

GreenDelta
sustainability consulting + software

openLCA

Life Cycle Assessment Beyond the Environment: Social Impacts and Criticality of Raw Materials

Dr. Jonas Hoffmann, Consultant, GreenDelta GmbH, Berlin

on 10th November, 2026, 2nd SMI Online Forum

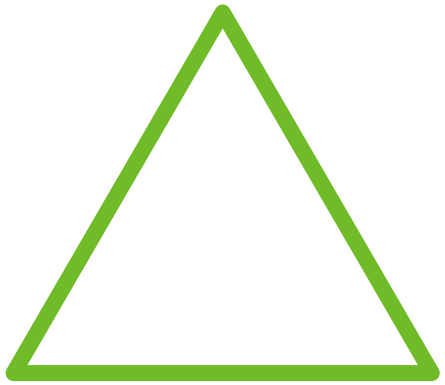
Picture: Julia Cilleruelo Palomero

GreenDelta, What we do

- Founded by Dr. Andreas Ciroth in 2004, Berlin; now ~ 25 employees (engineers, developers etc)
- Business world-wide: sustainability research, product carbon footprinting, life cycle assessments, databases, software for life cycle assessments and sustainability, environmental product declaration

Sustainability consultancy and research

environmental LCAs, resource criticality, social LCAs, Life Cycle Costing, Circular Economy



openLCA nexus

Database development and distribution

openLCA

Software development, especially open source

About openLCA

- Free and open-source project
- Developed by GreenDelta since 2007
- Constant development, continues updates
- Database flexibility and multifunctional
  - LCA, LCC, Social LCA and LCSA
  - Carbon & Water footprint
  - Product Environmental Footprint (PEF)
  - Environmental Product Declarations (EPDs)

2.6.2

- Better system dynamics tooling (needs to be enabled under experimental features File > Preferences > Experimental features)
  - Full graphical editor for variables and product system bindings
  - Usage of XMILE as data exchange format
- Fix: Regionalized LCIA missed some flows with some location combinations
- Fix: Monte Carlo Simulation did not include linked results. Further the respective error dialog got improved

2.6.1:

- Improved user interface, including a resized search box for certain display resolutions and a refined dark mode theme
- Major memory reduction for regionalized LCIA, resulting in smoother performance and making calculations more accessible for users with limited system resources
- Faster calculations overall, including direct impact calculations
- Bug fixes from v2.6.0 for a smoother user experience
- Easier deletion of process chains in the graphical editor (Model Graph)
- Better support for opening Python scripts on macOS and Linux

2.6.0:

- System Dynamics (SD) simulation and modeling (experimental feature)
- Hestia import functionality with flow mapping selection and data preview
- Improved Jython/Python integration: CodeMirror 6 editor with code completion and run keymap
- Library signing (experimental)
- GLAD mapping file import support
- Allow results as default providers in processes with drag and drop support
- Allow adding multiple impact categories and flows to results at once
- Better provider names in Sankey diagram
- Improved process names in model graph
- Social aspects: allow deletion of a set of indicators under social aspects tab
- Fix: direct impacts of processes
- Fix: deletion of database repository
- Fix: library signing UI issues

