openLCA (1.7)

AWARE – Regionalized LCIA in openLCA

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Content

1 Introduction

AWARE is the result of a two-year consensus building process developed by WULCA, a working group of the UNEP SETAC Life Cycle Initiative. AWARE complies with ISO 14046 and represents the *state-of-the-art* of current water LCIA methods[1]. AWARE is used for instance within the Environmental Footprint Initiative of the European Commission for Product Environmental Footprints (PEF).

2 Goal and scope of AWARE

AWARE is a regionalised Life Cycle Impact Assessment (LCIA) method in openLCA (more specifically: regionalised water scarcity footprint) and quantifies the relative **A**vailable **WA**ter **RE**maining per (specified) area after satisfying the demand of aquatic ecosystems and anthropogenic activities. Aim of AWARE is to assess the extent to which other water users in the same area are at risk of water scarcity. The findings are translated into a characterisation factor (CF) that ranges between 0.1 and 100 and can be utilised for calculating the water scarcity footprint in accordance with the respective ISO standard (14046).

3 AWARE in openLCA

3.1 openLCA

openLCA is a fast, reliable, high-performance open source software for sustainability management and Life Cycle Assessments (LCAs). Since 2006, openLCA has been developed and 'managed' by GreenDelta in Berlin and is continuously being improved. openLCA is designed with usability in mind and receives support from key actors of the global LCA community.

Despite being free of charge, openLCA includes all features which one would expect from an expert tool to model full-fledged LCA studies such as process and supply chain modelling, visualization of LCA models, calculation of impacts under use of various methodological approaches, analyzing contributions and main drivers for impacts, uncertainty analyses, and more.

3.1.1 openLCA download

openLCA can be downloaded for free via http://www.openlca.org/.

3.2 Implementation of AWARE in openLCA

3.2.1 Regionalized LCA in openLCA

Regionalized LCIA assess environmental impacts for a specific area in which the respective impact occurs. This is for instance relevant for freshwater consumption because freshwater

[1] Boulay, Anne-Marie, Jane Bare, Lorenzo Benini, Markus Berger, Michael J. Lathuillière, Alessandro Manzardo, Manuele Margni, et al. "The WULCA Consensus Characterization Model for Water Scarcity Footprints: Assessing Impacts of Water Consumption Based on Available Water Remaining (AWARE)." *The International Journal of Life Cycle Assessment* 23, no. 2 (February 2018): 368–78. https://doi.org/10.1007/s11367-017-1333-8.

availability and demand are highly dependent on the geographic location. To calculate regionalized impacts, openLCA processes spatially referenced data (shapefiles/*.shp). A process' location can be specified by drawing polygons using a KML editor or by using predefined polygons (e.g. countries).

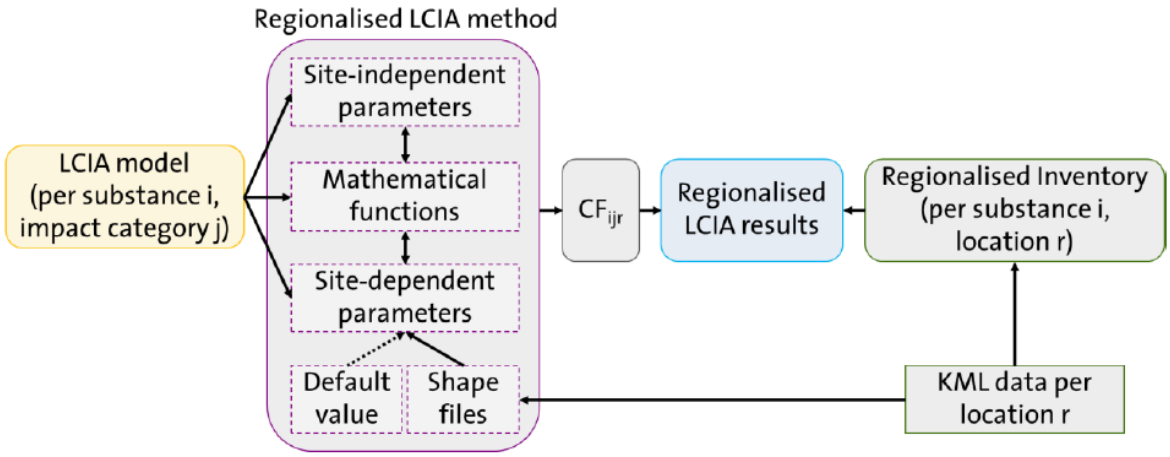

Figure 1:The openLCA approach for regionalised LCIA2.

