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Trase 'SEI-PCS Paraguay soy v1.2.2' 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 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 Paraguayan exports of soy, using a model called **'SEI-PCS Paraguay soy v1.2.2'**.

For all soy exports, this model determined the likely department of production. It used trade and production data, as well as information on company-specific soybean-storage silos and soybean-crushing facilities, and road networks. The model used linear programming to link exports to soybean-storage silos and soybean-crushing facilities, and then to link these soybean-storage silos and soybean-crushing facilities to the departments where the soy is produced. Table 1 provides an overview of key statistics.

Table 1. Summary statistics

	2014	**2015**	**2016**	**2017**	**2018**	**2019**
Soy exports (million tonnes*)	7.90	7.53	8.24	8.19	8.59	7.35
Number of exporting companies	63	54	57	48	56	38
Number of importing countries	49	49	44	55	49	47
Exports with unknown source of origin (%)	0	0	0	0	0	0

*= metric tons

Data and sources

Trade data

The model used per-shipment data (customs data, bills of lading and/or cargo manifests) for 2014-2019 covering all exports of soy classified under the 'HS' customs codes in Table 2. The Central Bank recalibrates customs declarations to account for the fact that much of Paraguay's exports are re-exported via Argentina (not from 2018), Uruguay and Brazil. We confirmed the quality of the data by comparing it with other data sources and with data in different aggregated forms.

Table 2. Soy products and their HS codes

Product	**HS code**
Soya beans, whether or not broken	1201
Soya-bean oil and its fractions; whether or not refined, but not chemically modified	1507
Oil-cake and other solid residues; whether or not ground or in the form of pellets, resulting from the extraction of soya-bean oil	2304
Bran, sharps and other residues of leguminous plants, whether or not in the form of pellets, derived from the sifting, milling or other workings thereof	230250

Domestic demand

This model does not include domestic demand for soy.

Production data

We derived soy production at the district level from maps of the relative soy planted area (Global Land Analysis and Discovery, University of Maryland). These soy maps were only available for 2016–2019 and so we also used the 2016 map as a proxy for 2014 and 2015. We combined the information on relative soy-planted area per district with government statistics on department-level production and yield to estimate annual soy production at the district level.

Supply chain data

Asset data

Soy silos

Through secondary research, we identified 178 soy silos. We gave each a unique asset ID and coordinates and, where available, we recorded company ownership. We assumed annual throughput to be the same for all silos and we calculated it by dividing the total amount of uncrushed soy by the number of silos.

Crushing facilities

We identified 17 crushing facilities in operation during 2014 to 2019. We gave each a unique ID and coordinates, and we recorded company ownership. We used data about the maximum daily capacities of these crushing plants as a proxy for the annual throughput of soy in each facility (Hinrichsen 2015; 2018). We distributed the total quantity of soy crushed nationally — according to CAPECO, the Paraguayan Grain and Oilseed Traders Association — across all active crushing facilities according to their relative maximum daily capacity (CAPECO 2018).

Transportation data

Road network

We used a map of the road network from OpenStreetMap to calculate a matrix of distances first between points of export and soy silos or crushing facilities, and then between these assets to the districts that produced soy.

Ports and customs offices

From the trade data, we identified 75 individual ports and customs offices associated with soy exports. We assigned each of them a unique ID and latitude/longitude coordinates (from secondary research). We grouped ports/customs offices in cases where there was more than one name for the same place.

Company data

We used the unique identifying number (the RUC code) of each soy-exporting company in the export records to identify all of their shipments, and to link companies to silos and crushing facilities they own.

Boundaries

We sourced jurisdictional boundaries from the Government Directorate of Statistics and Surveys (DGEEC), which provides the departmental and district boundaries of Paraguay, as of 2019 (DGEEC 2019).

SEI-PCS implementation

We used a logic-based decision tree (see Annex 1) to define weighting factors for linear programs that we used to a) link exports to soy crushing facilities and soy silos, and then b) link soy silos and crushing facilities to the districts where soy is produced.

