# The potential of multi-scale EE-MRIO to support sustainable development policies in Indonesia

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# Chapter 3

## Impact analysis of an EU import ban on palm oil

This chapter has been published as: Rum. I.A., Tukker, A., de Koning, A., Yusuf, A.A. (2022). Impact assessment of the EU import ban on Indonesian palm oil: Using multi-scale EE-MRIO. *Science of the Total Environment*. DOI: 10.1016/j.scitotenv.2022.158695

**Abstract**
This Under the Renewable Energy Directive (RED) II, the EU will phase out the use of palm oil for biodiesel feedstock. Environmental concerns are the main reasons for the EU to implement this initiative. This study analyzes the economic and environmental impact of EU import ban to Indonesia at provincial level, using 2 scenarios (a direct and direct-indirect import ban). The analysis is performed using a global-subnational Multi-Regional Input-Output (MRIO) with environmental extensions. This study shows that a direct (combined) import ban of palm oil by the EU will reduce Indonesia's GDP by -0.2% (-0.26%) and employment by -0.12% (-0.54%) from baseline. At provincial level, Riau, North Sumatra, Lampung, Central Kalimantan and South Kalimantan experience the highest impact on their domestic product (more than -0.5%). Under a direct import ban, job losses mostly happen in outside Java (96.26%) and in the oilseeds sector (75.21%). Low and middle skilled jobs decline more than high skilled jobs and count for 95% of the total loss. This study also shows that a direct (combined) import ban reduces national GHG emissions by -0.19% (-0.24%) and total land use by -0.48% (-0.6%). Potential carbon sequestration can be 34.55 (42.27) million tons C equivalent to 149.74 (182.67) million tons $CO_2$e under assumption a full rewilding from the reduction of land use in oilseed. Our study shows that an EU import ban on Indonesian palm oil has relatively small economic and environmental impacts at national and provincial level. Yet, this policy can create potential carbon sequestration that can absorb $CO_2$ by vegetation and soil.

**Keywords:** EU import ban, palm oil, Indonesia, multi-scale MRIO, land use, GHG emission, GDP, employment

## 3.1 Introduction

The EU plans to phase out the use of palm oil as feedstock for biofuels, and other applications. Under the Renewable Energy Directive (RED) II, the EU requires member states to limit the use of palm oil for biofuel for the period from 2021-2023 at the level of 2019. After this, a gradual phase out must be achieved to a use of 0% by 2030 (Directive (EU) 2018/2001, 2018). EU has classified palm oil feedstock as having a high risk to indirect land-use change (ILUC), compare to other vegetable oils like rapeseed and sunflower which are considered as a low-risk feedstock. Malins (2011) showed that feedstocks used for biodiesel production have a much higher total carbon intensity (direct emissions and ILUC) than any feedstock used for ethanol production. He further showed that the carbon intensity of palm oil feedstock with 130 g $CO_2$e/MJ is the highest of all biofuel feedstocks. This EU regulation has become a dispute in the WTO as the producer countries, like Indonesia and Malaysia, requested a dispute consultation (WTO, 2019).



In the last ten years, the EU has been the one of the largest consumers of palm oil in the world, along with Indonesia, India, and China. The EU imported palm oil around 6.44 million tons in 2010 and 6.95 million tons in 2019 worldwide (UN Comtrade, 2019). The imports are mainly used for biodiesel production in the EU. Transport and Environment (2019) reported that about 65% of all palm oil imported to the EU was used for energy (53% for biodiesel, 12% for electricity and heating). In 2018, the EU-27 was the largest biodiesel producer and consumer in the world, with 227.85 and 272.82 thousand barrels per day (EIA, 2019). In 2019, with 37% rapeseed oil was the main feedstock in the EU for biodiesel production, followed by palm oil (30%) and used cooking oil (18.5%) (CE Delft, 2020).

Several studies have shown that the expansion of oil palm plantations have contributed to environmental impacts such as biodiversity loss by deforestation. Carlson et al. (2012a) evaluated the impact of oil palm plantation development on forest conversion in Kalimantan. They showed that from 1990 to 2010, area of oil palm grew from 903 $km^2$ to 31,640 $km^2$ across Kalimantan. In that period, 90% of the lands converted to oil palm were forested (47% intact, 22% logged, and 21% agroforests). Only 10% of plantation were established on non-forested lands. This in total would lead to cumulative net carbon emission from land conversion to plantations between 0.32-0.39 billion tons C from 2000 to 2010. Another study by Carlson et al. (2012b) developed a longitudinal study on oil palm plantation development in Ketapang district, West Kalimantan from 1989 to 2008. They found that during the period, forest was the main original land cover of land transformed to oil palm plantations (21% intact, 21% secondary, and 7% logged forest; 49% in total). In addition, 37% of oil palm plantation was taken from agroforests and agricultural fallows and 14% was sourced from burned/cleared and bare lands (non-forests by recent clearing such as swidden rice production.

Other researchers show that deforestation caused by oil palm plantation is declining. Margono et al. (2012) monitored deforestation and forest degradation in Sumatra from 1990-2010 and found that in that period around 7.54 million hectare (ha) of primary forest was lost and 2.31 million ha of primary forest was degraded. The change of primary forest cover, for both forest cover loss and forest degradation, was slowing over the period, from 7.34 million ha between 1990 and 2000 to 2.51 million ha between 2000 and 2010. The study only included intact and degraded states. Forest timber and pulp plantations, oil palm estates, and secondary forests were excluded from their analysis. Gaveau et al. (2016) analyzed the industrial plantation expansion (oil palm and pulpwood combined) in Borneo and reported that oil palm plantations in Kalimantan expanded 4.8 million ha between 1973 and 2015. More than half of these plantations (3.3 million ha) were planted during 2005-2015. The oil palm plantation in Kalimantan was responsible for the clearance of 3.4 million ha of forest over the period 1973-2015. Austin et al. (2017) analyzed the patterns of how oil palm drives deforestation in Indonesia and found that the rate of deforestation due to new plantations has decreased from 54% during 1995-2000 to 18% during 2010-2015.

From an economic perspective, several studies have shown the important role of palm oil for the Indonesian economy. Palm oil has been the largest agricultural export for Indonesia in the last decade. In 2018, Indonesia exported 3.57 billion USD of Crude Palm Oil (CPO) and 3.45 billion USD of Refined Palm Oil (RPO). Around 3.94 million people are directly employed in palm oil industry (BPS, 2019). Edward (2015) analyzed the poverty alleviation impacts of oil palm plantations in Indonesia using panel data for 341 districts from 2002 to 2010. He estimated that a 10% increase in the share of land used for oil palm in a district in one year corresponded to a poverty reduction of 3% of the poverty rate in the next year. However, the study only captured the effects within the same district, and ignored spillovers across regions. Gatto et al. (2017) looked at the contribution of contract farming to the rural economic development in Jambi province using panel data for 78 villages at three points in time (1992, 2002, 2012). They found that contracts between oil palm companies and local communities that involve smallholder farmers have contributed to local development at the village level, both for contracted and non-contracted households. The study, however, ignored the economic heterogeneity across the regions.