[2] Rodriguez, C., and A. Ciroth. "Regionalized LCIA Implementation in LCA Software for Decision-Making Analysis in LCM." Poster presented at the 7th International Conference on Life Cycle Management – LCM 2015, Bordeaux, 2015. https://www.greendelta.com/wp-content/uploads/2017/03/LCM2015_Regionalization_in_openLCA_Rodriguez.pdf.

3.2.2 Aggregation of AWARE characterisation factors (CFs) in openLCA

To calculate the AWARE water scarcity footprint, the user needs to specify the process location to define the CF or aggregated CF that is to be used. The native CFs are based on monthly water availability and consumption. WULCA provides aggregated CFs for specific countries corresponding to a period of one year.

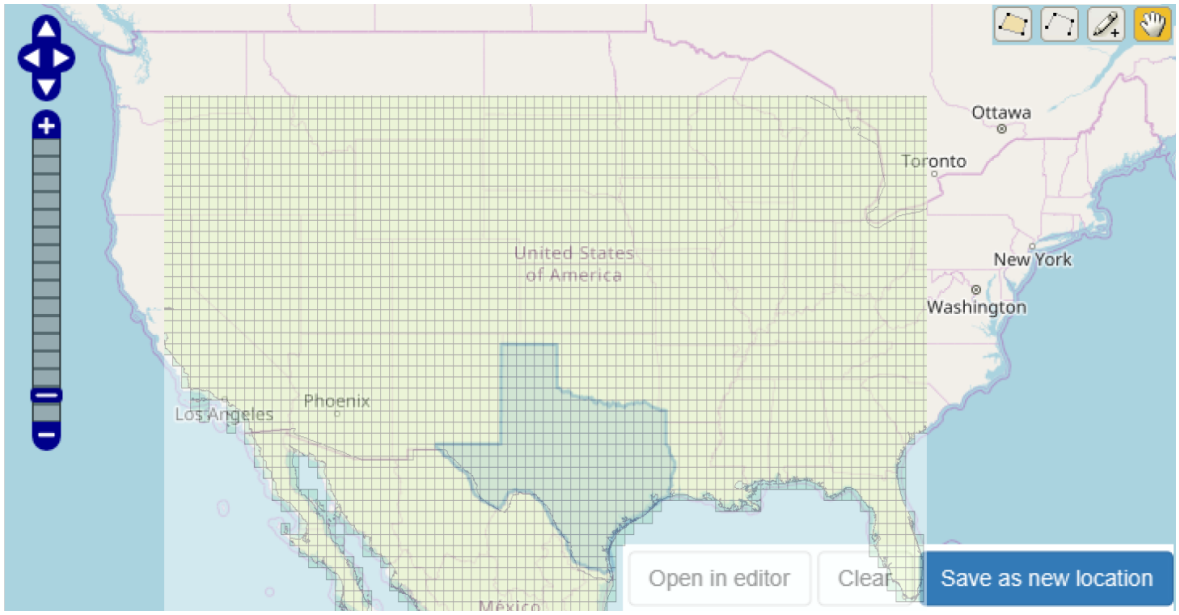

Figure 2: Example of GIS consumption raster data at native scale (0.5°*0.5°) with the state Texas selected, in openLCA.

3.2.3 Native characterisation factors

The native CFs are first calculated as the water availability subtracting the Demand (AMD) of humans and aquatic ecosystems and is relative to the area ($m^3/m^{-2}/month^{-1}$). Subsequently, the AMD is normalized with the world average. Thus, the native CF represents a value relative to the world average value (where water consumption occurs). [3].

3.2.4 Characterization factor aggregation in openLCA

If the polygon drawn for a process intersects more than one watershed the native CFs must be aggregated before calculating the WF.

Consumption weighted aggregation of CFs in openLCA:

$$\text{aggCF} = \frac{\sum_{i=1}^{n} CF \times c_i}{\sum_{i=1}^{n} ci}$$

[3] WULCA, (2014) Description of the AWARE method, available at: http://www.wulca-waterlca.org/aware.html accessed on 30/08/2017

$$CF \times c_i = m_i$$

$$aggCF = {}^{\frac{m_i}{2}}\Big/_{\frac{c_i}{2}}$$

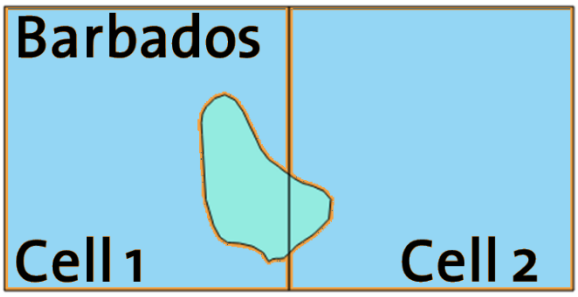

Figure 3: Example of Barbados CF aggregation. The selected polygon intersects 2 watersheds (cell1 and cell2) whose CFs must be aggregated using the consumption weighted average.