Stage 1 of implementation consisted of four separate linear programs that linked exports of commodity sub-products to soy silo and crushing facilities. The linear programs minimised the overall distance soy could have travelled between supply nodes (soy silos and crushing facilities) and demand nodes (exports) for:

a) soybean exports to soy silos;

b) soy oil exports to crushing facilities;

c) soy cake exports to crushing facilities, and

d) soy residual exports to crushing facilities.

Supply nodes were constrained by the throughput capacity of assets, namely annual silo storage capacity and crusher outputs of oil, cake and waste. The linear programs used the distance matrix, to minimise distances between export ports and soy silos and crushing facilities (assets). The model used information on asset-ownership to apply a 'cost discount' to the distance, to reflect that exporters preferentially source from their own facilities.

Stage 2 of implementation used a linear program to link silos and crushing facilities (demand nodes) to districts of soy production (supply nodes). The linear program minimised the overall distance soy would have travelled between supply and demand nodes. Demand from soy silos and crushing facilities was constrained by their annual throughput capacity, and supply from each district was constrained by its production. For soy cake, oil or residual exports, we converted the input of raw soy to crushing facilities (where the soy is processed), into outputs of oil, cake and residual in appropriate ratios.

Finally, we combined the two stages of linear programmes (exports to assets in Stage 1; and assets to production in Stage 2) to link exports to districts of production. We aggregated the results to the department level because of uncertainty in the accuracy of production data, which was only available from the government at the department level.

Subnational and company sustainability indicators

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

Changes from previous version(s)

Version	Release date	Changes
1.2.2	June 2021	• We used a different road network map. • We updated the time series to include 2019. • We corrected the 2018 annual soy export trade volume and FOB value, removing some erroneous duplicates.
1.2.1	June 2020	• We applied a new definition and calculation for soy deforestation and soy deforestation risk.
1.2.0	December 2019	• We updated the time series to include 2018. • The model also uses 2016 and 2018 crop maps in addition to the 2017 soy crop cover map that v1.1 used for production estimates. The 2016 map is used as a proxy for 2014 and 2015. This improves the accuracy of our estimates for district-level production. • We introduced company ownership of assets into the linear programming so we could link the outputs of soy silos and crushing facilities (logistic hubs) to exports. Where exporters own assets, we applied a 'cost discount' to the distance, to reflect that exporters preferentially source from their own facilities.
1.1	May 2019	• We updated the research into company-owned soy assets in Paraguay. • We extended the time series to include 2017. • We included soy pellet HS codes 230250 in the model. • We interpolated the governmental soy production data (departmental level data only) with a satellite crop map (2017) provided by the University of Maryland. This allowed us to estimate district level production and run the LP at the district level, improving the accuracy of results. • We created a new decision tree with two stage linear programming. See SEI-PCS Implementation (above) for detail. In this decision tree, we no longer allocated volumes of soy straight to department X where production in department X was greater than the amount demanded by the customs office per year.
1.0	November 2017	• First release

How to cite this document

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References

Hinrichsen, J.J. (2015). Paraguay: Capacidad instalada de elaboración de semillas oleaginosas al segundo semestre de 2015. [data cited in Mesquida, F. (2017). Aumentó un 7% (25.000 tn/día) la capacidad de molienda en el Mercosur. *Infocampo, 25 March* www.infocampo.com.ar/aumento-un-7-25-000-tndia-la-capacidad-de-molienda-en-el-mercosur/]