Rifin et al. (2020) analyzed the impact of a direct EU import ban of Indonesian palm oil on Indonesia's economy. The study used the GTAP model to assess this impact using 3 sectors (vegetable oil, oilseed, and other commodities) and 7 regions (EU-28, Indonesia, Malaysia, Thailand, Columbia, Nigeria, Singapore and rest of the world). They showed that the EU ban on Indonesian palm oil will not create a significant impact to the Indonesian economy. An EU import ban of Indonesian palm oil would create a 0.27e-2% decline in national real Gross Domestic Product (GDP). Total exports and imports would decline 0.128% and 0.242%, respectively. Within the palm oil sector, they calculated that there will be a loss 4.86% of unskilled jobs and 4.82% of skilled jobs. Land use by oil palm would decline by 2.33%.



A study by Yusuf et al. (2018a) analyzed the impact of a moratorium on oil palm expansion in Indonesia using INDOTERM, an interregional bottom-up Computable General Equilibrium (CGE) model for Indonesia. The study showed that the moratorium reduces Indonesian economic growth. The study also assessed the environmental benefits from a moratorium showing a decline of $CO_2$ emissions in all regions. International transfers of about $10 per avoided ton of $CO_2$ emission can compensate the welfare losses. Sumatra, which has less carbon stocks in its forest, received fewer transfers and suffers more economic loss compare to Kalimantan, which has relative less dependent on palm oil. The study showed different impact across the regions due to different economic and environmental condition.

The literature above has some clear gaps. Most studies studying effects of palm oil import restrictions look at Indonesia as a whole, while palm oil production is concentrated in a few provinces that potentially may suffer high income losses. Some don't cover environmental next to economic effects. Some only look at direct impacts on the palm oil sector and miss spillovers to other sectors. The only study discerning Indonesian provinces and spillovers between regions did use a model covering Indonesia only, rather than one embedding Indonesia in the global economic system. We further see that estimated impacts differ significantly across studies. In this paper we want to overcome these limitations by analyzing the implications of an EU import ban on Indonesian palm oil to the economy and environment at the provincial level, by integrating global and subnational Multi Regional Input-Output (MRIO) for Indonesia.

The remainder of the study is organized as follows: 'Databases and Methods' presents input data and the method applied for constructing and integrating database, and explains the simulation scenario. The section 'Results' presents an overview of the EU market for Indonesian palm oil and the impact of the RED II policies on economic and environmental indicators. A reflective discussion and conclusion finalize this paper.

## 3.2 Databases and Methods

To analyze the impact of an EU import ban of Indonesian palm oil on Indonesia's provincial economy and environment, we need a MRIO data set that connects the global economy with provincial information for Indonesia, and that includes environmental extensions. A number of Environmental Extended (EE) MRIO databases are currently available (Tukker et al., 2013), but some have limited sector detail or other drawbacks for environmental analysis (Stadler et al., 2018b). In this study, we chose to use EXIOBASE. It a global EE MRIO with a high level of sector detail for the economic activities and their environmental pressures (Stadler et al., 2014, 2018a; Tukker et al., 2009, 2013). For Indonesia, there is only one MRIO database available at provincial level, i.e., INDOTERM. Since the latest database is from 2010, we integrated EXIOBASE and INDOTERM in that year. We adopted the single-country national account consistent (SNAC) approach developed by Edens et al. (2015a) to have an global MRIO dataset that is made consistent with Indonesian national accounts data.

### 3.2.1 Databases

***EXIOBASE***

The EXIOBASE database is a global environmentally extended Supply-Use (SU) / Input-Output (IO) data covering 44 countries (with EU-27 countries) and 5 rest-of-continent blocks (Wood et al., 2015; Stadler et al., 2018a). In this study, we use the EXIOBASE 3.3 Supply Use Table (SUT) for 2010. The EXIOBASE SUT have been compiled by gathering information from national and international statistical offices, and linking national SUT via trade. EXIOBASE discerns 163 industries and 200 products, and has as extensions around 40 emissions, 14 types of land use, next to resource extraction and water use. It further gives employment numbers per industry by skill level. This makes EXIOBASE a very suitable EE

MRIO for analyzing trade-related policies, especially for trade flows from and to the EU.

***INDOTERM***

We used the Indonesia TERM (INDOTERM) database that includes an interregional SU/IO data of Indonesia. INDOTERM is based on The Enormous Regional Model (TERM) framework for CGE modelling of multiple regions within a single country developed by Horrridge (2012). The TERM model was created for countries with large provinces. It has been used for Australia (Wittwer, 2012), and adopted for many countries such in China (Horridge & Wittwer, 2008), Brazil (de Souza et al., 2010), South Africa (Stofberg, 2016), and Indonesia (Yusuf et al., 2018a). INDOTERM has been developed by the Centre of Policy Studies, Padjadjaran University, the Ministry of National Development Planning, and the Asian Development Bank (ADB). It contains detailed accounts for 34 provinces, including inter-provincial trade, and is consistent with the national and provincial domestic product for 2010. INDOTERM discerns 185 industries and products, but has no employment accounts nor environmental extensions.



### 3.2.2 Methods

***Integrating INDOTERM with EXIOBASE***

To integrate INDOTERM with EXIOBASE, we took the following steps. First, we restructured the INDOTERM database from TERM database structure into the form of a SUT at purchaser price. The TERM database is presented in multi-dimension matrixes and in purchaser price. Second, we removed trade margins and taxes from TERM to obtain an inter-province SUT in basic prices. Third, we converted the TERM database from national currencies to Euro using IDR/EUR exchange rates from OECD (2010). Fourth, we created a correspondence between the 185 industries and products in INDOTERM and the 163 industries and 200 products in EXIOBASE, finding that both databases at a more aggregated level have 80 industries and products in common. We aggregated both INDOTERM and EXIOBASE to these common 80 categories. Fifth, we disaggregated provincial import accounts in INDOTERM using the total share of imports from each country in EXIOBASE to Indonesia to get provincial imports by origin countries. We assumed that the provincial to national import ratio is proportional with the provincial to national output ratio. Provincial exports by destination country were estimated in the same way. The total import and export by commodities, by industry, by provinces, and by countries add to the total exports and imports given in INDOTERM. Sixth, we replaced Indonesia’s national SUT in EXIOBASE with the 80 sector and product level INDOTERM interregional SUT. We analyzed per product how much imports and exports to and from Indonesia differed between INDOTERM and EXIOBASE and found the differences were in general modest, certainly in comparison to global trade of specific products. We readjusted all regions minus Indonesia in EXIOBASE using the Richard A. Stone (RAS) technique to get the same imports and exports for Indonesia as in INDOTERM. This leads to a global-subnational SUT discerning Indonesian province that covers 80 industries and products, 34 Indonesian provinces, 43 other countries and 5 rest-of-continents. This database allows for analyzing the role of the Indonesian provinces in the global economy, and vice versa. We refer to the Supporting Information (SI) for further information on aggregation.

***Adding environmental extension for Indonesia***

In addition to assessing economic impacts, our study also focuses on measuring environmental impacts of international policies at the provincial level in Indonesia. EXIOBASE includes already environmental extensions for all sectors and countries including Indonesia as a whole. This is however not sufficient, since environmental extension by sector by province in Indonesia are needed. In this study, we sourced Indonesia's GHG emissions data from SIGN-SMART, a database developed by the Indonesian Ministry of Environment and Forestry (MoEF) for national and provincial GHG emission monitoring (MoEF, 2015b). SIGN-SMART consists of 3 emission categories and 75 activities of 5 sectors which are based on Intergovernmental Panel on Climate Change (IPCC) guidelines of 2006, i.e., energy, Industrial Processes and Product Use (IPPU), agriculture, forestry, and waste. We correspond these 75 activities with 80 sectors and final demands. The sectoral emission by province is derived from the national sectoral emission using output share. The total national emission from SIGN-SMART in 2010 was 875.16 million tons $CO_2$e. To get the same dimension for other countries, we aggregate 19 GHG related-emission categories in EXIOBASE into 3 emission categories available in SIGN-SMART, i.e., $CO_2$, $CH_4$, and $N_20$.

Next, we construct land use data by province. For land use, we initially based on data from SIMONTANA, a geoportal information system on environment and forest developed by MoEF (2020). We use data for the year 2009, which is the closest to our base year of 2010 but is not available in SIMONTANA. It discerns 20 land use cover categories for 33 provinces (North Kalimantan was included in East Kalimantan). There are however only three agricultural land use categories, and we had to disaggregate them. For this detailing, we use provincial crop land data from the Spatial Production Allocation Model (SPAM) database for 2010, developed by International Food Policy Research Institute (IFPRI). SPAM contains global spatially-disaggregated crop production of 42 crops (IFPRI, 2019). SPAM gives per crop the physical area and harvested area (which can be bigger as the physical area if more than one harvest per year takes place). We used physical area as the extension. SPAM database divides the land use per crop further according to production system (variety, pesticide, fertilizer, water use, mechanization, and market), which we use complete crops from all technology used. By mapping and scaling to SIMONTANA in this way, we obtain a land use database by province in 58 land use categories. The total land area is 187.16 thousand ha (forest and non forest land). We correspond the 58 categories of land use with the 80 sectors in the multiregional SUT and final demand (most notably households). The total provincial land use adds up to the total national land use. To ensure land extensions are in the same classification as of other countries, we aggregate them into 12 land use categories used by EXIOBASE.



We further created a data set on net carbon stock and net GHG emission/removal by land use change for the year 2010 by province. While this is no environmental extension, such data can help analyzing how reduction of land use can lead to $CO_2$ sequestration by rewilding. We use national carbon accounting data from the Indonesian Carbon Accounting System (INCAS), developed by the MoEF (2015a). It contains annual net carbon stock and net GHG emission/removal that are presented using United Nations Framework Convention on Climate Change (UNFCCC) land use categories, that discern into cropland and forest land. We only use carbon stocks from land converted to forest land. We calculate carbon sequestration rate by province and calculate its potential carbon sequestration from land use reduction.

For employment extensions, we used provincial employment data from the National Labor Force Survey (SAKERNAS) database 2010, developed by the Indonesian Statistic Office (BPS, 2010b). The database covers 28 labor types, 1099 industries and 34 provinces. We corresponded the 1099 industries with the 80 sectors in our MRIO, and aggregated the 28 labor types into the 6 classes available in EXIOBASE, i.e., low, medium, and high skilled work, both male and female.

This completes the environmental extended multi-scale MRIO for Indonesia that includes as extensions GHG emissions, land use and employment, called EXIOBASE – INDOTERM, as shown in **Figure SI3.3**.

***Transformation from SUT to Input-Output Table (IOT)***

We transform multiregional SUT into multiregional IOT using the industry technology assumption, one of the transformation methods suggested in UN (2018). Via this approach a square IOTs can be produced with as many rows and columns as the number of products from the existing dimension of the SUTs. Suppose that vector $\boldsymbol{g}$ is row vector of industry output, $\boldsymbol{V}^T$ is matrix of supply (product by industry) and $\boldsymbol{U}$ is matrix of use (product by industry), we can calculate share of each product in output of an industry using the formula $\boldsymbol{C} = \boldsymbol{V}^T(\boldsymbol{g})^{-\mathbf{1}}$. The transformation matrix can be derived for intermediate use matrix as $\boldsymbol{Z} = \boldsymbol{UT}$, gross value added as $\boldsymbol{F} = \boldsymbol{WT}$, where $\boldsymbol{T} = \boldsymbol{C}^T$. In this transformation, the final demand is left unchanged.

***Multiregional IO analysis***

We use multiregional IO analysis based on Miller and Blair (2009b) for analyzing the impacts of changes of palm oil exports on GDP, output, employment, GHG emissions and land use at provincial level. It requires intra and interregional transaction data of different industry in different regions. Knowing interindustry transaction $\boldsymbol{Z}^{rr} = \left[z_{ij}^{rr}\right]$ and output $\boldsymbol{x}^r = [x_i^r]$ for the $n$-sector economy within the region, along with $\boldsymbol{Z}^{rs} = \left[Z_{ij}^{rs}\right]$ –interregional industry transactions from sector $i$ in region $r$ to sector $j$ in region $s$ and $\mathbf{f}^{rs} = [fd_{ik}^{rs}]$ –interregional final demand transactions from sector $i$ in region $r$ to final user $k$ in region $s$, for every $(r, s) \in R\ X\ S$, the output of sector $i$ in region $r$ can be expressed as

$$x_i^r = \sum_{s=1}^{R}\sum_{j=1}^{n} z_{ij}^{rs} + \sum_{s=1}^{R}\sum_{k=1}^{f} fd_{ik}^{rs} \qquad (3.1)$$

where $R, n, f$ is number of regions, sectors and final users. From here, a set of intraregional and interregional input coefficients matrix can be derived as $a_{ij}^{rs} = z_{ij}^{rs}/x_j^s$. Using these regional input and trade coefficients, (2.1) can be expressed by

$$x_i^r = \sum_{s=1}^{R}\sum_{j=1}^{n} a_{ij}^{rs} x_{ij}^{rs} + \sum_{s=1}^{R}\sum_{k=1}^{f} fd_{ik}^{rs} \qquad (3.2)$$

And by moving all terms involving $x_i^r$ and $x_i^s$ to the left, (2.2) becomes

$$\left(1-a_{ij}^{rr}\right)x_i^r-\sum_{s=1}^{R-\{r\}}\sum_{j=1}^{n}a_{ij}^{rs}x_{ij}^{rs}=\sum_{s=1}^{R}\sum_{k=1}^{f}fd_{ik}^{rs} \tag{3.2}$$

Following the same procedure as for a single-region IO model, the coefficient matrix for intraregional and interregional model can be expressed as $\boldsymbol{A}^{rs}=\left[a_{ij}^{rs}\right]$. Thus (2.3) can be expressed as the usual Leontief formula as $(\boldsymbol{I}-\mathbf{A})\mathbf{x}=\mathbf{f}$ or $\mathbf{x}=\mathbf{Lf}$, where $\mathbf{L}=(\boldsymbol{I}-\mathbf{A})^{-1}$.

In this study, we use multiplier impact analysis to measure the change in final demand due to a potential EU import ban. An approach to account for economic impact is to measure the amount of value added and jobs generated per unit of industry output. The level of value added and employment associated with a given vector of total output can be expressed as $\mathbf{VA}=\boldsymbol{S^{VA}}\mathbf{x}$ and $\mathbf{p}=\boldsymbol{S^{p}}\mathbf{x}$, where $\boldsymbol{VA}$ is the vector of value added and $\mathbf{p}$ is the vector of employment. Hence, by adding the usual Leontief formula, we can compute the total value added and employment of each type generated by the economy in supporting the final demand as $\mathbf{VA}=[\boldsymbol{S^{VA}}\mathbf{L}]\mathbf{f}$ and $\mathbf{p}=[\boldsymbol{S^{p}}\mathbf{L}]\mathbf{f}$. The same applied to account for environmental impacts, such as GHG emission and land use.

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In the interregional IO model, the total multiplier effect can be decomposed into intraregional and multiregional effects. Intraregional effects capture the impact in one region caused by its region while interregional effects capture the impact in one region caused by the change from other regions or called the spillover effect. We can decompose 6 multipliers as shown in **Table 3.1**.

**Table 3.1** Multiplier Decomposition. Source: Extended by Authors from Miller and Blair (2009b)

| Multiplier | [1] Intraregional | [2] Interregional | [3] Total effect |
|---|---|---|---|
| **[1] Output** | Output-Intra | Output-Inter | Output multiplier |
| **[3] Value Added** | VA-Intra | VA-Inter | VA multiplier |
| **[4] Employment** | Employment-Intra | Employment-Inter | Employment multiplier |
| **[5] Emission** | Emission-Intra | Emission-Inter | Emission multiplier |
| **[6] Land use** | Land use-Intra | Land use-Inter | Land use multiplier |

***Simulation scenarios***

In this study, we simulate an import ban of Indonesian palm oil by the EU. There are two scenarios in this simulation. The first scenario is a direct import ban. In this scenario, the EU restricts all direct imports of vegetable oil from Indonesia (which is around 80% palm oil). The second scenario is a direct and indirect import ban, or combined import ban. Here, in addition to the direct import ban, the EU also restricts any import of products from any country that contain vegetable oil from Indonesia. We set import cut by the EU for each country by product using how much export value of that product contain indirect Indonesian vegetable oil. According to the EXIOBASE-INDOTERM, the direct EU's import of vegetable oil from Indonesia reached 1.19 billion Euros in 2010. If we assume that input share of vegetable oil to total input is proportional to the share of output containing vegetable oil, then according to the database, the total EU's import of any products containing vegetable oil from Indonesia reached 1.98 billion Euros in 2010. In the first scenario, each province experiences a cut in final demand according to its initial export value to the EU. In the second scenario, in addition to first scenario, each country experienced a cut in final demand according to its direct and indirect export value to the EU.

We aggregated the EU countries to one economic block as the EU-27. This leaves us with 45 regions: 34 provinces, EU-27, UK, US, China, Japan, India, and 5 rest-of-continents. For the purpose of this study, we concentrated on vegetable oil and related sectors that may potentially experience a high impact of import bans. We aggregate for our analysis the MRIO into 12 sectors: oilseeds, other agriculture, forestry, fishery, mining, food processing, vegetable oil, chemicals, other manufacturing, hotel and restaurant, transportation, and other services. A problem with the data set is that EXIOBASE and INDOTERM do not make a distinction between vegetable oils and palm oil. Since 80% of the Indonesian exports of vegetable oils consists of palm oil, we make a minor error when calculating effects on GDP, output, employment, carbon emissions and land use due to lower exports of vegetable oil. Another issue is that palm oil production relates to both the oilseeds and vegetable oil sector. However, almost all Indonesian export of palm oil is in crude of refined oil, not in Fresh Fruit Bunches (FFB). The FFB export was only 0.1% of the vegetable oil export. Palm oil export of Indonesia was coming from vegetable oil sector. Thus, we impose import restriction on vegetable oil sector from Indonesia. More detail information can be found in SI Annex 2.

## 3.3 Results

### 3.3.1 Contribution of Indonesian vegetable oil in global value chains

**Figure 3.1** describes the global value chain of vegetable oil retrieved from EXIOBASE-INDOTERM. We can identify three layers in the global value chain, i.e., origin country, destination country, and the users in the world (industry and final demand). In the first layer, Indonesia is aggregated into 5 main regions: Java, Sumatra, Kalimantan, Sulawesi and Eastern Indonesia. It shows a world supply and use of vegetable oil in 2010 of around 90 billion Euros. In total, Indonesia supplied around 21.39% of world's vegetable oil. At the same time, Indonesia used only 11% of world's vegetable oil. Indonesia is hence a net exporter of vegetable oil.

In the first layer, we can see that 45.98% of national production of vegetable oil is used within the country and 54.02% of it is exported. For the domestic market, national production of vegetable oil contributed 89.37% of domestic use. The remainder, 10.63%, is from import. Sumatra itself contributed to 78.88% of national vegetable oil production, and followed by Kalimantan with 13.66%.



The flows from the first to the second layer shows how each region (province or country) supplies to and uses from other regions. There are three destination countries that use most of Indonesian vegetable oil outside domestic market, i.e., India, China and the EU. Only 6.2% of Indonesian vegetable oil production is supplied to the EU. Indonesia also only contributed 6.22% of total vegetable oil supplied to the EU. This is less than in China and India, where Indonesia contributed 36.56% and 20.15% of total vegetable oil supplied in that country, respectively. As shown in **Figure 3.1**, most of the use of vegetable oil in the EU comes from EU domestic production (especially from rapeseed and sunflower).

The flows from the second and the third layer shows how each region used vegetable oil in their economy. Overall, the main use of vegetable oil in the world was in households and the food processing industry. In the EU, the food processing industry was the main users of vegetable oil. It accounts for 57.8% of the total use of vegetable oil in the EU, or almost twice of household use. The same is the case for China where 43.89% of the vegetable oil was used in the food processing industry. Indonesia, India and Rest of the World (RoW) used more vegetable oil in households.

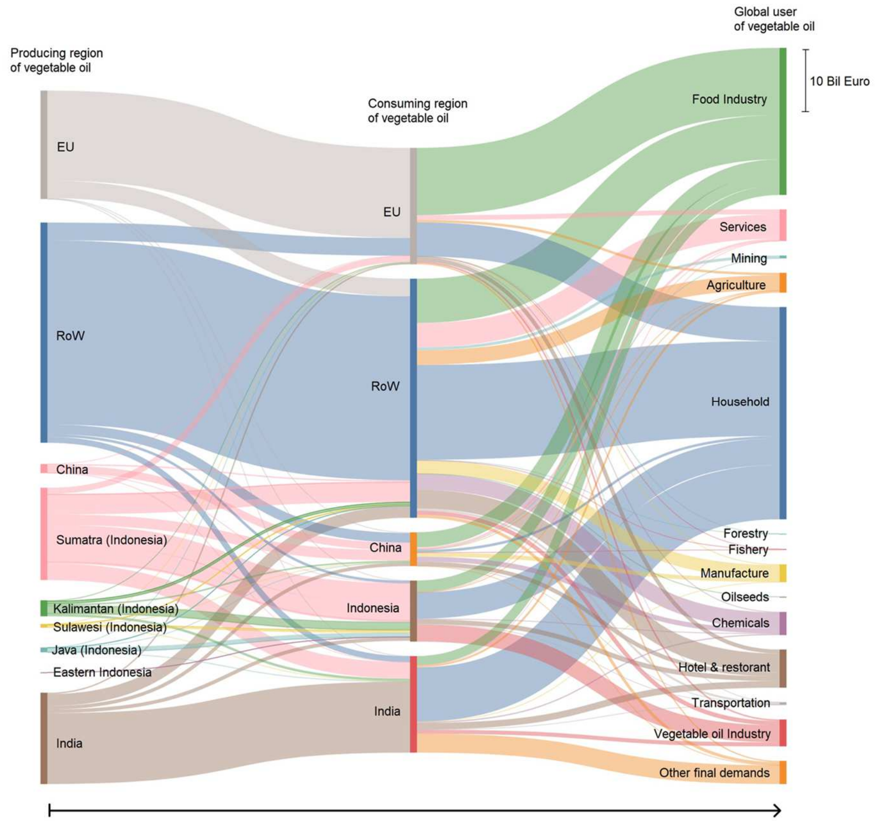


**Figure 3.1** Indonesia on global value chain of vegetable oil. The flow color indicates source and target node's color. The first layer is the producing region of vegetable oil, consists of 5 Indonesian regions, EU-27, China, India, and Rest of the World (RoW). The second layer is the consuming region of vegetable oil, consists of Indonesia as a total, EU-27, China, India, and RoW. The third layer is the global users of vegetable oil, consists of 12 industries and final demands.

### 3.3.2 Output of vegetable oil sector in Indonesia

**Figure 3.2** shows a map of Indonesia discerning 34 provinces. It gives per province the output of vegetable oil, the contribution to provincial GDP and employment in 2010. The contribution of the vegetable oil sector to national output is only 1.75%. Output from the vegetable oil sector in Indonesia is concentrated in 3 provinces i.e., Riau (42.55% of national output), North Sumatra (19.45%) and Lampung (12.64%). And these provinces are all located in Sumatra region. The contribution of the vegetable oil sector to national GDP is only 1.2%.

There are 5 provinces where vegetable oil production has a relatively high contribution to their provincial GDP. It concerns 3 provinces in Sumatra i.e., Riau (9.37% of its GDP), North Sumatra (4.98%), and Lampung (6.54%) and 2 provinces in Kalimantan i.e., Central Kalimantan (4.72%) and West Kalimantan (3.16%). The contribution of the vegetable oil sector to the national employment is 0.13%. There is only one province where vegetable oil sector has above 1% contribution to its provincial employment, i.e., Riau with 1.57%.

In INDOTERM, oilseeds sector consists of 2 subsectors, oil palm and coconut subsector. Oil palm contributes 83% of national oilseeds output. Oilseeds sector mostly represent oil palm plantation and production of palm FFB. And vegetable oil sector is related to palm oil processing from FFB to crude or refined palm oil. This sector uses most of their input from oilseed sector, showing strong relation between these two sectors. If we include oilseeds sector, as the upstream sector for vegetable oil, the position become more relevant. Both sectors contribute 3.01% of national output, 3.08% of national GDP. For certain provinces, these sectors are important to their economy. Both sectors contribute around 23.18% of total output and 24.02% of total employment in Riau. And in Central Kalimantan, both sectors contribute around 10.04% and 14.15%, respectively.

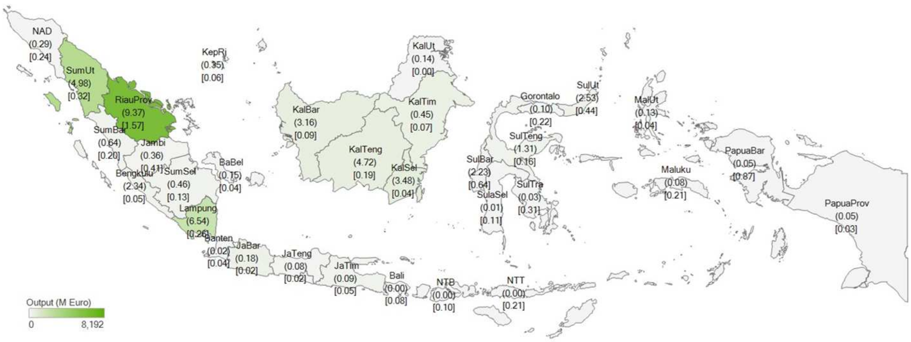


**Figure 3.2** Output of vegetable oil by province and its contribution to its GDP and employment (in %) in 2010. The color scale indicates output level of vegetable oil. The number in (round brackets) is the contribution of vegetable oil sector to provincial GDP (in %). The number in [square brackets] is the contribution of vegetable oil sector to provincial employment (in %).

### 3.3.3 The economic impact

***On national and subnational level***

A direct import ban by the EU on Indonesian palm oil cuts 1.19 billion Euros of direct exports. This leads to a reduction of Indonesia's GDP by 1,155.28 million

Euros (-0.2 from baseline). **Figure 3.3** shows that national output and employment declines by 2.37 billion Euros (0.22%) and 132.9 thousand jobs (-0.12%), respectively. However, this import ban scenario creates different implication at regional level. If we look at the GDP, regions that experience most loss are Sumatra (-0.72%) and Kalimantan (-0.24%). Job losses in these regions are -0.43% and -0.26% from baseline, respectively. If we look closer at provincial level, provinces that experience most output loss are Riau (by -1.87%), North Sumatra (by -0.98%) and Central Kalimantan (by -0.89%). Job losses mostly happen mainly in outside Java (96.26% of total) and in oilseed sector (75.21%).

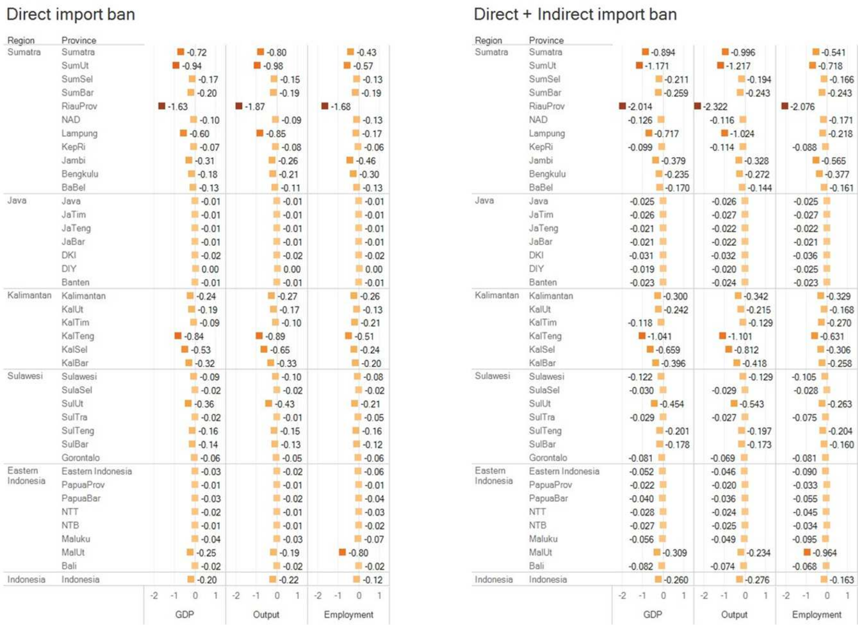


**Figure 3.3** The economic impact at regional and provincial level in Indonesia from the EU import ban (in % deviation from baseline)

If we also consider an indirect import ban, then the total impact becomes somewhat higher. Under a combined direct-indirect import ban scenario, the Indonesian exports of palm oil are reduced by 1.98 billion Euros, leading to a GDP reduction of 1.47 billion Euros (-0.26% from baseline). The national output declines by -0.27%, or 0.05% more than in the direct import ban scenario only. National employment declines by 178.2 thousand jobs (-0.26%). Sumatra, the most effected region, experiences a jobs loss by 124.8 thousand jobs (-0.54%). These job losses mainly occur in the Riau and North Sumatra provinces.

**Figure 3.4** shows the decomposition of total output multiplier effect into an intraregional and interregional effect under a direct import ban. From the perspective of the intraregional effect, there are 3 provinces in Sumatra that experience an output decline because of the changes in final demand of vegetable oil due to the direct import ban. These provinces are Riau, North Sumatra, and Lampung. They have a higher output of vegetable oil which creates a higher intraregional output multiplier in the province. The oilseeds and services sector also experience an output decline because of it.

Riau, the most affected provinces, experiences an output decline due to the intraregional effect by 1.02 billion Euros (-1.82% from baseline). Compared to other provinces, this is the highest decline, which is around twice of what North Sumatra experiences (497.9 million Euros) and 6 times of Lampung (149.2 million Euros). This result shows that economy of Riau relies relatively on the vegetable oil sector. If we look closer at sectoral level within the Riau province, the vegetable oil sector experiences an output decline by 664.2 million Euros (-8.11%). And the oilseeds sector also suffers from a decline, by 271.3 million Euros (-5.65%). These two sectors experience most of output decline because of its final demand change within Riau province.



From the interregional effect, more provinces and sectors experience an output decline because of the spillover effect. This effect is caused by the changes in final demand of vegetable oil from other provinces due to the direct import cut. Almost all provinces in Sumatra and Kalimantan experience a decline in oilseeds output. Riau, for example, experiences an output decline in vegetable oil by 4.03 million Euros (-0.05% from baseline). This is the interregional output multiplier effect to the vegetable oil sector in Riau, that is caused by changes in final demand of vegetable oil from other provinces. This effect is very small compare to intraregional effect shown before.

Now, we can calculate the total multiplier effect of output decline on the vegetable oil sector in Riau by adding the intra and interregional output multiplier, i.e., 668.19 million Euros (664.2+4.03), or -8.15% from baseline. Provinces like Jambi and South Sumatra experience a higher output decline in the oilseeds sector due to the interregional effect, i.e., by 23.71 million Euros (-3%) and 18.96 million Euros (-2.75%), respectively. Other sectors are also affected by these changes, especially service sector. Almost all province in Java, Sumatra and Kalimantan experiences an output decline. The capital, Jakarta province, experiences the highest decline in the service sector.

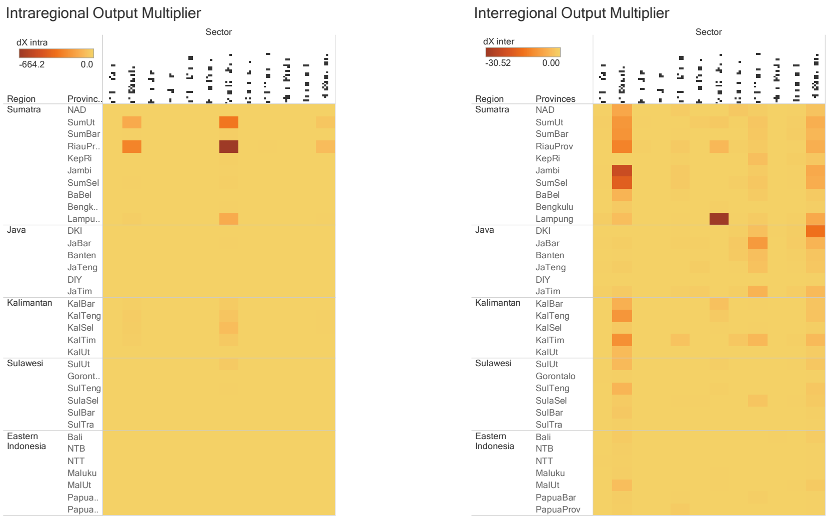


**Figure 3.4** Decomposition of output multiplier effect by sector and province under direct import ban scenario (in million Euro). Note: dark color indicates high decline.

**Figure 3.5** shows employment multiplier effect across 5 regions in Indonesia under the direct import ban scenario. The total employment multiplier is differentiated by 3 skill levels, i.e., low, middle, and high skilled jobs. As indicated before, Indonesia losses around 132.9 thousand jobs or -0.12% from baseline.

Of all sectors, the oilseeds sector experiences the highest total employment decline, i.e., 99.97 thousand jobs (-4.32% from baseline). For comparison, the vegetable oil sector only experiences a total employment decline by 7.33 thousand jobs (-5.23%). The services sector accounts for 17.46 thousand jobs cuts (-0.04%). Since the oilseeds sector is more job intensive compare to vegetable oil, a direct import ban on vegetable oil will lead to relatively higher job loss in oilseeds sector.

If we decompose the employment multiplier effect by skill level, we can identify which skill level is most impacted. Under the direct import ban scenario, total national low and middle skilled jobs decline by 56.42 thousand jobs and 69.91 thousand jobs, respectively. They contribute 95% of total job loss. The remainder, 6.57 thousand jobs is from high skilled jobs. If we look closer at sectoral level, the oilseeds sector experiences most job loss in low and mid skilled level, with 94.82 thousand jobs in total (94.5% of total). While in vegetable oil, most job loss occurs in mid skilled level, with 5.65 thousand jobs (77.15% of total).

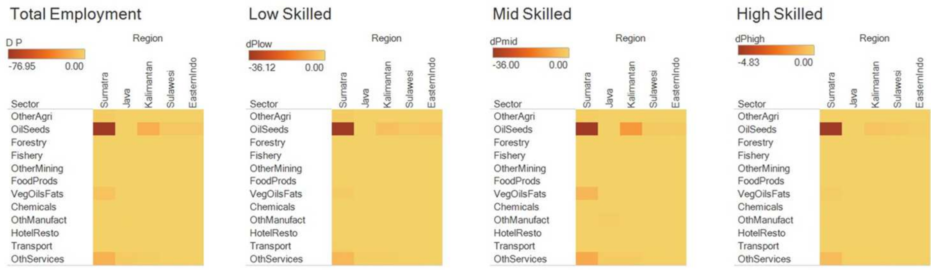


**Figure 3.5** Decomposition of employment multiplier effect by skill level under a direct import cut scenario (in 1000 people)

***On global level***

The EU import cut on Indonesia palm oil gives insignificant impacts to other countries at global level. This study shows that under direct import cut the global output will decline by 93.3 million Euros, global GDP by 38.8 million Euros, and global employment by 4.12 thousand jobs. If we consider both direct and indirect import cut, then the global decline will be much higher with 1.13 billion Euros in output, 510.6 million Euro in GDP, and 100.6 thousand hobs in employment. Since indirect import cut is related to palm oil related commodities, we found that the impacts disperse widely across commodities and countries as shown in **Figure 3.6**. Rest of Asia Pacific experiences most the declines, especially in various manufacture and service sectors, with different magnitude. China experiences a GDP loss in all service sectors, India experiences a GDP loss in agriculture sector, while Africa continent experiences GDP loss in almost all sectors. China, India, Rest of Asia Pacific (including Malaysia) and Africa continent experience the most employment loss in agriculture sector.

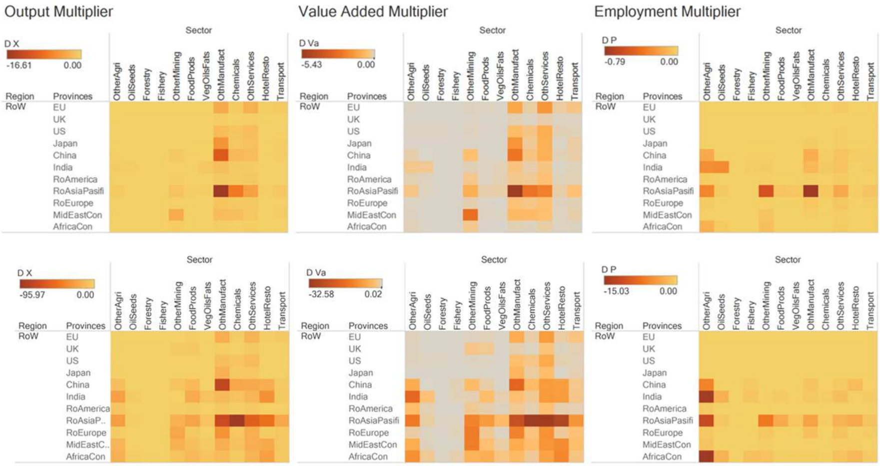


**Figure 3.6** Global multiplier effect on output, value-added and employment (in M Euro and 1000 people)

### 3.3.4 The environmental impact

The EU direct import ban on Indonesian palm oil reduces national output by 2.37 billion Euros. This leads to a reduction of national GHG emissions by 1.57 million tons $CO_2$-equivalent or -0.19% from baseline. If we also consider an indirect import ban, then the combined import ban will reduce national GHG emission by 1.99 million tons $CO_2$e (-0.24%). Regions that contribute to this reduction are the ones with high output in oilseeds or vegetable oil. **Figure 3.7** shows emission and land use multiplier across 34 provinces under direct import ban. Sumatra reduces its GHG emission by 1.27 million tons $CO_2$e (-0.57%). This region contributes 81% to national GHG emission reduction. Kalimantan experiences an emission decline by 0.2 million tons $CO_2$e (-0.23%) and contributes 13.2% to national reduction. In the Sumatra region, 2 provinces with the highest GHG emission reductions are Riau and North Sumatra. They reduce GHG emission by 0.68 million tons $CO_2$e (-1.01%) and 0.34 million tons $CO_2$e (-0.74%), respectively. They together contribute 65.42% to the national GHG emission reduction. Other provinces in Sumatra also experience emission reductions, such as Lampung, South Sumatra and Jambi. In Kalimantan region, most provinces experience a small reduction on GHG emission.

Under a direct import ban, GHG emission reductions mainly take place in the oilseeds and vegetable oil sectors. The oilseeds sector reduces its national GHG emission by 0.73 million tons $CO_2$e (4.75% from baseline). This sector contributes 46.92% to national GHG emission reduction. The vegetable oil sector has a 0.55 million tons $CO_2$e reduction (-7.26%) and contributes 35.55% of the national reduction. Other sectors see a combined reduction of 0.27 million tons $CO_2$e.

Land use also declines under both import ban scenarios. Indonesia sees a decline of land use of 541.33 thousand ha (-0.48% from baseline) under the direct import ban scenario. For comparison, under the combined import ban, national land use declines by 670.28 thousand ha (-0.6%). The impact is concentrated mostly in Sumatra and followed by the Kalimantan region. Sumatra sees a decline in land use by 369.64 thousand ha (-1.47%), which is 68.28% of the national land use reduction. This is twice more than the reduction in Kalimantan, where the decline is 135.75 thousand ha (a share of 25% of the national reduction of land use). Other regions see a combined contribution of 6.63% to the national reduction.



At sectoral level, land use in the oilseeds sector declines by 514.2 thousand ha (-4.51% from baseline) under a direct import ban scenario. This sector contributes 95% to the national land use reduction. Other sectors see a combined contribution of 5% to the national reduction.

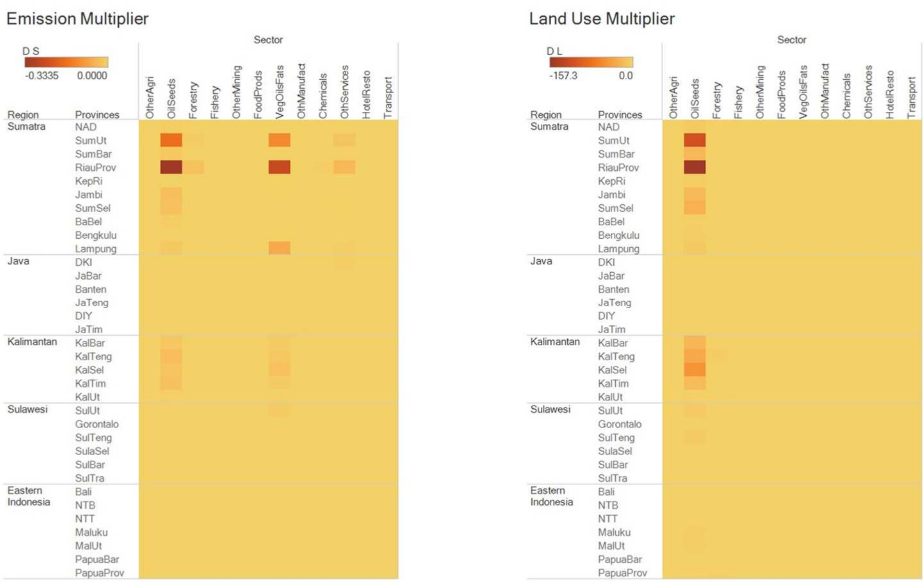


**Figure 3.7** Emission and land use multiplier effect by sector and province under direct import ban scenario (in Mt $CO_2$e and 1000 ha)

From the results of land use reduction above, we can calculate the potential carbon sequestration by rewilding. We assume that land use from oilseeds can rewild by 100%. As shown in **Figure 3.8**, under a direct import ban scenario, the potential carbon sequestration can reach 34.55 million tons C which equals 149.74 million tons $CO_2e$. Under a combined direct and indirect import ban, this increases to 42.27 million tons C or 182.67 million tons $CO_2e$. **Figure 3.8** shows the different potential carbon sequestration (million tons C) across the regions. The Sumatra region contributes 80.9% of total potential carbon sequestration, and for Kalimantan this number is 15%. At provincial level, North Sumatra and Riau have the highest potential carbon sequestration with 15.35 million tons C in total. These provinces contribute to 44.44% of the total potential carbon sequestration.