Table 1: Results of CF aggregation for Barbados considering irrigation, non-irrigation and unspecified water consumption (GreenDelta AWARE Mar 2017).

Flow type	BASIN0_ID (Cell)	Water-shed (natCF)	Consump-tion (ci)	Consumption share (ci/c_total)	Result according to AWARE formula (aggCF)
Irri	48,777	18.882	1,350,622	0.697	17.511
	48,778	14.349	585,772	0.303	
Non-irri	48,777	7.665	6,564,469	0.915	7.600
	48,778	6.905	610,736	0.085	
Unknown	48,777	9.579	7,915,091	0.869	9.707
	48,778	10.550	1,196,508	0.131	

3.2.5 Corrected and improved country aggregation

GreenDelta improved the initial AWARE country aggregation (AWARE_country 2017) through (1) correction of misaligned cells in the original country aggregation and (2) introduction of a more representative split of cells along the border of two countries.

In comparison to the corrected and improved values (AWARE_country_2.0), the average deviation from WULCA's original country-aggregated CFs was 4.98%, -3.27% and -1.14% for agricultural, non-agricultural and unspecified use, respectively (Table 2).

However, it should be noted that the extent to which deviations occur differs considerably. Hence, a different sample may lead to different percentage deviation.

Table 2: Comparative overview of WULCA's aggregated country values published in 2017 and factors following the refined area aggregation modelling of corrected values, calculated in openLCA.

	AWARE_country 2017			AWARE_country_2.0 (2018)			AWARE_Country / AWARE_country_2.0 (2018)		
Country	Agri	Non-Agri	Unspeci-fied	Agri	Non-Agri	Unspeci-fied	Agri	Non-Agri	Unspeci-fied
Barbados	14.35	6.93	10.52	17.511	7.604	9.707	0.819	0.912	1.084
Belgium	2.28	1.16	1.37	2.048	1.19	1.358	1.113	0.975	1.009
Burkina Faso	13.66	18.37	15.87	16.827	18.7	17.705	0.812	0.982	0.896
China	45.53	27.67	42.43	45.767	26.989	42.388	0.995	1.025	1.001
Egypt	98.51	97.79	98.42	95.593	98.366	95.888	1.031	0.994	1.026
Gambia	7.78	13.33	11.79	6.452	13.3	10.858	1.207	1.003	1.086
Guate-mala	1.17	1.13	1.20	1.119	1.085	1.1	1.046	1.045	1.087
Haiti	2.09	5.08	2.56	7.688	6.169	7.486	0.272	0.823	0.342
Japan	0.51	0.95	0.90	0.597	0.573	0.589	0.854	1.658	1.528
Monaco	5.05	1.73	3.04	5.051	1.723	3.042	1.000	1.004	0.999
Rwanda	72.15	81.72	80.66	60.044	71.353	69.685	1.202	1.145	1.157
Spain	79.13	31.49	77.70	79.821	30.886	78.39	0.991	1.020	0.991
Turkey	57.39	20.68	55.57	59.792	23.083	58.215	0.960	0.896	0.955
Zambia	5.31	6.52	5.58	5.3	6.683	5.596	1.002	0.976	0.997

3.2.6 How to use AWARE in openLCA

Download the AWARE LCIA[4] and start openLCA. Right-click into the navigation window and select *New database → Empty database*. Unfold the new database in the navigation tab and navigate to *Indicators and parameters*. Right-click on *Impact assessment methods* and select *import → Linked Data (JSON-LD)*. Click on *next* and choose the directory in which you saved the AWARE LCIA and select the respective file.

[4] http://www.openlca.org/download/ (the corrected and improved country aggregation *AWARE_country_2.0* is also available for download on the WULCA website)

The AWARE LCIA contains the AWARE impact assessment method and country-specific polygons to calculate the aggregated characterisation factors (section3.2.2, p.6).

After importing AWARE into openLCA, a regionalised process must be created (Figure 4). The process should contain flows that use AWARE elementary flows.

