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Trase 'SEI-PCS Indonesian palm oil v1.1.0' supply chain map: Data sources and methods

Trase maps supply chains for agricultural commodities, making it possible to link products and supply chain actors with specific areas of production, and associated sustainability risks and opportunities. It uses an approach called Spatially Explicit Information on Production to Consumption Systems (SEI-PCS) as the basis for this work (see this webpage or our manual for more detail). This document describes the data and methods that Trase used to map the subnational supply chain for Indonesian exports of crude and refined palm oil in 2015, using a model called **'SEI-PCS Indonesia palm oil v1.1.0'**.

For all palm oil exports, this model determined the likely districts (*kabupaten*) of production. It used trade and production data, as well as information on company asset-ownership, company traceability reports, and road networks. The model used linear programming to establish supply chain connections and link exports to districts of production. Table 1 provides an overview of key statistics.

Table 1. Summary statistics

	2015
Palm oil exports, as crude palm oil (CPO) equivalent (million tonnes*)	25.45
Number of exporting companies	156
Number of exporting groups	64
Number of importing countries	91
Domestic market (% share of production)	14.6
Exports with unknown source of origin (%)	5.29

* = metric tons

Data and sources

Trade data

International exports

The model used per-shipment data (such as customs data, bills of lading and/or cargo manifests) for 2015 covering all exports of crude palm oil (CPO) and refined palm oil (RPO) classified under the 'HS' customs codes in Table 2. It did not include palm kernel oil, biodiesel or palm oil derivatives. We used a commodity-equivalence factor (see Table 2) to convert different products to a standard commodity equivalent, in this case crude palm oil. We confirmed the quality of the data by comparing it with other data sources and with data in different aggregated forms (such as the monthly aggregated data of export volumes published by BPS, the government statistics agency).

Table 2: Palm oil products, HS codes and commodity-equivalence factors (to CPO equivalent)

HS code	Product category	Commodity-equivalence factor
15111000	Crude palm oil	1.00
15119091	Solid fractions of refined palm oil	1.05
15119092	Unsolid fractions of refined palm oil	1.05
15119099	Unsolid fractions of refined palm oil	1.05

Domestic trade

We used per-shipment domestic trade data for 2015 covering CPO and RPO. This data follows a similar structure to the per-shipment international export data. The data covers 5.4 million tonnes of palm oil (CPO equivalent), which equates to 21% of international exports. While we believe this to be comprehensive, we have not been able to verify the volumes. It is therefore possible that there are gaps in the data.

Figure 1. Domestic trade flows of crude and refined palm oil in 2015

Production data

We derived district-level (*kabupaten*) data on palm oil production from province-level statistics on crude palm oil production provided by the Directorate General of Estate Crops via the government statistics agency (BPS). We derived the district-level production data from the province level using palm oil land-use cover data generated by Auriga on the basis of 2016 SPOT satellite imagery.

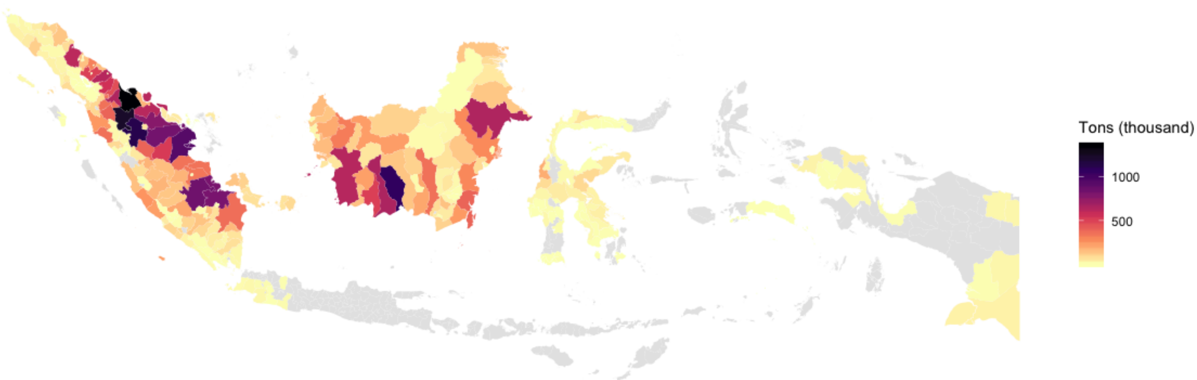

Figure 3. Palm oil production at the district (*kabupaten*) level in 2015

Supply chain data

Asset data

Mills

We used the recently-released (November 2019) update to the Universal Mill List (UML), a collaborative effort among more than 10 nongovernmental organisations and research institutions, including Trase. The UML includes 1,096 mills with verified locations, and information on ownership and mill capacity. For the **'SEI-PCS Indonesia palm oil v1.1'** supply chain model**,** we used the 758 mills that were known to be in operation in 2015 (Figure 4).