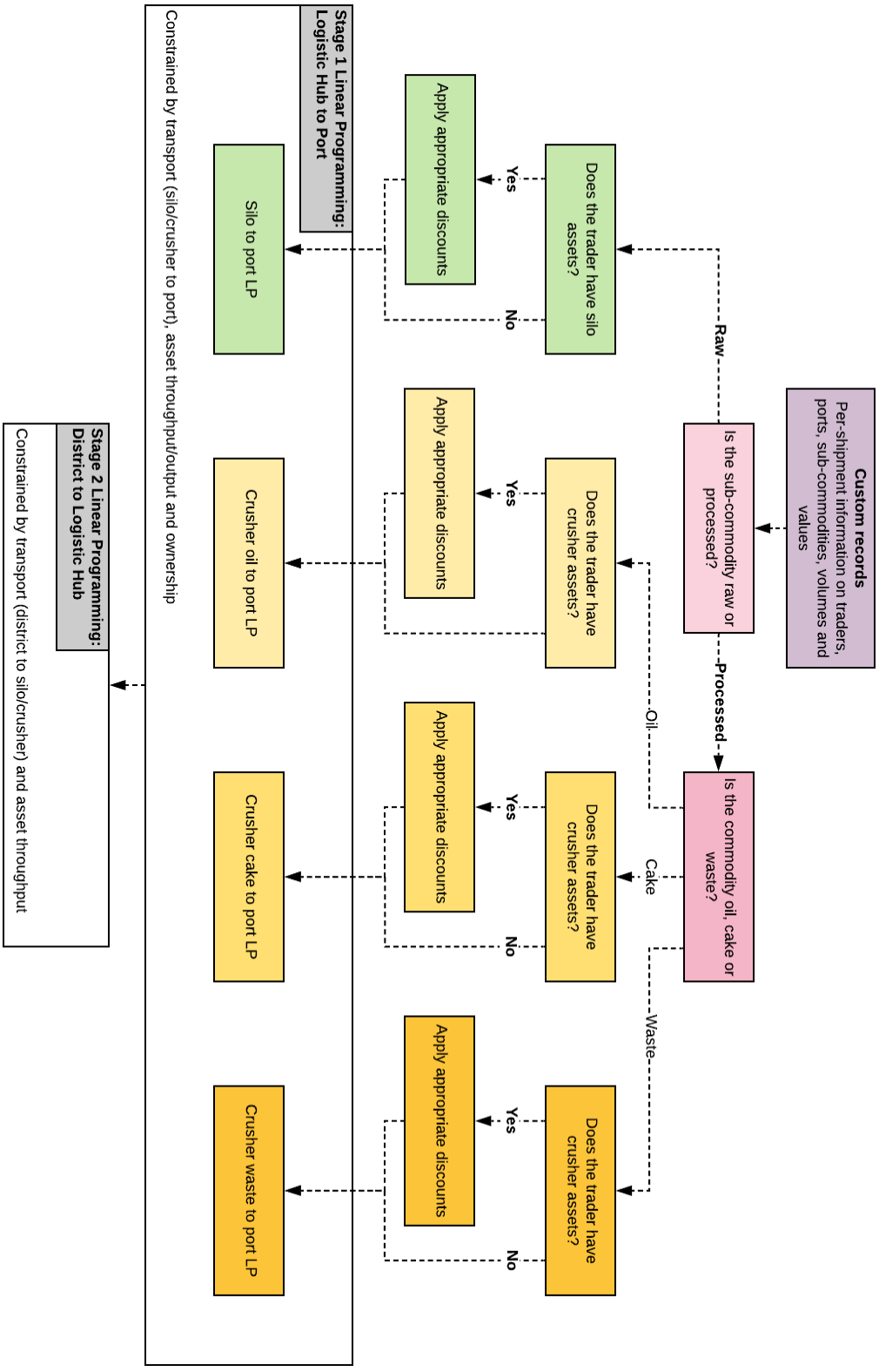
Hinrichsen, J.J. (2018). Paraguay: capacidad instalada de elaboración de semillas oleaginosas al segundo semestre de 2017.

CAPECO. (2019). Uso de la soja. https://capeco.org.py/uso-de-la-soja-es/

DGEEC. (2019). Datasets: 'paraguay_2019_distritos.' Dirección General de Estadística, Encuestas y Censos. http://geo.stp.gov.py/user/dgeec/datasets

Open Street Map (2020) https://www.openstreetmap.org/#map=7/-24.312/-56.459

Annex 1: Decision tree for the 'SEI-PCS Paraguay soy v1.2' supply chain model



Annex 2: 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.	