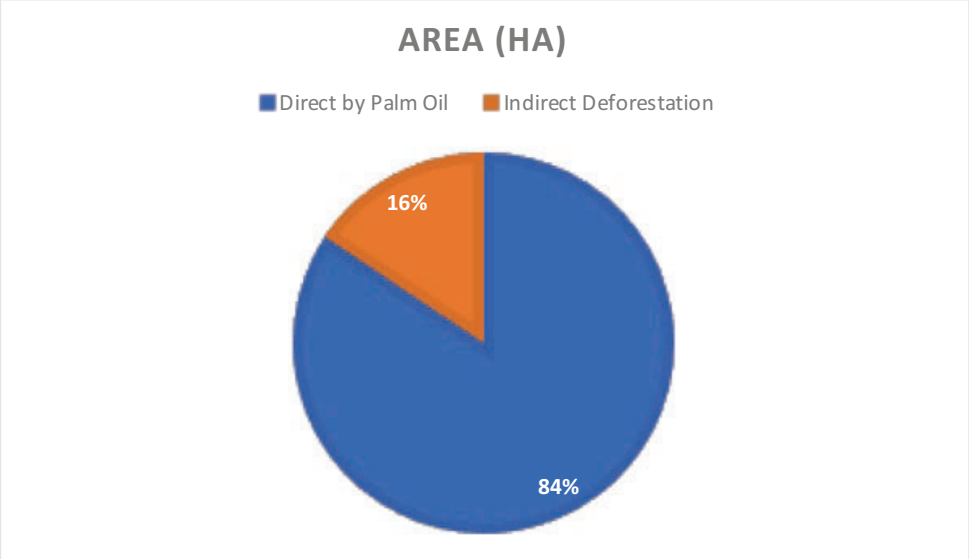

Fig. 10.8 Percentage of land-use change activity in Riau Province. (Source: Data Processing)