We obtained mill capacity values through reports from provincial plantation agencies (Dinas Perkebunan), the initial SIPERIBUN (Plantation Licensing Information System) results, and data from the Roundtable on Sustainable Palm Oil (RSPO) and the Indonesian Sustainable Palm Oil system (ISPO) . There were 86 mills for which we could not find a capacity value. For these mills, we used a spatial interpolation at the district (*kabupaten*) or province level (depending on the availability of other mills).

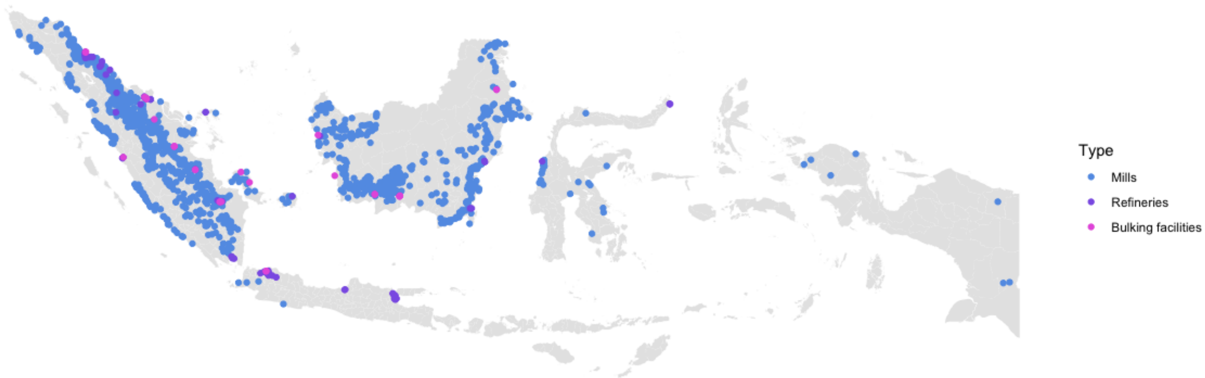

Figure 4. Locations of mills, refineries and bulking facilities

Refineries and bulking facilities

We used refinery and bulking facility data from Aidenvironment and from Auriga's desk-based research. The data does not yet include comprehensive information on capacity, but it does include ownership and location information that unlocks the value of traceability reports.

Traceability reports

To link palm oil refineries and bulking facilities with their supplier mills, we used traceability reports, which are corporate self-declarations detailing sourcing patterns. In 2015, four of the 37 exporting groups published traceability reports outlining the mills associated with their refineries and bulking facilities. For the **'SEI-PCS Indonesia palm oil v1.1.0'** supply chain model, we linked these processing facilities to ports of export on the basis of proximity and ownership. The reports do not contain volumes of palm oil, but we could use the connections provided to constrain allocation during the model's implementation (see below).

Plantations

We used spatially explicit data on plantation licences (HGUs by their Indonesian acronym) to determine the location and ownership of oil palm estates. Auriga and Greenpeace provided this data. It is not comprehensive, however, and importantly does not include information on smallholder plantations.

Transportation data

Road network

We used road network data from the geospatial agency (Badan Informasi Geospasial; BIG) to determine the cost of transport between ports and mills, and between mills and districts (*kabupaten*) of production. This data was available for Sumatra, Kalimantan, Sulawesi, Java, Maluku, Papua. As such, the quality varies across the country. In some locations, such as Riau Islands Province, we could not access the data and so we used straight-line distance.

Ferries

To include fresh fruit bunches (FFB) produced on small islands off Sumatra, we added connections to the road network to allow for the roll-on-roll-off ferries that transport the FFB to Sumatra, as they are not captured by the domestic shipment data.

Company data

We generated a unified dictionary of company names and parent groups in order to align and connect exporting companies, domestic traders and asset owners. We drew parent group information from Indonesian corporate research (by CDMI Consulting Research) and company filings (AHUs, by their Indonesian acronym).

Boundaries

We used jurisdictional boundaries for districts (*kabupaten*) and provinces, as defined by the Indonesian Geospatial Agency (BIG) in 2016. We paired each jurisdiction with geocodes provided by BPS to give a standard identifier for each area.

SEI-PCS implementation

We used a logic-based decision tree to link exports back to refineries and mills (assets). The decision tree allocated exports to logistics hubs based on a series of conditional rules.

First, we defined international export nodes. These are groups of international export shipments that have the same exporting company, port of export and sub-commodity (either crude palm oil or refined palm oil).

Next, we triangulated information on the export node with information on asset ownership. If neither the exporting company nor the exporting company's parent group owned assets (such as refineries, mills or plantations) in the supply chain data, then we declared the origin of the palm oil to be 'unknown' (< 1% of volume; 40 exporters).

Palm oil can be shipped domestically between islands before being exported internationally. In order to map international exports to districts of production, we therefore needed to connect international export nodes to domestic trade shipments of palm oil.

If the export node was listed as a recipient of a domestic trade shipment (meaning it was a domestic importer), then we connected the two. In doing so, we attached a new domestic node to the export node to account for the domestic exporter and the domestic port of loading. This step allowed international export nodes to be connected to other parts of the country, including other islands, and, importantly, other companies (domestic exporters). Depending on the volume of domestic shipments received by the export node, there were two possible outcomes:

- The domestic shipment volume imported to the export node exceeded the internationally exported volume: If so, we re-allocated the export volume proportionally to each of the ports of origin stated in the domestic shipment data.
- The internationally exported volume exceeded the domestic shipment volume imported to the export node: If so, we re-allocated the volume given in the domestic shipment data. The remaining internationally exported volume must have been supplied by the island on which the port of export is situated (unless that island is Java or within Riau Islands Province, in which case we declared the origin of the volume as *unknown* due to limited production in these regions and a lack of information on sourcing).

Note — domestic shipment data plays a critical role in determining the origin of palm oil consumed in the domestic market in Indonesia. Any palm oil that is not exported internationally or domestically remains in the Indonesian market.

Next, we connected international export nodes (and any associated domestic nodes) to mills. There are three pathways here: traceability reports; direct ownership of a mill by an international exporting company (or domestic exporter); and indirect ownership of a mill by an international exporting company's group (or domestic exporter's group). In each case, the connections act to establish a network of mills, which we then passed to a mathematical optimisation model.

Stage 1 of implementation used a simple linear program to allocate volumes of palm oil from international export nodes to mills. The linear program used a distance matrix, based on the road network data, to calculate distances between the demand nodes (international exports) and supply nodes (mills). Demand nodes were constrained by annual international exported volume and supply nodes were constrained by annual throughput capacity.

The model used information on asset-ownership to apply a 'discount' to the distance, to reflect that companies preferentially source from their own facilities. Where the connection was from a traceability report, an expected sourcing pattern was calculated beforehand, and penalties in the form of transport distances were applied to any deviation from that pattern.

Stage 2 of implementation used a linear program to link mills (which in this case are demand nodes) to the district (kabupaten) of production (supply nodes). The linear program minimised the overall distance palm oil could have travelled between demand and supply nodes. The linear program used the road network in a distance matrix between mills and the geometric centre of districts of production. Demand by mills was constrained by each mill's annual throughput capacity and supply from each district was constrained by that district's production. The distance matrix used information on mill ownership of plantations to include weighting factors that discount the transport distance linking mills to districts where they own plantations.

Subnational and company sustainability indicators

The Trase indicator manual for Indonesia describes the connection of these supply chain data to municipal level sustainability indicators including palm oil deforestation risk and cover agriculture, environment, territorial governance, actor commitments, socio-economic and contextual (e.g. biomes).

Changes from previous version(s)

Version	Publication date	Changes from previous version
1.1.0	December 2019	• Integration of traceability report data, improvements to the mill and company data.
1.0	July 2019	• First release on demo site.

How to cite this document

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Annex: Glossary

Term	Definition	Example

Asset	In the context of Trase, a physical or material resource owned by a business or an economic entity that relates to the production, storage or processing of a commodity.	Soy silo, slaughterhouse, refinery, mill, farm.
Commodity equivalent	Measure used to relate the trade flows of different products to a commodity equivalent. This is obtained by using the commodity equivalence factor.	Soy oil and cake products are converted into soybean equivalents.
Commodity-equivalence factor	Factor used to convert the amount of a product into a commodity equivalent.	1 kg of soy meal and oil are equivalent to 1.031 kg of soybeans (3 g are waste).
Decision tree	Outlines the conditional filtering of trade data in order to link commodity exports to a logistic hub.	Each supply chain map manual contains a figure of their respective decision trees.
Distance matrix	The distances between different demand and supply nodes. This is used in the linear programming step to solve the problem of minimising the total distance incurred in meeting all of the demand.	Supply nodes are jurisdictions of production. Demand nodes include exports from ports and domestic demand nodes such as chicken farms for Brazil soy. Distances are based on the available road networks.
HS code	Unique code from the Harmonized System (HS) which describes the nature of the products being traded internationally.	1201: Soya beans, whether or not broken 120110: Soya beans, seed; whether or not broken
Jurisdiction	The territorial administrative units into which a country is divided.	Municipality in Brazil, kabupaten (district) in Indonesia, department in Argentina, department in Paraguay (lower resolution, with departments comprised of districts).
Linear programming	Linear programming (LP, also called linear optimisation) is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships.	Use linear program to minimise the distance between logistic hubs and production municipalities.
Logistics	Activities related to the production, storage, processing, transport, trade, etc., of commodities in supply chains.	Chicken rearing, cattle slaughtering, soybean crushing, palm oil bulking, shipping.

Logistics hub	Jurisdiction containing one or more assets that are nodes in the commodity supply chain.	Municipality, department of silo location, slaughterhouse, palm oil mills.
Node	Jurisdiction, asset, trader or country representing a point of aggregation or transfer of a commodity through its supply chain.	
Supply chain	Sequence of nodes linking a jurisdiction of production to a country of import.	