https://www.openlca.org/download/

Foreground, Background

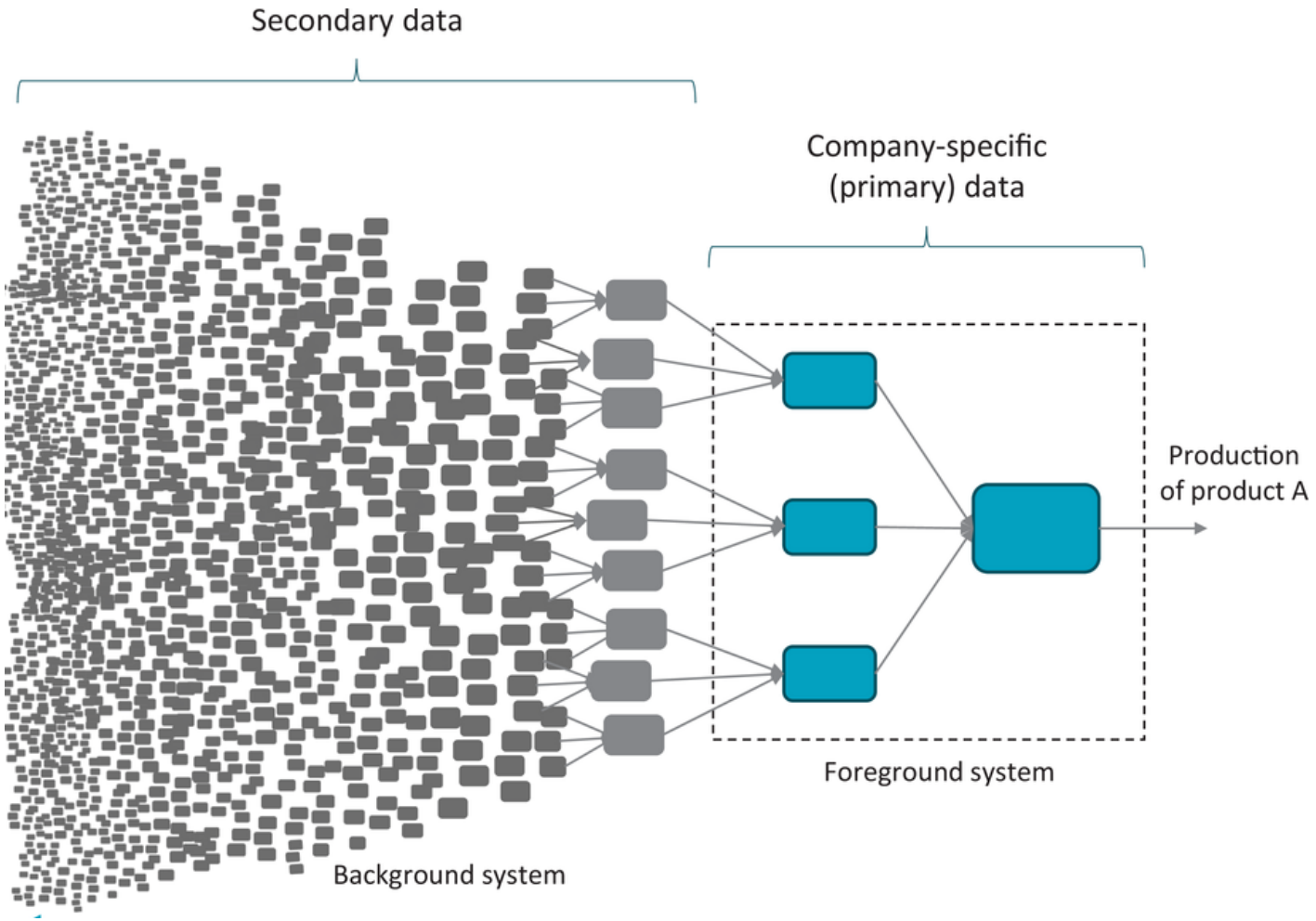


Chart from Rognan et al. 2025 J. Ind. Ecol. 29, 1397–1413.

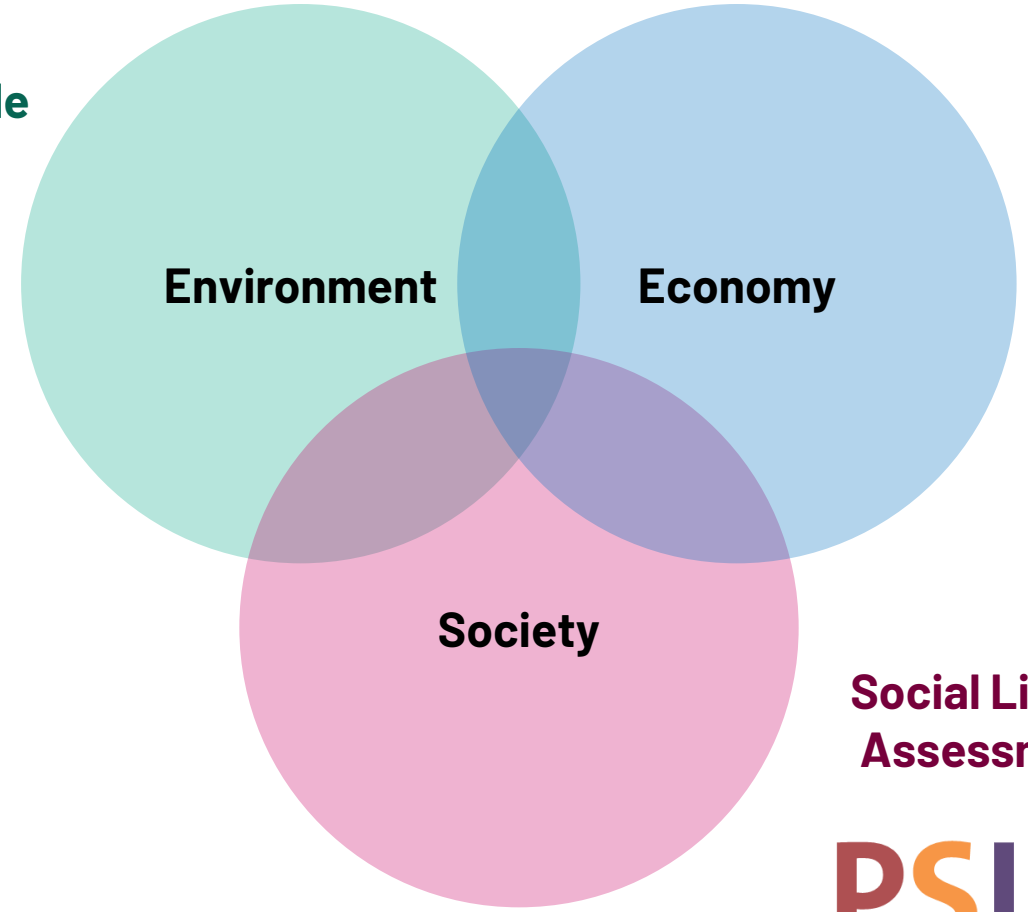
Foreground, Background

Environmental Life Cycle Assessment (eLCA)

ecoinvent

Bundesamt für Umwelt BAFU

carbonminds



Life Cycle Costing (LCC)

Social Life Cycle Assessment (sLCA)

PSILCA

GreenDelta

Foreground, Background

- Using modification of background databases, we can assess more dimensions:



Circularity across Life Cycle:
- Material Circularity Index
- Circularity Index









Plastic Littering:
- Based on a probalistic model

Criticality across Life Cycle:
- Inventory along the supply chain
- Weighting (SH2E method) for CRMs

Social Risk across Life Cycle:
- Using data from PSILCA
- Added to ecoinvent

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Circularity package

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ecoinvent

SH2E

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soca

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PLEX

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Foreground, Background: Criticality

- a critical raw material is a raw material that is very important to the EU economy and has a high risk of supply disruption - **EU's Critical Raw Materials Act** (EU2024/1252)
- Criticality investigates the usages of CRM and SRM (by EU definition)

Bauxite	**Coking Coal**	**Lithium**	**Phosphorus**
Antimony	**Feldspar**	Light rare earth elements	Scandium
Arsenic	Fluorspar	Magnesium	Silicon metal
Baryte	Gallium	**Manganese**	Strontium
Beryllium	Germanium	Natural Graphite	Tantalum
Bismuth	Hafnium	Niobium	Titanium metal
Boron/Borate	**Helium**	Platinum group metals	Tungsten
Cobalt	Heavy rare earth elements	Phosphate Rock	Vanadium
		Copper	**Nickel**

https:/a/single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en

Foreground, Background

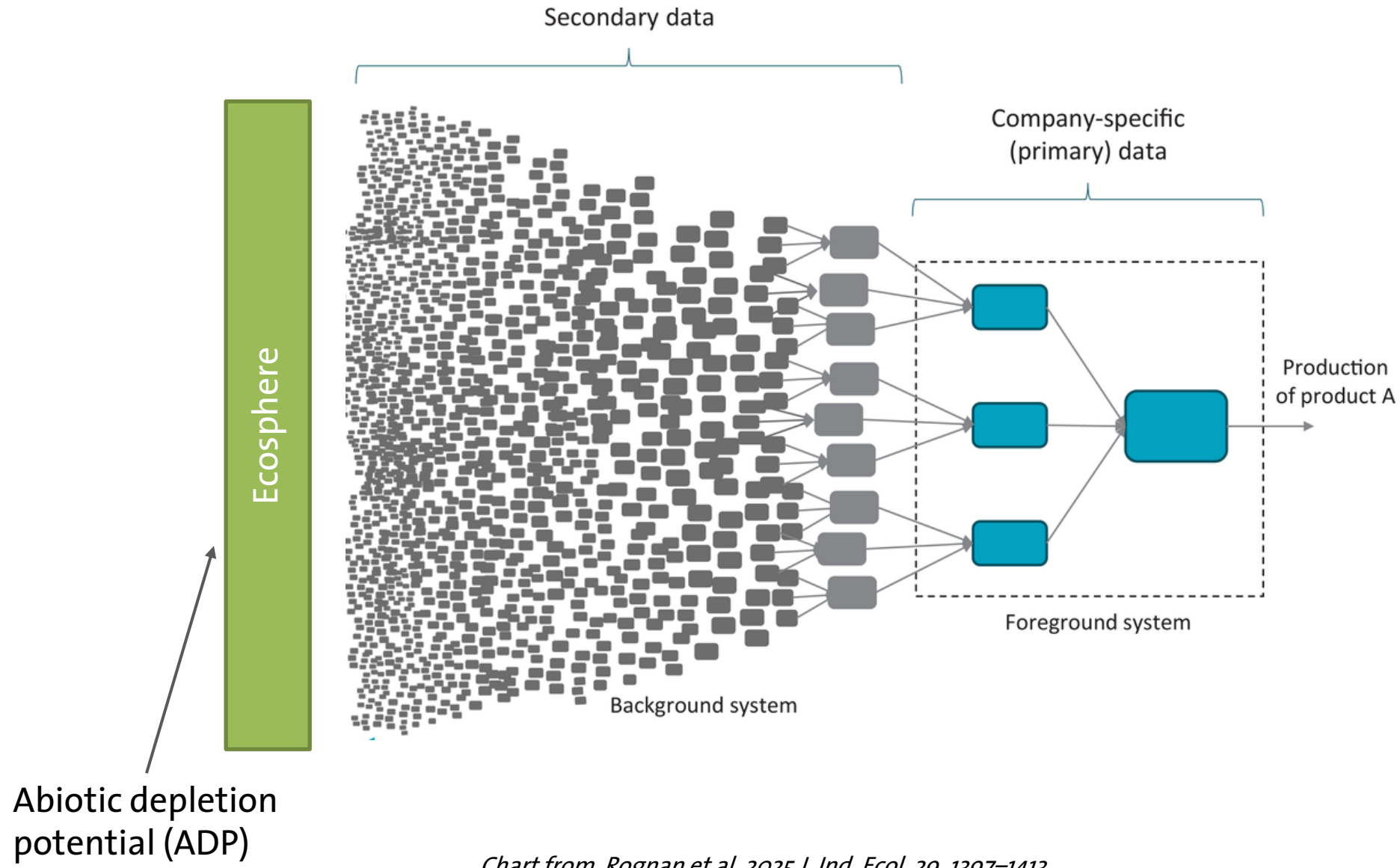


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Foreground, Background: Criticality