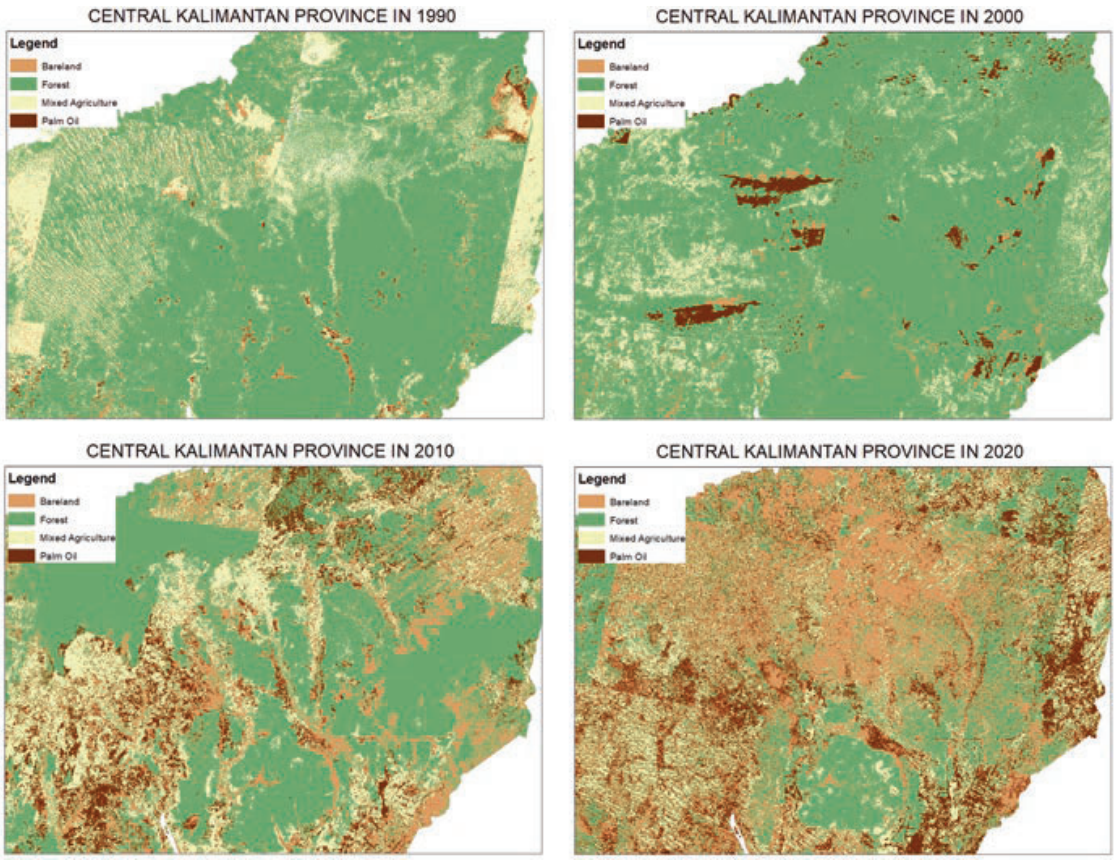

Fig. 10.9 Land-use change in Central Kalimantan (1990–2000). Same as in the Riau province, in Central Kalimantan, oil palm plantations have appeared since 1990, but their development has been very rapid from 2010 to 2020. (Source: Data Processing from USGS satellite imagery)

Table 10.4 Total area by land-use change activity in Central Kalimantan Province

Land use change	Area (Ha)
Direct by palm oil	459524.283
Indirect deforestation	384596.101
Total area	**844120.384**

Source: Data Processing

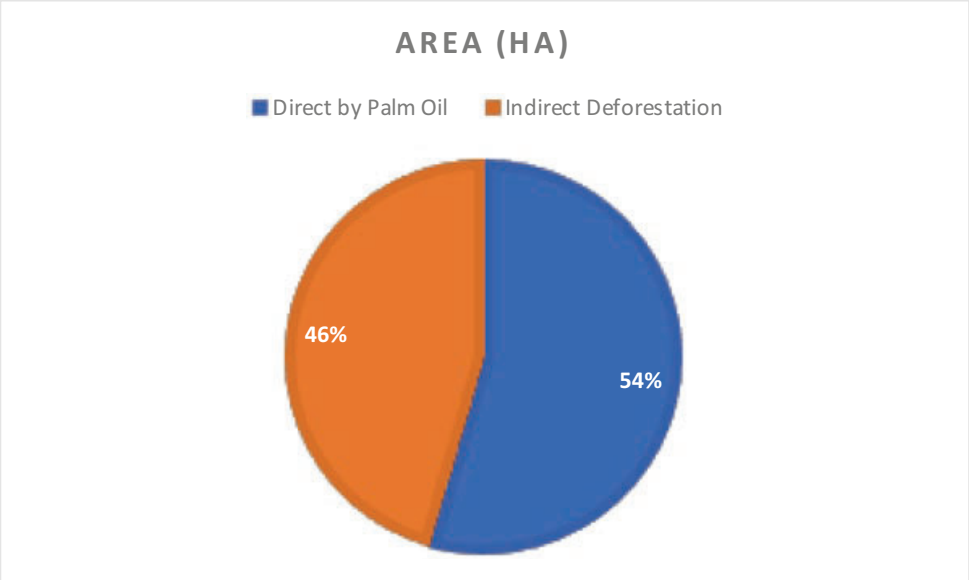

Fig. 10.10 Percentage of land-use change activity in Central Kalimantan Province. (Source: Data Processing)

10.5 Discussion

10.5.1 Palm Oil Moratorium and Indirect Deforestation in Riau and Central Kalimantan

The results of the GIS analysis show that indirect deforestation occurs in large forested provinces such as both Riau and Central Kalimantan provinces. In particular, for the Central Kalimantan Province, almost half the forest is open due to indirect deforestation. The palm oil moratorium is one of the triggers for indirect deforestation.

The palm oil moratorium is through Presidential Decree No. 8/2018 concerning postponement and evaluation of palm oil plantation permits and increasing productivity of palm oil plantation. This government regulation minimizes the opening of palm oil plantations in forest areas. Responding to the regulation, the company opened its palm oil plantations in nonforest areas. In most cases, the community generally uses the land for farming. Palm oil plantation development in nonforest

areas causes local communities to lose land for agriculture. The development of palm oil plantations in several areas triggers domestic migration and encourages local communities to give up their lands to immigrants (Pacheco et al., 2017).