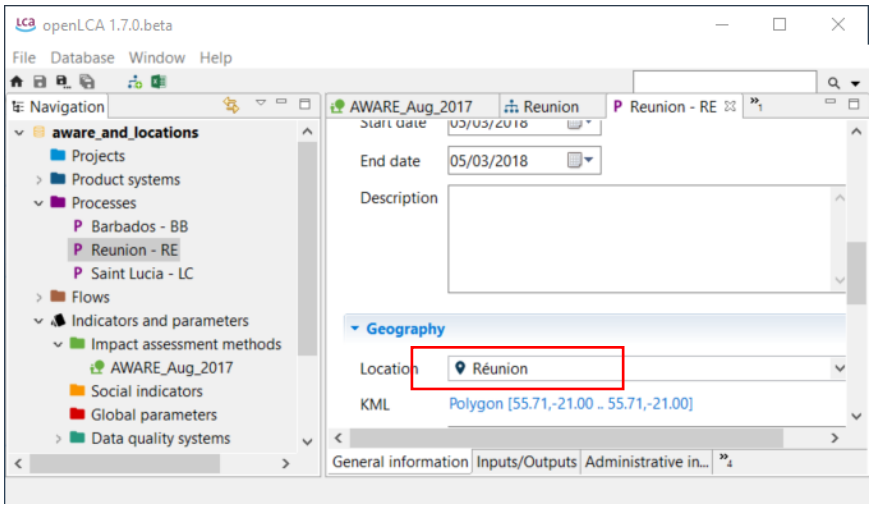

Figure 4: Specifying a process location in openLCA.

It is noteworthy that to exploit the full potential of regionalized LCA in openLCA, custom polygons can be drawn and imported (click on Polygon next to *KML*) under use of the openLCA KML editor (Figure 5).

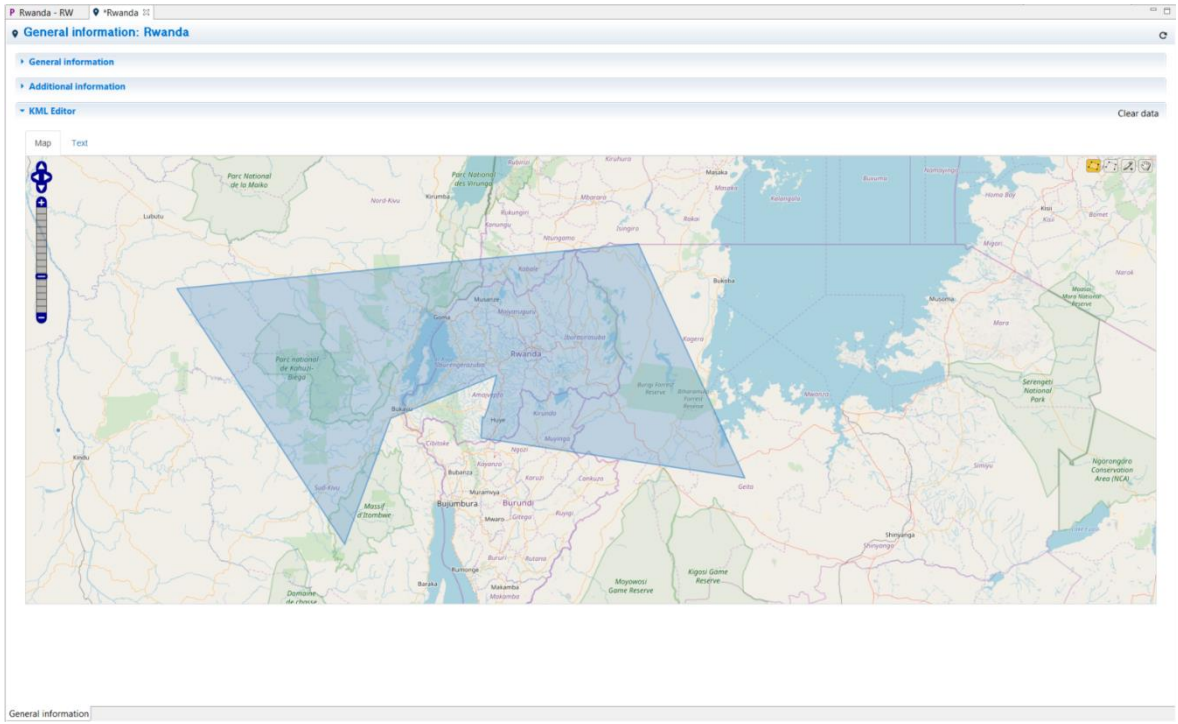

Figure 5: openLCA's KML editor allows drawing or import of custom polygons.

Then, a product system should be created for the process. Based on the product system, the impact can be calculated under use of the AWARE impact assessment method and *Regionalized LCIA* as the impact assessment method (Figure 6). