Regionalised LCIA implementation in LCA software for decision-making analysis in LCM

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Content

- Regionalised LCIA in openLCA
  - Corn production case study

- The perspectives concept applied to regionalised LCIA

- Next steps and conclusions
Regionalised LCIA in openLCA
Regionalised LCIA in openLCA

- **Inventory:**
  - Extension of locations: KML editor

- **LCIA methods:**
  - Parameterisation of the models + GIS
    - Reduction of the amount of data which needs to be included in the method in openLCA
LCIA MODEL  
(per substance i, impact category j)

Site-independent parameters  
Mathematical functions  
Site-dependent parameters

Impact factors

<table>
<thead>
<tr>
<th>Impact category</th>
<th>Flow</th>
<th>Category</th>
<th>Unit</th>
<th>Factor</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupation, arable</td>
<td>resource/land</td>
<td>UBP/m2*a</td>
<td>(0.60*ratio bioma)/s_area</td>
<td>lognormal:</td>
<td></td>
</tr>
</tbody>
</table>

Example: Land use model from de Baan et al. (2012), as implemented in Ecological Scarcity 2013 (Frischknecht and Büsser Knöpfel 2013)

\[ \text{Eco} - \text{factor}^{\text{Region}_1} = K^{\text{Region}_1} \cdot \frac{1 \cdot UBP}{F_n^{CH}} \cdot \left( \frac{F}{F_k} \right)^2 \cdot c \]

\[ K^{\text{biome}_i} = \frac{BDP^{\text{biome}_i}}{BDP_{settlement\_area\_biome5}} = \frac{BDP^{\text{biome}_5}}{BDP_{settlement\_area\_biome5}} \]
LCIA MODEL
(per substance $i$, impact category $j$)

- Site-independent parameters
- Mathematical functions
- Site-dependent parameters

Default value
Shape files

Site-independent parameters

Mathematical functions

Site-dependent parameters

Impact factors

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</table>

$CF_{ijr}$

Regionalised LCIA results

Inventory (per substance $i$, location $r$)

KML data per location $r$
Case study: corn production, at farm gate

Inventory:

Functional Unit: 1kg corn grain, 85-91% moisture, at harvest
Locations: Colorado, Georgia, Kansas, Minnesota and Texas

<table>
<thead>
<tr>
<th>System</th>
<th>LCI data</th>
<th>KML data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreground</td>
<td>USDA crop database</td>
<td>US Census Bureau</td>
</tr>
<tr>
<td>Background</td>
<td>ecoinvent 3.1 allocation, default</td>
<td>ecoinvent Geographies.xml</td>
</tr>
</tbody>
</table>

Regionalised impact categories

<table>
<thead>
<tr>
<th>Impact category</th>
<th>LCIA method</th>
<th>Regionalised parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land use</td>
<td>de Baan et al. (2012), as implemented in Ecological Scarcity 2013</td>
<td>Ratio of species densities of biomes 1 to 4 to species density in biome 5</td>
</tr>
<tr>
<td>Freshwater consumption</td>
<td>Ecological Scarcity 2013</td>
<td>Water stress index (WSI).</td>
</tr>
</tbody>
</table>
LCIA results: Land use

- Major contributor (>99%): corn grain production, at farm
LCIA results: Land use (II)

Characterisation factors (Occupation, arable)

UBP/kg corn:
- Default
- Biome

UBP/m²a SA-eq:
- Default = 420

States compared:
- Colorado
- Georgia
- Kansas
- Minnesota
- Texas

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LCIA results: Freshwater consumption

UBP/kg corn

- Global
- Country

Colorado, Georgia, Kansas, Minnesota, Texas
Hotspots of freshwater consumption

Colorado, Georgia, Kansas, Minnesota, Texas

UBP/kg corn

irrigation - US
petroleum production, onshore - RME
electricity production, natural gas, ... - SA
electricity production, oil - SA
copper mine operation - RAS
other
Where is the hotspot in the supply chain?

