SOCA – A database add-on for Life Cycle Sustainability Assessment

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Introduction

Sustainable Development Goals (SDG):

• To eradicate poverty and ensure human well-being three dimensions of sustainable development are interconnected and crucial

• Globalization → sustainability does not stop a national borders

→ Life Cycle approach necessary
Introduction: LCA

Environmental LCA (E-LCA)

Life Cycle Costing (LCC)

Social LCA (S-LCA)

Environmental LCC
Introduction: LCSA

- **Aim:** contribute to research of Life Cycle Sustainability Assessment (LCSA) by providing a tool
  - combine 3 elements in a database
Introduction: LCSA with soca

<table>
<thead>
<tr>
<th>Impact category</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Association and bargaining rights</td>
<td>1.28 med risk h</td>
</tr>
<tr>
<td>Fair Salary</td>
<td>39.41 med risk h</td>
</tr>
<tr>
<td>Violations of employment laws and regulations</td>
<td>5.05 med risk h</td>
</tr>
<tr>
<td>Indigenous rights</td>
<td>0.99 med risk h</td>
</tr>
<tr>
<td>Climate change - GWP100</td>
<td>5.45 kg CO2-Eq</td>
</tr>
<tr>
<td>Freshwater eutrophication - FEP</td>
<td>0.003 kg P-Eq</td>
</tr>
<tr>
<td>Human toxicity - HTPinf</td>
<td>2.07 kg 1,4-DCB-Eq</td>
</tr>
<tr>
<td>Total value added</td>
<td>1.19 USD</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Methodology: Database

• Develop add-on containing social inventory information for ecoinvent v.3.3
• Ecological inventory data and costs are based on ecoinvent v.3.3
• Social inventory data based on PSILCA
Methodology: Database mapping (1/2)

- Assigning risk-assessed indicators from PSILCA country-specific-sectors to ecoinvent categories

  **PSILCA “Spain: Products of agriculture”** → **ecoinvent “Spain: Growing of citrus fruits”**

- Exception: market processes, activities for administration and database modelling
Methodology: Database mapping (2/2)

- Ecoinvent processes of trans-national (or global) regions get an average of same/similar sectors of all related countries in PSILCA

  - PSILCA Germany Logging
  - PSILCA Austria Logging
  - PSILCA Spain Logging
  - ...

  Europe Logging

- Ecoinvent processes of “Rest-of-World” regions get an average of similar/same sectors of all countries in PSILCA not covered individually for these activities
Methodology: Activity variable (1/2)

- Worker hours
  \[ \text{Working time/USD sector output } \times \text{cost of reference product} \]
- Average of PSILCA working times assumed for global and regional processes
Methodology: Activity variable (2/2)

- For ecoinvent activities without costs, parameters were defined (for each production unit)

<table>
<thead>
<tr>
<th>Flow</th>
<th>Category</th>
<th>Amount</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur dioxide</td>
<td>Emission to air/high population density</td>
<td>0.00088</td>
<td>kg</td>
</tr>
<tr>
<td>Calcium</td>
<td>Emission to air/high population density</td>
<td>2.3777E-6</td>
<td>kg</td>
</tr>
<tr>
<td>NMVOC, non-methane volatile organic</td>
<td>Emission to air/high population density</td>
<td>2.2813E-6</td>
<td>kg</td>
</tr>
<tr>
<td>Zinc, ion</td>
<td>Emission to air/high population density</td>
<td>1.1156E-7</td>
<td>kg</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Emission to air/high population density</td>
<td>9.7122E-6</td>
<td>kg</td>
</tr>
<tr>
<td>Copper, ion</td>
<td>Emission to air/high population density</td>
<td>4.3013E-6</td>
<td>kg</td>
</tr>
<tr>
<td>Chromium</td>
<td>Emission to air/high population density</td>
<td>3.3805E-5</td>
<td>kg</td>
</tr>
<tr>
<td>Zinc, ion</td>
<td>Emission to air/high population density</td>
<td>9.4866E-7</td>
<td>kg</td>
</tr>
<tr>
<td>Lead</td>
<td>Emission to air/high population density</td>
<td>5.9952E-7</td>
<td>kg</td>
</tr>
<tr>
<td>Cyanide</td>
<td>Emission to air/high population density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate of fatal accidents at workplace;</td>
<td>Workers/Health and Safety (Workers)</td>
<td>1*WH,m3</td>
<td>h</td>
</tr>
<tr>
<td>medium risk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of indigenous population; no</td>
<td>Local Community/Respect of indigenous rights</td>
<td>1*WH,m3</td>
<td>h</td>
</tr>
<tr>
<td>risk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human rights issues faced by indigenous</td>
<td>Local Community/Respect of indigenous rights</td>
<td>1*WH,m3</td>
<td>h</td>
</tr>
<tr>
<td>people; not applicable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum wage, per month; very high risk</td>
<td>Workers/Fair Salary</td>
<td>1*WH,m3</td>
<td>h</td>
</tr>
<tr>
<td>Living wage, per month; high risk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sector average wage, per month; very low</td>
<td>Workers/Fair Salary</td>
<td>1*WH,m3</td>
<td>h</td>
</tr>
<tr>
<td>risk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children in employment, total; no risk</td>
<td>Workers/Child labour</td>
<td>1*WH,m3</td>
<td>h</td>
</tr>
</tbody>
</table>