- Following the LCA logic described by (SH2E project, 2021, 2022), the characterization factor for a resource i is calculated based on:

$$A = \frac{SR_i}{c_i \cdot \left(1 - IR_i \cdot (1 - EoL_{RIR})\right)}$$

SR_i Supply Risk of resource I;
c_i European consumption of resource I;
IR_i Import reliance of resource I;
EoL_{RIR} End-of-life recycling input rate;

- In general, several of the listed CRMs are not purely elementary flows in LCA terms; many are typically represented as intermediate (technosphere) flows
- Application of **economic allocation** significantly influences inventory results
- Mass balance distortion: 1 kg of lithium mined is only account for by 0.55 kg of lithium depleted; so use of CFs for this is problematic

Foreground, Background

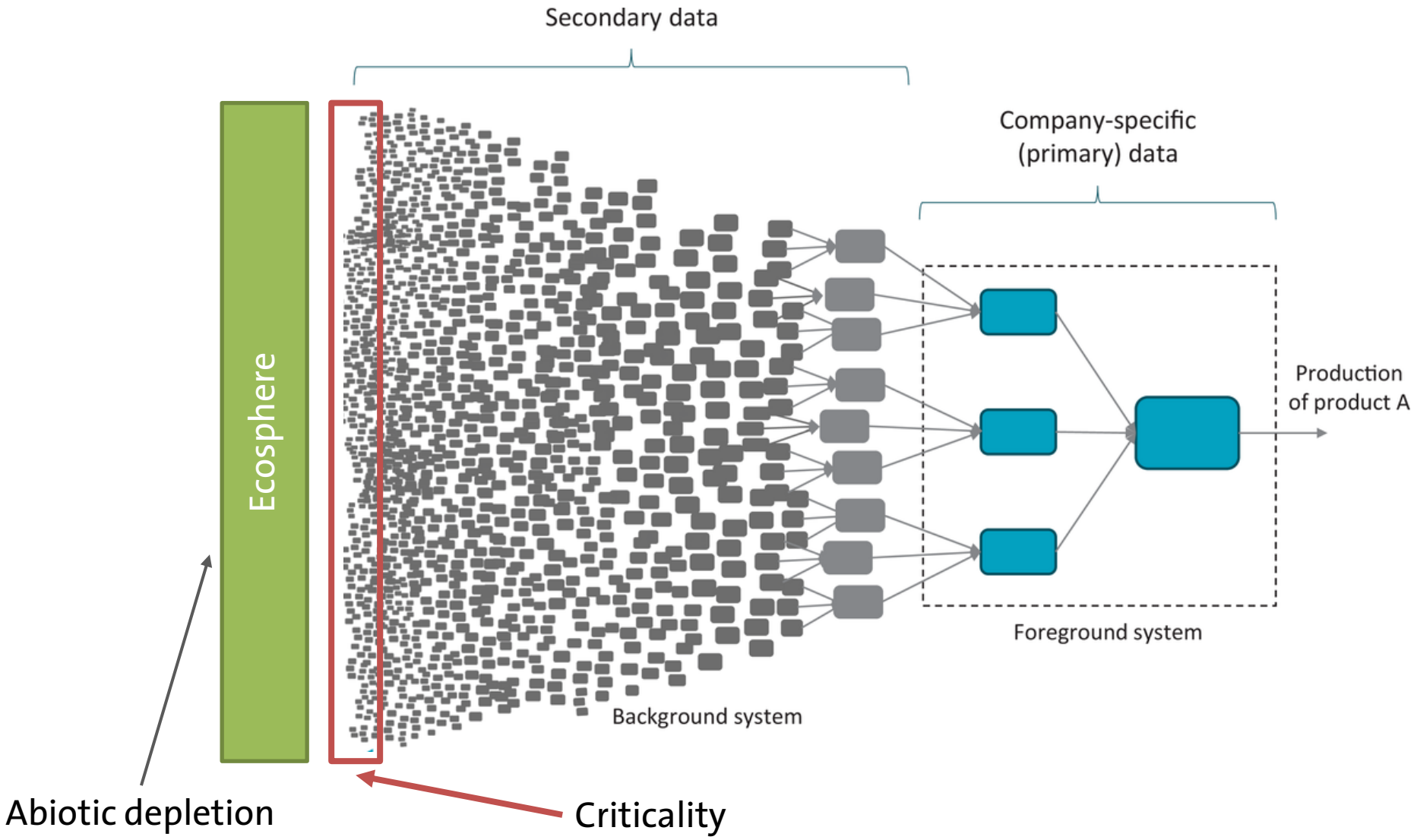


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Foreground, Background: Criticality

- We added shadow flows in the ecoinvent database
  - If you use 1 kg of a CRM, the shadow flow will account for 1 kg of the material (corrected)
- To this we added SH2E CFs to assess the Criticality to weight the importance
- Tested for $LiPF_6$ (CRM expected Lithium, Phosphate Rock, Fluorspar):

Impact analysis - criticality overview

Sub-group by ○ Processes ● Flows | Don't show < 1 %

Name	Inventory result	Characterization factor	Impact assessment result
SH2E Criticality Indicator (origin			7.61232E-6 dimensionless
Lithium	0.02343 kg	0.00015 dimensionless/kg	3.47210E-6 dimensionless
Neodymium	0.00032 kg	0.00561 dimensionless/kg	1.81580E-6 dimensionless
Samarium	1.42132E-5 kg	0.12545 dimensionless/kg	1.78302E-6 dimensionless
Cerium	0.00088 kg	0.00016 dimensionless/kg	1.40359E-7 dimensionless
Scandium	1.59098E-6 kg	0.06486 dimensionless/kg	1.03199E-7 dimensionless
Gadolinium	1.22647E-5 kg	0.00738 dimensionless/kg	9.05446E-8 dimensionless

Impact analysis - criticality overview

Sub-group by ○ Processes ● Flows | Don't show < 1 %

Name	Inventory result	Characterization factor	Impact assessment result
SSbD CRM inventory			9.25297 kg
Phosphate Rock CRM	6.11851 kg	1.00000 kg/kg	6.11851 kg
Fluorspar CRM	1.73028 kg	1.00000 kg/kg	1.73028 kg
Coking Coal CRM	1.10608 kg	1.00000 kg/kg	1.10608 kg
Phosphorus CRM	0.23264 kg	1.00000 kg/kg	0.23264 kg
SSbD CRM with SH2E CFs			6.88942E-6 dimensionless
Lithium CRM	0.04638 kg	0.00015 dimensionless/kg	6.87171E-6 dimensionless
Phosphate Rock CRM	6.11851 kg	1.60000E-9 dimensionless/kg	9.78962E-9 dimensionless
Fluorspar CRM	1.73028 kg	4.13692E-9 dimensionless/kg	7.15801E-9 dimensionless
Phosphorus CRM	0.23264 kg	1.60000E-9 dimensionless/kg	3.72219E-10 dimensionless
Magnesium CRM	0.00052 kg	2.62000E-7 dimensionless/kg	1.37026E-10 dimensionless

- Results represent the criticality of materials (hot spots) and led to further studies

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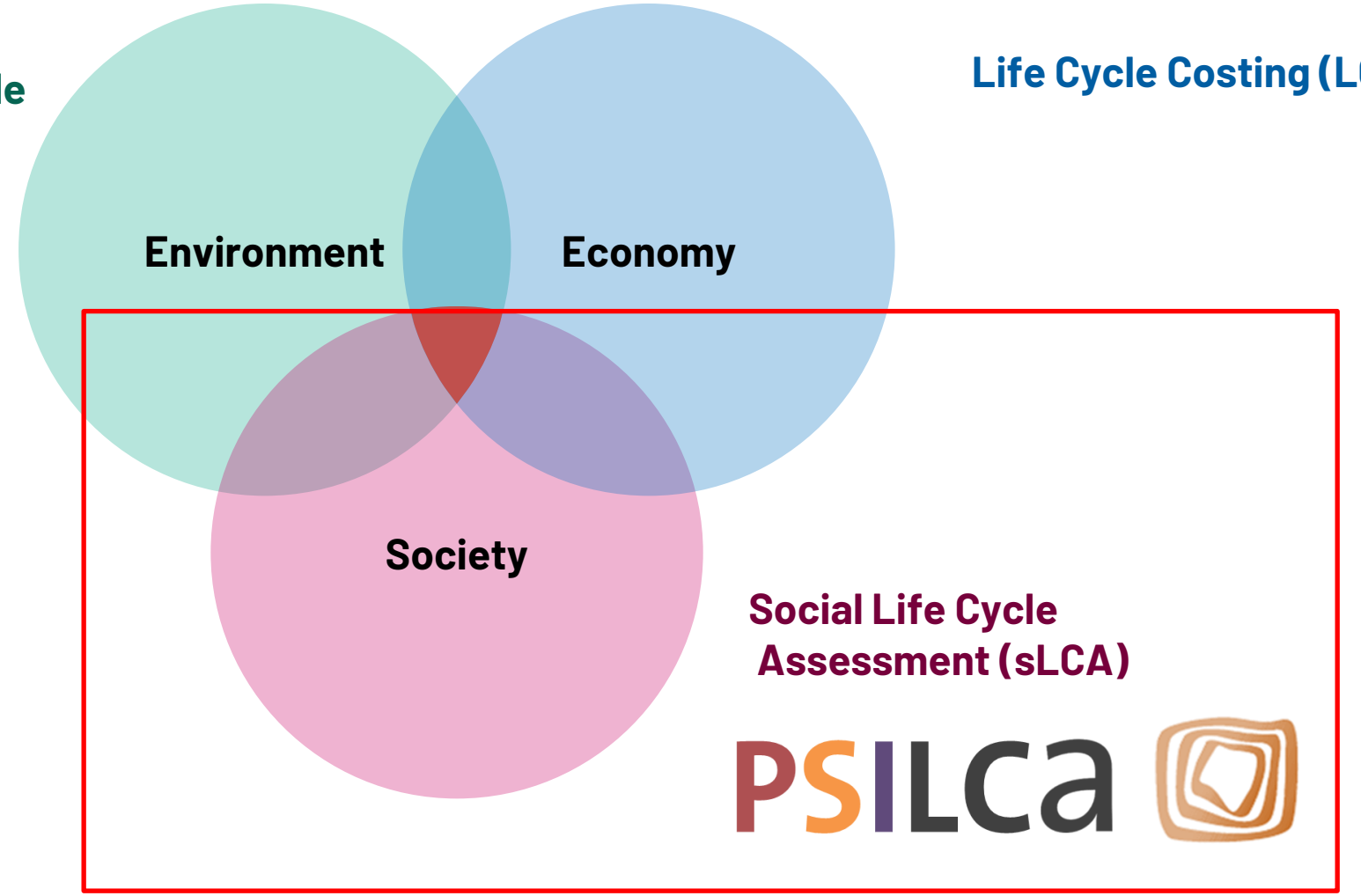
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SH2E

soca

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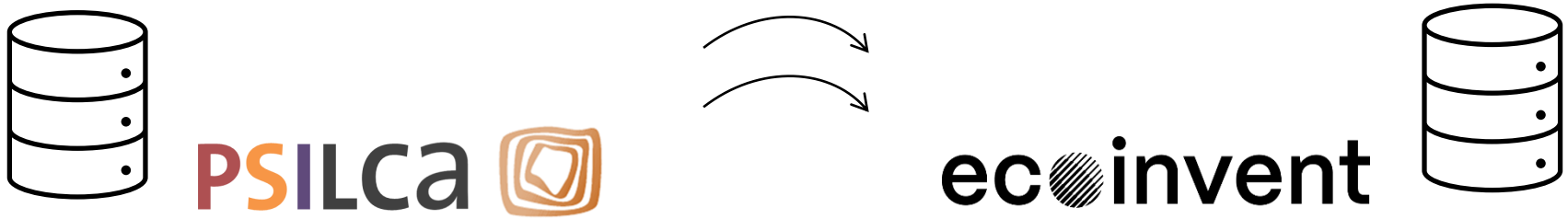
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Social Risk across Life Cycle:
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Foreground, Background: Social

- ecoinvent is identified as an internationally recognized LCA database that provides comprehensive life cycle inventory (LCI) data for various sectors
- It is noted that while ecoinvent includes data for environmental impacts (LCA) and cost/revenue data (could be used for LCC), **it lacks information on social impacts**
- The SOCA database was developed to fill this social impact data gap, thereby enabling users to perform a complete Life Cycle Sustainability Assessment, which combines social LCA, environmental LCA, and LCC
- The availability of the SOCA database is limited to the openLCA software platform
- SOCA is based on our PSILCA database, which covers 189 countries and approximately 15,000 industry sectors and commodities, providing comprehensive social data for the assessment of global supply chains

Foreground, Background: Social



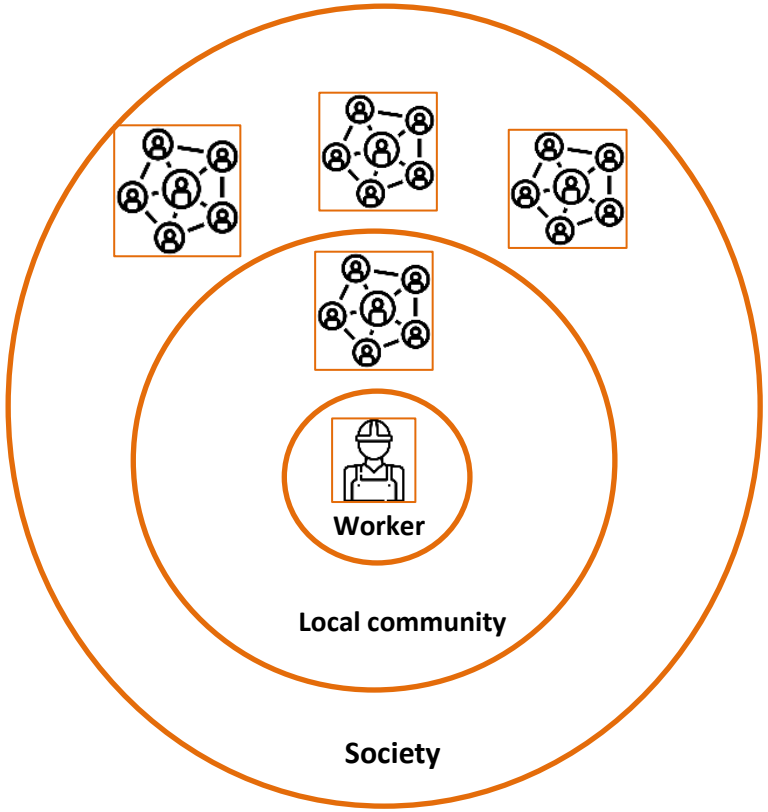
raw values per each of the 106 social indicators, from PSILCA to ecoinvent processes