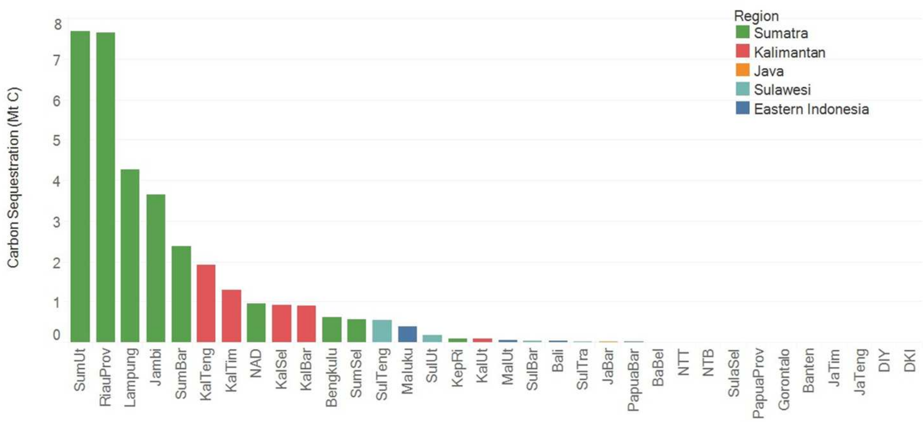


**Figure 3.8** Potential carbon sequestration by province under direct import ban scenario (in million tons C)

## 3.4 Discussion and conclusions

Despite the fact that a large part of the vegetable oil imports of the EU comes from Indonesia, the impact on GDP, output and employment of an import ban by the EU is limited (less than 1% national, 2% provincial level). There are three reasons behind this outcome. First, about 45.98% of Indonesian palm oil is used domestically. Household consumption plays important role in domestic market. Although the B30 biofuel program starting 2020 just contributed a small role to Indonesia domestic market (i.e., 14% of domestic CPO in 2021), its roles on palm oil market can change in the future. Supply shifting of CPO to energy sector will cause disruption in food product sector and international trade (Boly & Sanou, 2022; Hausman et al., 2012; Putrasari et al., 2016). Higher domestic demand on

CPO will create additional domestic supply which will can require more land resource or create export reduction in the future (Kharina et al., 2016; Khatiwada et al., 2018).

Second, if we look from EXIOBASE-INDOTERM, export share of Indonesian vegetable oil to the EU is only 11.48% of total national vegetable oil export (which is around 80% is palm oil). For comparison, national export share to India is 30.78% and China is 19.57% of its total export. Thus, import cut from the EU will not create significant impulse into the economy. Third, the contribution of vegetable oil sector to the national GDP is 1.2% share, or 3.08% if we include oilseeds sector. And in employment, vegetable oil sector contributed 0.12% of national employment, or 2.24% if we include oilseeds sector. This combination of relative low importance for the Indonesian economy and limited fraction of exports of production to the EU explain the low impact of an import ban by the EU (Rifin et al., 2020). For the same reasons, the impact of an EU import ban on reduction of carbon emissions and land use occupation. If a 100% rewilding of the freed-up land occurs, the direct (combined) import ban can create potential carbon sequestration to 34.55 million tons C (42.27 million tons C) or equivalent to 149.74 million tons $CO_2e$ (182.67 million tons $CO_2e$).



Due to limitations in data availability, this paper described the implications of a direct and an indirect import ban by the EU of Indonesian palm oil for the year 2010. UN COMTRADE shows that the total EU imports of vegetable oils, palm oil in particular and palm oil from Indonesia were relatively stable between 2010 and 2019 (see Supporting Information, Annex 1). Total Indonesian GDP, employment and GHG emission rose about 59.51%, 16.92%, and 51.42% between 2010 and 2019. This suggests that the absolute impact of an EU import ban of Indonesian palm oil at this point in time will not be very different as in our calculations. The relative impacts however will be even lower as we show here for 2010.

Another limitation is that EXIOBASE-INDOTERM cannot discern palm oil from other vegetable oils. Since 80% of Indonesia's export of vegetable oil consists of palm oil (see SI Annex 2), this leads to a limited error. The magnitude of economic and environmental impacts to Indonesia hence should be slightly lower than what we report in this study.

This study did further a static analysis, while one can expect that an EU import ban on Indonesian palm oil will lead to a change in trade and production patterns of vegetable oils. Indonesia will look for alternative markets for the surplus on domestic production of vegetable oils, both domestic and foreign market, reducing the impacts on GDP, output, employment, carbon emissions and land use even more. An EU import ban may hence not be the optimal approach to realize the intended outcome. The EU wants to ban palm oil for use in biodiesel due to the concern that oil palm cultivation accelerates deforestation and global warming. Other oil crops like rapeseed and sunflower have been suggested as potential replacement. However, at present none of the existing alternative products would be economically and environmentally viable at scale. These crops required more land, water and fertilizer, low productivity, higher cost and short lifespans (Liao et al., 2020; Meijaard et al., 2020b; Parsons et al., 2020). They may be able to play a role in replacing palm oil, but large-scale replacement with alternative oil crops presents significant sustainability challenges.

An alternative policy would be to create better incentives to make the process of palm oil production more sustainable. This could e.g., be achieved by implementing more reliable national sustainability certification scheme. The Indonesia Sustainable Palm Oil (ISPO) scheme issued by the government in 2011 (Permentan No. 19/2011) has not been able to address issues such as deforestation (only focused on primary forest land) and effectiveness (firms are not mandatory to have ISPO). This cause international concern on the impact of oil palm plantation in Indonesia. Now the government has issued a new regulation (Permentan No. 38/2020) to address these issues. This may be able to address the issue, but the government still needs to continue with its intensification program (Monzon et al., 2021; Purnomo et al., 2020).

As a complement, efforts should be made to make other oil crops to be economically and environmentally viable at scale. After all, environmental impacts are not unique to palm oil, and all other oil crops can have negative consequences. In their pursuit of sustainable development, policymakers in palm oil producing and consuming countries have to deal with trade-offs between environmental conservation, social inclusion and economic growth.

Moreover, the results from this study could be relevant to the WTO dispute on Indonesian palm oil. This study shows that the implication of an EU import ban on Indonesian palm oil is limited. There are two points of view that we can look at. It can be used to support evidence for the EU that this policy will not affect much of the Indonesian economy, thus it can be implemented. But on the other hand, it also supports evidence that the environmental impact is very small, thus it will not be relevant for environmental protection.

## Supplementary Information

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