Screenshot from openLCA
Methodology: Data quality

- Data quality assessment is basically transferred from PSILCA original data
- regarding geographical and technical conformance assessment, mapping and data attribution procedures were considered

<table>
<thead>
<tr>
<th>Forcible Labour</th>
<th>Goods produced by forced labour</th>
<th>No data</th>
<th>5.1912E-4</th>
<th>(2;4;3;3;2)</th>
<th>ILO 2012: Forced Labour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of forced labour</td>
<td>1.5 [%]</td>
<td>Very low risk</td>
<td>5.1912E-4</td>
<td>(2;1;1;1;4)</td>
<td>U.S. Department of State 2014: Trafficking in Persons</td>
</tr>
<tr>
<td>Trafficking in persons</td>
<td>1 [Tier]</td>
<td>Very low risk</td>
<td>5.1912E-4</td>
<td>(2;2;4;2;2)</td>
<td>Mean over differen…</td>
</tr>
<tr>
<td>Living wage, per month</td>
<td>883,91 (USD)</td>
<td>High risk</td>
<td>5.1912E-4</td>
<td>(2;2;1;1;2)</td>
<td>WageIndicator 2014: Living wage</td>
</tr>
<tr>
<td>Minimum wage, per month</td>
<td>1400 (USD)</td>
<td>Very low risk</td>
<td>5.1912E-4</td>
<td>(2;2;2;1;2)</td>
<td>Data scope: count…</td>
</tr>
<tr>
<td>Sector average wage, per month</td>
<td>6759,41 (USD)</td>
<td>Very low risk</td>
<td>5.1912E-4</td>
<td>(2;2;2;1;2)</td>
<td>Risk level referen…</td>
</tr>
</tbody>
</table>
Results and discussion

• S-LCA add-on for ecoinvent v3.3 → LCSA database
• Complements environmental and cost data by social risk information:

Workers, Local communities, Value chain actors, Society

17 sub-categories

53 indicators

• “Social aspects”: raw values, data quality, sources…
Results and discussion: Application

- LCSA of 1kg woven textile fabrics of jute in India
- From cradle-to-gate:
  - System model: Allocation, cut-off by classification
Results and discussion: Application

Impact Assessment:
- ReCiPe Midpoint (H)
- Rudimentary method for social impacts (exponential relation between impact factors)
- Value added approach by Moreau and Weidema (2015)
Results and discussion: E-LCA

Relative distribution for direct contributions of selected processes to selected environmental impact categories:

- Climate change - GWP 100a
- Ecosystem quality - freshwater and terrestrial acidification
- Ecosystem quality - freshwater ecotoxicity
- Human health - respiratory effects, inorganics
- Resources - land use

Processes:
- Electricity production, hard coal | electricity, high voltage | IN
- Hard coal mine operation | hard coal | RoW
- Jute production, rainfed | jute fibre | RoW
- Jute production, irrigated | jute fibre | RoW
- Onshore well production, oil/gas | onshore well, oil/gas | GLO
- Treatment of spoil from hard coal mining, in surface landfill | spoil from hard coal mining | GLO
- Others

- Electricity production, lignite | electricity, high voltage | IN
- Jute production, rainfed | jute fibre | IN
- Jute production, irrigated | jute fibre | IN
- Soybean production | soybean | US
- Treatment of spoil from lignite mining, in surface landfill | spoil from lignite mining | GLO
- Treatment of hard coal ash, residual material landfill | hard coal ash | RoW
Results and discussion: S-LCA

Relative distribution for direct contributions of selected processes to selected social impact categories

- Restriction of trade unionism
- Unfair Salaries
- Corruption
- Restrictions of indigenous rights
- Fatal accidents
- Restrictions of association and bargaining rights
- Child Labour, total
- Insufficient safety measures
- Non-fatal accidents

Textile production, jute | textile, jute | IN
Treatment of spoil from lignite mining, in surface landfill | spoil from lignite mining | GLO
Spinning, bast fibre | spinning, bast fibre | RoW
Jute production, rainfed | jute fibre | IN
Electricity production, hard coal | electricity, high voltage | IN
Petroleum refinery operation | diesel | RoW
Yarn production, jute | yarn, jute | RoW
Transmission network construction, electricity, high voltage | transmission network, electricity, high voltage | RoW
Yarn production, jute | yarn, jute | IN
Spinning, bast fibre | spinning, bast fibre | IN
Lubricating oil production | lubricating oil | RoW
Others
Results and discussion: LCC

Relative distribution for direct contributions of selected processes to total added value

- Textile production, jute | textile, jute | cut-off, U - IN
- Electricity production, hard coal | electricity, high voltage | cut-off, U - IN
- Jute production, rainfed | jute fibre | cut-off, U - IN
- Transmission network construction, electricity, high voltage | transmission network, electricity, high voltage | cut-off, U - RoW
- Jute production, rainfed | jute fibre | cut-off, U - RoW
- Transmission network construction, electricity, high voltage | transmission network, electricity, high voltage | cut-off, U - CH
- Yarn production, jute | yarn, jute | cut-off, U - IN
- Others

<table>
<thead>
<tr>
<th>Contribution</th>
<th>Process</th>
<th>Amount</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.41%</td>
<td>textile production, jute</td>
<td>0.25549</td>
<td>USD</td>
</tr>
<tr>
<td>10.59%</td>
<td>electricity production, hard coal</td>
<td>0.12639</td>
<td>USD</td>
</tr>
<tr>
<td>09.67%</td>
<td>jute production, rainfed</td>
<td>0.11541</td>
<td>USD</td>
</tr>
<tr>
<td>08.89%</td>
<td>transmission network construction, electricity, high voltage</td>
<td>0.10613</td>
<td>USD</td>
</tr>
<tr>
<td>05.26%</td>
<td>jute production, rainfed</td>
<td>0.06306</td>
<td>USD</td>
</tr>
<tr>
<td>04.42%</td>
<td>transmission network construction, electricity, high voltage</td>
<td>0.05274</td>
<td>USD</td>
</tr>
<tr>
<td>04.18%</td>
<td>yarn production, jute</td>
<td>0.04992</td>
<td>USD</td>
</tr>
<tr>
<td>02.88%</td>
<td>jute production, rainfed</td>
<td>0.03452</td>
<td>USD</td>
</tr>
</tbody>
</table>
Results and discussion: Analysis

Reasons for different hotspots regarding sustainability aspects:

- Different absolute risks
- Different impact calculation approaches
  - LCC = sum of value added over LC (scaled to target amount)
  - EI = scaled (e.g. by mass) and characterized emissions over LC
  - SI = scaled (e.g. by mass and worker hours) and characterized social risks over LC
- Eco-efficiency hotspots may provide new insights
Conclusions: soca

Soca is first database allowing complete, comprehensive LCSA

+ automated, efficient calculation of social and environmental impacts and costs for several LC stages
+ three sustainability dimensions can be evaluated for the same product system simultaneously, and
+ independently of process connection types
+ clear visualizations and comparisons of results showing different environmental, social and cost hotspots
Conclusions: soca – next steps

• Mapping from input/output database to LCA database
→ Average social risks for all activities of same category

• Prices are global averages for many activities → not only distorts overall costs but also worker hours (hence social impacts)

• Environmental and social inventory data, and especially costs should be much more country- and process-specific
Conclusions: SDG

• Importance & necessity of LCSA emphasized in SDG

• Core feature of SDGs: strong focus on means of implementation, a.o. capacity-building and technology, as well as data and institutions

• Urgent action is needed to achieve most targets

\[ \text{soca} = \text{tool contributing to achievement of goals} \]

• Promising advance for LCSA

• Starting point for further developments and studies in the field
Muchas gracias!

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