Loss of land for agriculture due to palm oil plantation development in local community areas forced local people to open forest areas for cultivation. Palm oil expansion in nonforest areas triggers deforestation by local people in other areas (Feintrenie et al., 2010; Nelson et al., 2014; Ramadhan et al., 2021).

10.5.2 Indirect Deforestation and the Small-Scale Farmers

Small-scale farmers are also the driving factors for deforestation in Indonesia. Twenty-two percent of deforestation comes from activities carried out by small-scale farmers (Austin et al., 2019), which is almost the same as research conducted by Agus et al. (2013) and Gaveau et al. (2016). Small-scale farmers commonly employ slash-and-burn practices with shifting cultivation systems. They burn land to fertilize the soil and then use the land to cultivate the desired crop (Comte et al., 2012; van Vliet et al., 2013). This activity can usually only support a few years of production, after which the community will leave the land and move to another area. The increasing population and limited land due to competition with oil palm commodities have made the fallow time significantly shortened (Ramadhan et al., 2019). The shorter rotation pattern makes the soil lack nutrients. It affects the amount of production from the plants they grow, driving farmers to clear out further sections of forest (Azhar et al., 2021). Furthermore, to prevent the impact of slash-burn cultivation, the zero-burn technic can be used as an alternative. However, the use of zero-burning will decrease the profitability and increase the cost of local farmers (Sofiyuddin et al., 2021).

The development of oil palm in nonforest areas exerts indirect pressure on the forest areas elsewhere (Ramadhan et al., 2021). Community needs for sources of income and limited land due to competition with oil palm plantations for biofuels increase the possibility of indirect deforestation.

10.5.3 Integrated and Sustainable Environmental Governance for Forestry and Agriculture

An alternative would be developing the concept of communal palm oil plantations for the community. This method is considered essential to improve the community's welfare, especially for those who live in limitations such as rural areas (Baharuddin, 2012; Kumar et al., 2015). In order to prevent the "tragedy of the commons," as mentioned by Hardin (1968), an agreement regarding the rules for using resources is needed (Marten, 2001; see also Ostrom, 1990). Communal ownership is not a

new thing, especially in Indonesia. One example as mentioned by Mulyoutami et al. (2009), is the "*simpukng*" of the Dayak community in East Kalimantan. *Simpukng* is a secondary forest that is managed by the community, where its utilization is regulated by customary rules to avoid over-exploitation. The development of communal oil palm plantations gives communities access to equal production areas and prevents them from clearing forests in the future.

The development of biofuels using vegetable oil or what we often call first-generation biofuels, although economically it is cost-effective, has a relatively large environmental impact from an environmental point of view. The development of second (production of biofuel using waste) and third (development of biofuel using microalgae) generation can be an alternative to be developed so as to reduce the impact on the environment, although economically it is more expensive because it requires advanced technology (Naik et al., 2010; Sadatshojaei et al., 2020; Saladini et al., 2016).

10.6 Concluding Remarks

The development of biofuels under the moratorium regulation indirectly encourages oil palm companies to open oil palm plantations in areas originally used as cultivation areas. The development of oil palm in nonforest areas puts pressure on forest areas elsewhere. This is because people still need land to grow the crops they need for their daily needs.

The loss of land for cultivation due to the development of oil palm plantations for biofuels has encouraged local communities to clear land for cultivation in forest areas. The community does this to maintain their livelihoods. Indirect deforestation that occurs due to the loss of community-owned cultivation land is difficult to prevent.

Integrated and sustainable governance is needed, with an understanding of indirect deforestation, local plantation practices, and their role in the surrounding community. The development of secondary and third-generation biofuels can be an alternative to reduce the environmental impact caused by biofuels based on oil palm plantations. Another option is to develop communal palm oil plantations for the community. With communal ownership, it is expected that the benefits obtained could be distributed more evenly, providing security to the poor by converting individual risk into collective risk, increasing management capabilities, and facilitating each individual involved in business development (Ishak et al., 2020; Ortmann & King, 2007). In that condition, the community has a livelihood and prevents the clearing of land in forest areas.

We explored why the ISPO is underperforming and how the governance of ISPO has been improved. A case study is a relevant method for exploring "how" question and when the observation has no control over behavioral events (Yin, 2017). We used the establishment of the ISPO as a case study and treated the implementation

of ISPO regulation as a policy action resulting from KCP for governance (Table 10.1). We analyzed the Bappenas policy paper used for ISPO regulation as a form of coproduced knowledge using principles of successful sustainability research (Norström et al., 2020).

References

Agus, F., Gunarso, P., Sahardjo, B. H., Harris, N., van Noordwijk, M., & Killeen, T. J. (2013). Historical CO2 emissions from land use and land use change from the oil palm industry in Indonesia, Malaysia and Papua New Guinea. *Roundtable on Sustainable Palm Oil*. https://www.tropenbos.org/file.php/1344/5_historical_co2_emissions_agus_et_al.pdf

Andrianto, A., Komarudin, H., & Pacheco, P. (2019). Expansion of oil palm plantations in Indonesia's frontier: Problems of externalities and the future of local and indigenous communities. *Land, 8*(4), 56.

Austin, K. G., Schwantes, A., Gu, Y., & Kasibhatla, P. S. (2019). What causes deforestation in Indonesia? *Environmental Research Letters, 14*(2), 24007.

Azhar, B., Nobilly, F., Lechner, A. M., Tohiran, K. A., Maxwell, T. M. R., Zulkifli, R., Kamel, M. F., & Oon, A. (2021). Mitigating the risks of indirect land use change (ILUC) related deforestation from industrial palm oil expansion by sharing land access with displaced crop and cattle farmers. *Land Use Policy, 107*, 105498. https://doi.org/10.1016/j.landusepol.2021.105498

Baharuddin, A. H. (2012). Risk and poverty in agriculture: Expanding roles for agricultural cooperatives in Malaysia. *Geografia: Malaysian Journal of Society and Space, 8*(4), 1–11.

[BPS] Statistics Indonesia Badan Pusat Statistik. (2019). *Angka deforestasi netto Indonesia di dalam dan diluar kawasan hutan tahun 2013–2019* [Deforestation rate netto in Indonesia, inside and outside forest area 2013–2019]. https://www.bps.go.id/statictable/2019/11/25/2081/-angka-deforestasi-netto-indonesia-di-dalam-dan-di-luar-kawasan-hutan-tahun-2013-2019-ha-th-.html

Breetz, H. L. (2017). Regulating carbon emissions from indirect land use change (ILUC): U.S. and California case studies. *Environmental Science & Policy, 77*, 25–31. https://doi.org/10.1016/j.envsci.2017.07.016

Castiblanco, C., Etter, A., & Ramirez, A. (2015). Impacts of oil palm expansion in Colombia: What do socioeconomic indicators show? *Land Use Policy, 44*, 31–43. https://doi.org/10.1016/j.landusepol.2014.10.007

Cazzolla Gatti, R., & Velichevskaya, A. (2020). Certified "sustainable" palm oil took the place of endangered Bornean and Sumatran large mammals habitat and tropical forests in the last 30 years. *Science of the Total Environment, 742*, 140712. https://doi.org/10.1016/j.scitotenv.2020.140712

Comte, I., Davidson, R., Lucotte, M., de Carvalho, C. J. R., de Assis Oliveira, F., da Silva, B. P., & Rousseau, G. X. (2012). Physicochemical properties of soils in the Brazilian Amazon following fire-free land preparation and slash-and-burn practices. *Agriculture, Ecosystems & Environment, 156*, 108–115. https://doi.org/10.1016/j.agee.2012.05.004

Corley, R. H. V. (2009). How much palm oil do we need? *Environmental Science & Policy, 12*(2), 134–139. https://doi.org/10.1016/j.envsci.2008.10.011

Council of Palm Oil Producing Countries. (2021). *Palm oil supply and demand outlook report 2021*. https://www.cpopc.org/wp-content/uploads/2020/12/2021-PO-SUPPLY-AND-DEMAND-OUTLOOK-REPORT-1.pdf

Directorate General of Estate Crops. (2019). *Statistik Perkebunan Indonesia 2018–2020 : Kelapa Sawit* [Tree Crop Estate Statistics of Indonesia 2018–2020: Palm Oil]. https://drive.google.com/file/d/1FVxpBNihnuB3ayAALBi-FtsBShIUxMTD/view

Directorate General of Estate Crops. (2020). *Statistik Perkebunan Unggulan Nasional 2019–2021* [Statistical of National Leading Estate Crops Commodity 2019–2021]. https://drive.google.com/file/d/1ZpXeZogAQYfClNBOgVLhYi8X_vujJdHx/view

Feintrenie, L., Chong, W. K., & Levang, P. (2010). Why do farmers prefer oil palm? Lessons learnt from Bungo District, Indonesia. *Small-Scale Forestry, 9*(3), 379–396. https://doi.org/10.1007/s11842-010-9122-2

Gaveau, D. (2018). *Drivers of forest loss in Papua and West Papua*. Cifor. https://www.cifor.org/publications/pdf_files/factsheet/7444-factsheet.pdf

Gaveau, D. L. A., Locatelli, B., Salim, M. A., Husnayaen, Manurung, T., Descals, A., Angelsen, A., Meijaard, E., & Sheil, D. (2022). Slowing deforestation in Indonesia follows declining oil palm expansion and lower oil prices. *PLoS One, 17*(3), e0266178. https://doi.org/10.1371/journal.pone.0266178

Gaveau, D. L. A., Sheil, D., Husnayaen, Salim, M. A., Arjasakusuma, S., Ancrenaz, M., Pacheco, P., & Meijaard, E. (2016). Rapid conversions and avoided deforestation: Examining four decades of industrial plantation expansion in Borneo. *Scientific Reports, 6*(1), 32017. https://doi.org/10.1038/srep32017

Gollnow, F., de Hissa, L. B. V., Rufin, P., & Lakes, T. (2018). Property-level direct and indirect deforestation for soybean production in the Amazon region of Mato Grosso, Brazil. *Land Use Policy, 78*, 377–385. https://doi.org/10.1016/j.landusepol.2018.07.010

Hardin, G. (1968). The tragedy of the commons. *Science, 162*(3859), 1243–1248. http://www.jstor.org/stable/1724745

Impor Solar Oktober 2018 Melonjak 78% [Solar imports in October 2018 jumped 78%]. (2018, November 19). Katadata. https://databoks.katadata.co.id/-datapublish/2018/11/19/impor-solar-oktober-2018-melonjak-78

Ishak, S., Omar, A. R. C., Sum, S. M., Othman, A. S., & Jaafar, J. (2020). Smallholder agriculture cooperatives' performance: What is in the minds of management? *Journal of Co-Operative Organization and Management, 8*(2), 100110. https://doi.org/10.1016/j.jcom.2020.100110

Jafari, Y., Othman, J., Witzke, P., & Jusoh, S. (2017). Risks and opportunities from key importers pushing for sustainability: The case of Indonesian palm oil. *Agricultural and Food Economics, 5*(1), 0–16. https://doi.org/10.1186/s40100-017-0083-z

Janda, K., Kristoufek, L., & Zilberman, D. (2012). Biofuels: Policies and impacts. *Agricultural Economics, 58*(8), 372–386. https://doi.org/10.17221/124/2011-agricecon

Jensen, H. T., Keogh-Brown, M. R., Shankar, B., Aekplakorn, W., Basu, S., Cuevas, S., Dangour, A. D., Gheewala, S. H., Green, R., Joy, E. J. M., Rojroongwasinkul, N., Thaiprasert, N., & Smith, R. D. (2019). Palm oil and dietary change: Application of an integrated macroeconomic, environmental, demographic, and health modelling framework for Thailand. *Food Policy, 83*, 92–103. https://doi.org/10.1016/j.foodpol.2018.12.003

Kamahara, H., Hasanudin, U., Widiyanto, A., Tachibana, R., Atsuta, Y., Goto, N., Daimon, H., & Fujie, K. (2010). Improvement potential for net energy balance of biodiesel derived from palm oil: A case study from Indonesian practice. *Biomass and Bioenergy, 34*(12), 1818–1824. https://doi.org/10.1016/j.biombioe.2010.07.014