Location

Process/Sector

soca

Foreground, Background: Social



Stakeholder categories

Working conditions

Impacts

- Social benefits / social security
- Fair salary
- Forced Labour

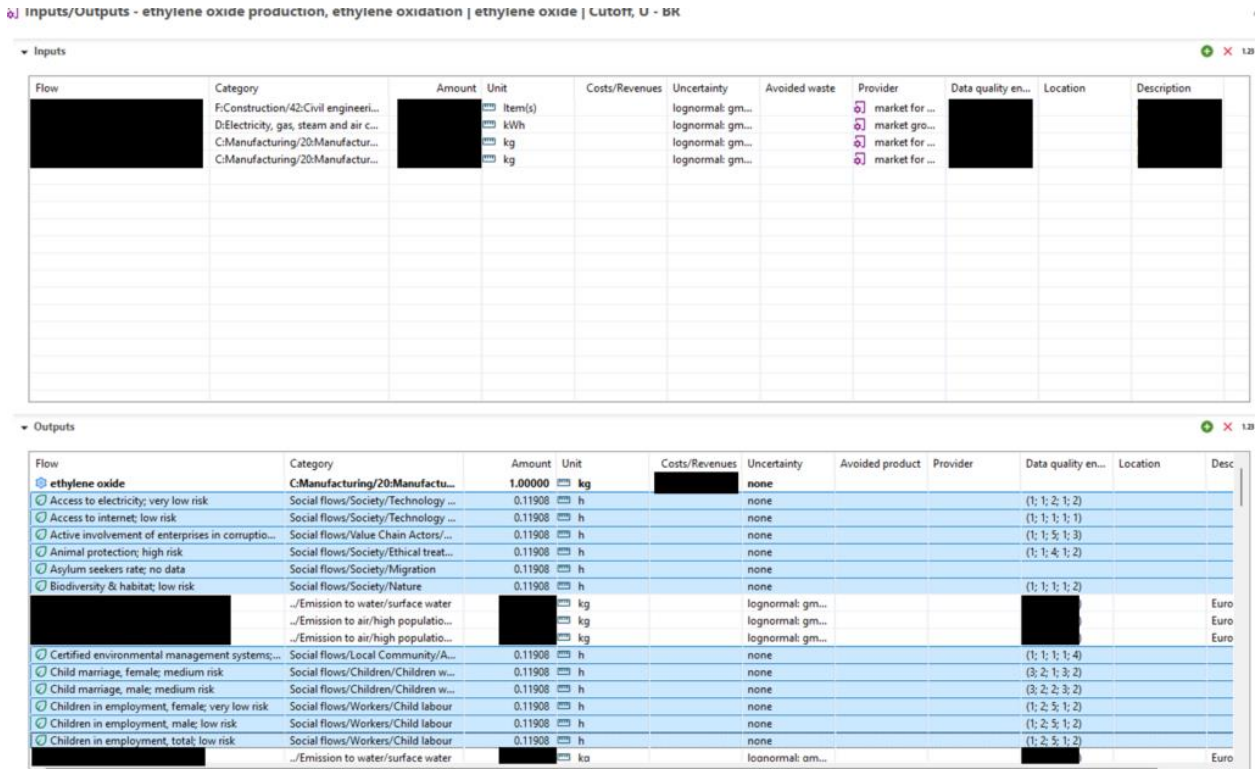
Subcategories

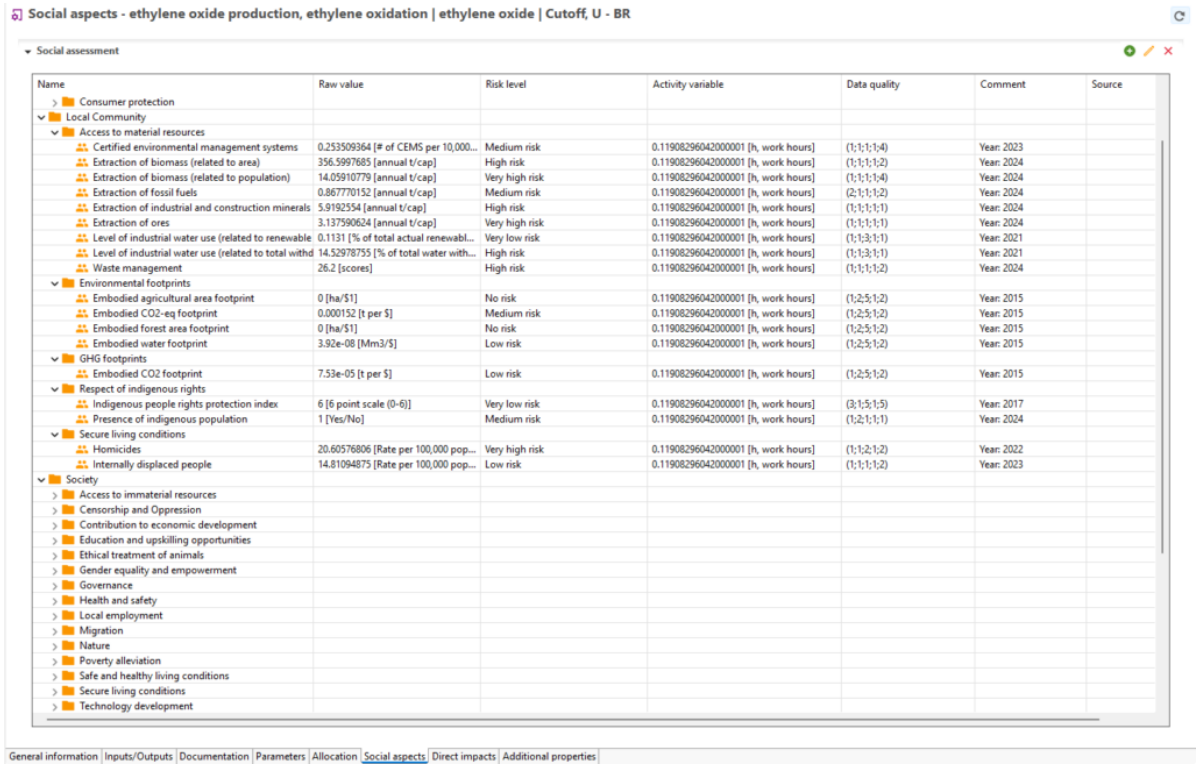
- Social benefits / social security → Paid Maternity Leave
- Fair salary → Average income of workers as percentage of minimum wage/ living wage
- Forced Labour → Presence of forced labour in the supply chain