corn production, at farm – US-MN

harvest, corn – US-MN

market for combine harvesting – GLO

combine harvesting - RoW

market for diesel – Europe without Switzerland

petroleum refinery operation – Europe without Switzerland

market for petroleum - GLO

petroleum production, onshore - RME

- Contribution to inventory: 0.11%
- Contribution to LCIA: 67%
Proposal of improvement

- Should regionalised CFs be applied to flows from the background system?
  - Low inventory results may lead to high impact contributions
  - Spatial uncertainty distributions are not included in generic databases

→ The perspectives concept
The perspectives concept
Perspectives in LCA

- **LCIA:** Hofstetter in 1998
  - “the cultural perspectives leading to models that depend on world views”
    - hierarchist, egalitarian and individualistic perspectives
  - Used in LCIA methods like ReCiPe or EcoIndicator

- **LCI:** Ciroth & Schebek in 2011
  - Modelling decisions may not fit for the specific case
    - Perspectives specify application contexts for data sets
  - Applied as proof of concept in the research project BioEnergieDat
Perspectives in LCI

Core: it contains aspects required by almost all perspectives
Deltas: additions or omissions from the core
Mods: modifications of aspects in the core (exceptions)
Perspectives applied to regionalised LCIA

- Fully regionalised perspective
  - Core: Regionalised LCIA
    - Regionalised CFs applied to all processes with a location defined

- Decision-making perspective
  - $\Delta$: Emissions from background datasets
    - Global CFs used for processes which location is not known by the user or do not contain spatial uncertainty

Selected processes: default LCIA
Regionalised LCIA
Perspectives implemented in openLCA

- Determine the type of CF (global, regionalised) to use depending on the dataset and product system
  - A dataset can be included in the background system of one study and in the foreground system of another
- Specific editor containing all processes in the product system and their location

Product system: corn grain; at harvest in 2005; at farm; 85%-91% moisture

<table>
<thead>
<tr>
<th>Process</th>
<th>Location</th>
<th>Generic</th>
</tr>
</thead>
<tbody>
<tr>
<td>cork forestry, alloc. default, U</td>
<td>Europe</td>
<td></td>
</tr>
<tr>
<td>cork forestry, alloc. default, U</td>
<td>Rest-of-World</td>
<td></td>
</tr>
<tr>
<td>corn grain; at harvest in 2005; at farm; 85%-91% m...</td>
<td>US-CO</td>
<td></td>
</tr>
<tr>
<td>corrugated board box production, alloc. default, U</td>
<td>Rest-of-World</td>
<td></td>
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Perspectives implemented in openLCA (II)

- Determine the type of CF (global, regionalised) to use depending on the dataset and product system
  - Specific editor containing all processes in the product system and their location
  - In the model graph, it is possible to determine the “depth” in the supply chain where regionalised LCIA should be performed
  - Datasets can be identified by default as “background datasets” in the process level
Case study results applying perspectives

- Land use

![Bar chart showing UBP/kg corn for Colorado, Georgia, Kansas, Minnesota, and Texas across Generic, Biome, and Perspective categories.](chart.png)
Case study results applying perspectives

- Freshwater consumption

![Bar chart showing freshwater consumption for different regions. The chart compares Global, Country, and Perspective perspectives. The regions include Colorado, Georgia, Kansas, Minnesota, and Texas. The chart indicates significant variations in UBP/kg across different regions and perspectives.]
Conclusions and outlook
Conclusions

- Regionalised LCIA in openLCA works successfully without affecting significantly the calculation time required
  - Regionalised LCIA methods are welcome! (ideally, parameterised)

- Complexity added to the interpretation of results for decision-making

- The perspectives concept might be useful to adapt the LCIA calculation to the geographical relevance of each process
Next steps in software development

- Enhancement of uncertainty assessment of regionalised results

- Same regionalised parameters defined at different resolutions might be needed for a single product system
  → Ability to select the shape file (i.e. level of resolution) for a specific parameter depending on the process dataset
    - It will facilitate the use LCIA method developers own average estimations
    - Other option: weighted aggregations (e.g. emission proxies)

→ Support welcome!
Merci!

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