Khatiwada, D., Palmén, C., & Silveira, S. (2021). Evaluating the palm oil demand in Indonesia: Production trends, yields, and emerging issues. *Biofuels, 12*(2), 135–147. https://doi.org/10.1080/17597269.2018.1461520

Kumar, V., Wankhede, K. G., & Gena, H. C. (2015). Role of cooperatives in improving livelihood of farmers on sustainable basis. *American Journal of Educational Research, 3*(10), 1258–1266. https://doi.org/10.12691/education-3-10-8

Lima, M., Skutsch, M., & de Medeiros Costa, G. (2011). Deforestation and the social impacts of soy for biodiesel. *Ecology and Society, 16*(4). http://www.jstor.org/stable/26268958

Marten, G. G. (2001). *Human ecology: Basic concepts for sustainable development*. Earthscan.

Miettinen, J., Stibig, H.-J., & Achard, F. (2014). Remote sensing of forest degradation in Southeast Asia—Aiming for a regional view through 5–30 m satellite data. *Global Ecology and Conservation, 2*, 24–36. https://doi.org/10.1016/j.gecco.2014.07.007

Ministry of Energy and Mineral Resources. (2021). *Biodiesel, Jejak Panjang Sebuah Perjalanan* [Biodiesel, a long trail of a journey]. https://www.esdm.go.id/assets/media/content/content-buku-biodiesel-jejak-panjang-perjuangan-.pdf

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

Mulyoutami, E., Rismawan, R., & Joshi, L. (2009). Local knowledge and management of simpukng (forest gardens) among the Dayak people in East Kalimantan, Indonesia. *Forest Ecology and Management, 257*(10), 2054–2061. https://doi.org/10.1016/j.foreco.2009.-01.042

Naik, S. N., Goud, V. V., Rout, P. K., & Dalai, A. K. (2010). Production of first and second generation biofuels: A comprehensive review. *Renewable and Sustainable Energy Reviews, 14*(2), 578–597. https://doi.org/10.1016/j.rser.2009.10.003

NASA Earth Observatory. (2021, August 14). *Deforestation in Papua*. NASA. https://earthobservatory.nasa.gov/-images/148021/deforestation-in-papua

Nelson, P. N., Gabriel, J., Filer, C., Banabas, M., Sayer, J. A., Curry, G. N., Koczberski, G., & Venter, O. (2014). Oil palm and deforestation in Papua New Guinea. *Conservation Letters, 7*(3), 188–195. https://doi.org/10.1111/conl.12058

Oon, A., Ngo, K. D., Azhar, R., Ashton-Butt, A., Lechner, A. M., & Azhar, B. (2019). Assessment of ALOS-2 PALSAR-2L-band and Sentinel-1 C-band SAR backscatter for discriminating between large-scale oil palm plantations and smallholdings on tropical peatlands. *Remote Sensing Applications: Society and Environment, 13*, 183–190. https://doi.org/10.1016/j.rsase.2018.11.002

Oosterveer, P. J. M. (2020). Sustainability of palm oil and its acceptance in the EU. *Journal of Oil Palm Research, 32*, 365–376. https://doi.org/10.21894/jopr.2020.0039

Ortmann, G. F., & King, R. P. (2007). Agricultural cooperatives I: History, theory and problems. *Agrekon, 46*(1), 40–68.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge university press.

Pacheco, P., Gnych, S., Dermawan, A., Komarudin, H., & Okarda, B. (2017). *The palm oil global value chain: Implications for economic growth and socialand environmental sustainability*. Cifor. https://doi.org/10.17528/cifor/006405

Public Relation Directorate General of New and Renewable Energies and Energy Conservation. (2019, December 19). *FAQ : Program mandatori biodiesel 30% (B30)* [FAQ: 30% biodiesel mandatory program (B30)]. Esdm. https://ebtke.esdm.go.id/post/2019/12/19/2434/faq.program.mandatori.biodiesel.30.b30

Ramadhan, R., Mori, A., & Abdoellah, O. S. (2019). Shifting cultivation or oil palm plantation? Integrated assessment of land use change in Dusun Tonggong, Parindu, West Kalimantan, Indonesia. *International Journal of Sustainable Future for Human Security, 7*(1), 11–17. https://doi.org/10.24910/jsustain/7.2/1117

Ramadhan, R., Salman, F., Mori, A., & Abdoellah, O. S. (2021). *Shifting cultivation* (pp. 1–20). Journal of Sustainable Forestry. https://doi.org/10.1080/10549811.2021.2007491

Rausch, L. L., & Gibbs, H. K. (2016). Property arrangements and soy governance in the Brazilian state of Mato Grosso: Implications for deforestation-free production. *Land, 5*(2) https://doi.org/10.3390/land5020007

Sadatshojaei, E., Wood, D. A., & Mowla, D. (2020). Third generation of biofuels exploiting microalgae. In Inamuddin & A. Asiri (Eds.), *Sustainable Green chemical processes and their allied applications* (pp. 575–588). Springer. https://doi.org/10.1007/978-3-030-42284-4_21

Saikkonen, L., Ollikainen, M., & Lankoski, J. (2014). Imported palm oil for biofuels in the EU: Profitability, greenhouse gas emissions and social welfare effects. *Biomass and Bioenergy, 68*, 7–23. https://doi.org/10.1016/j.biombioe.2014.05.029

Saladini, F., Patrizi, N., Pulselli, F. M., Marchettini, N., & Bastianoni, S. (2016). Guidelines for emergy evaluation of first, second and third generation biofuels. *Renewable and Sustainable Energy Reviews, 66*, 221–227. https://doi.org/10.1016/j.rser.2016.07.073

Saswattecha, K., Hein, L., Kroeze, C., & Jawjit, W. (2016). Effects of oil palm expansion through direct and indirect land use change in Tapi river basin, Thailand. *International Journal of Biodiversity Science, Ecosystem Services & Management, 12*(4), 291–313. https://doi.org/10.1080/21513732.2016.1193560

Silalertruksa, T., & Gheewala, S. H. (2012). Food, fuel, and climate change: Is palm-based biodiesel a sustainable option for Thailand? *Journal of Industrial Ecology, 16*(4), 541–551. https://doi.org/10.1111/j.1530-9290.2012.00521.x

Sofiyuddin, M., Suyanto, S., Kadir, S., & Dewi, S. (2021). Sustainable land preparation for farmer-managed lowland agriculture in Indonesia. *Forest Policy and Economics, 130*, 102534. https://doi.org/10.1016/j.forpol.2021.102534

Song, X.-P., Hansen, M. C., Potapov, P., Adusei, B., Pickering, J., Adami, M., Lima, A., Zalles, V., Stehman, S. V., Di Bella, C. M., Conde, M. C., Copati, E. J., Fernandes, L. B., Hernandez-Serna, A., Jantz, S. M., Pickens, A. H., Turubanova, S., & Tyukavina, A. (2021). Massive soybean expansion in South America since 2000 and implications for conservation. *Nature Sustainability, 4*(9), 784–792. https://doi.org/10.1038/s41893-021-00729-z

The Gecko Project. (2018). *The secret deal to destroy paradise: The story behind the single biggest threat to the rainforests of Indonesia*. https://thegeckoproject.org/the-secret-deal-to-destroy-paradise-715b1ffc0a65

van Vliet, N., Adams, C., Vieira, I. C. G., & Mertz, O. (2013). "Slash and burn" and "shifting" cultivation systems in forest agriculture frontiers from the Brazilian Amazon. *Society & Natural Resources, 26*(12), 1454–1467. https://doi.org/10.1080/08941920.2013.-820813

Vijay, V., Pimm, S. L., Jenkins, C. N., & Smith, S. J. (2016). The impacts of oil palm on recent deforestation and biodiversity loss. *PLoS One, 11*(7), e0159668. https://doi.org/10.1371/journal.pone.0159668

Wiratmini, N. P. E. (2019, September 5). *Pemerintah pastikan harga biodiesel tak lebih mahal dari solar* [The government ensures that the price of biodiesel is not higher than diesel]. Bisnis.com. https://ekonomi.bisnis.com/read/20190905/44/1145105/pemerintah-pastikan-harga-biodiesel-tak-lebih-mahal-dari-solar

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