Social indicators

Foreground, Background: Social

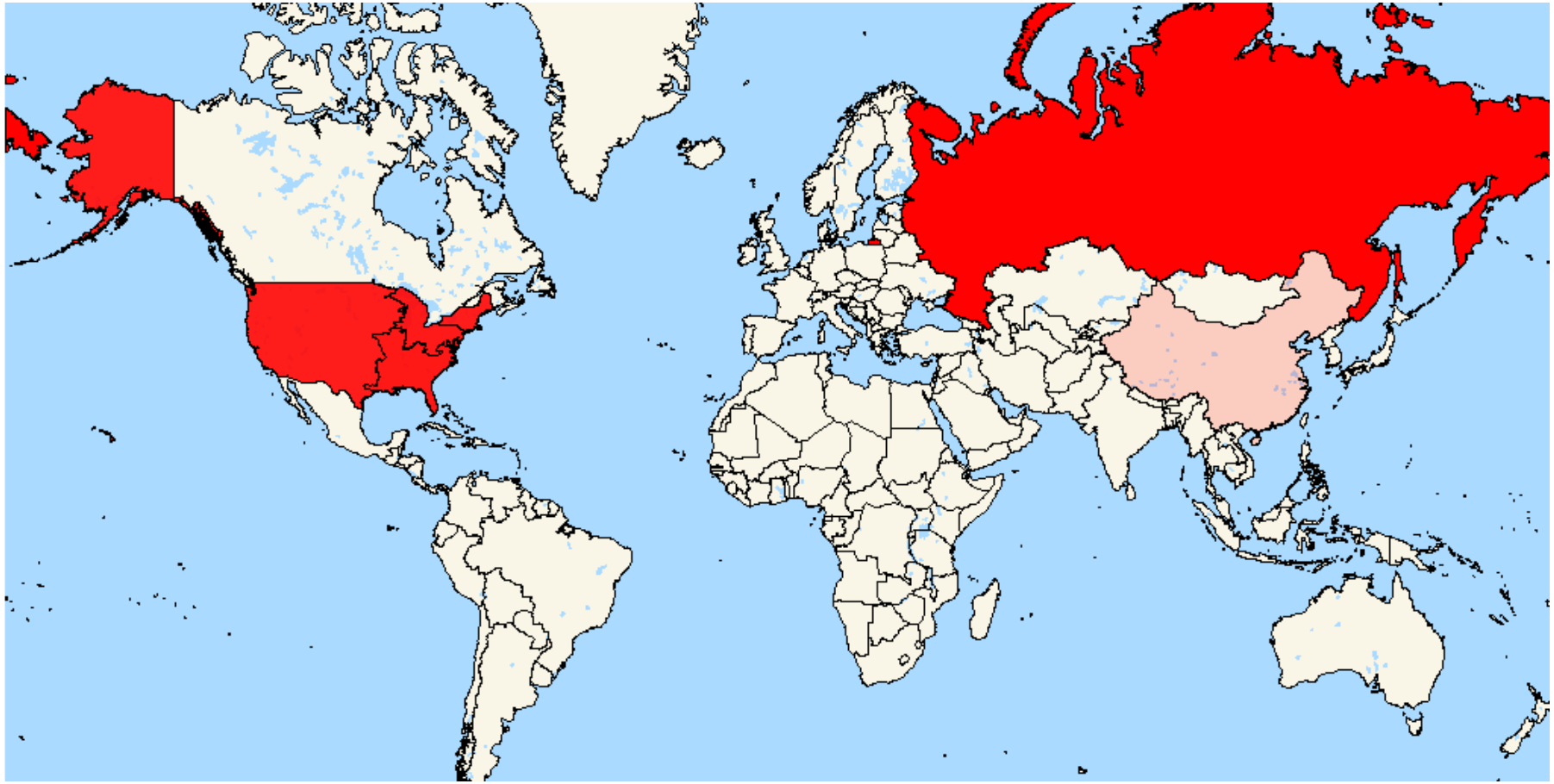
- Inventory of a chemical based process in soca with social risk information and results:





Foreground, Background: Social

- Results of “Indigenous People Rights Protection” of beryllium (GLO) in soca v4:



Key takeways

- openLCA provides an open-source platform for integrating databases
- **Foreground and background** systems within the Life Cycle Inventory
- Modifying background databases allows the assessment of additional sustainability dimensions beyond conventional LCA
- Transparent LCI databases serve as basis for **indicator-based** frameworks (circularity, criticality)
  - Criticality assessment helps identify CRMs and evaluate potential supply risks along the supply chain and life cycle
  - Performing the assessment on Tier-1 gives rise to unallocated indicators
- Social risk along global supply chains can be assessed using Social LCA (PSILCA/SOCA)
- Combining environmental, social and economic assessments together with circularity and criticality supports a more comprehensive Life Cycle Sustainability Assessment (LCSA)

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Thank you!

Picture: Julia Cilleruelo Palomero

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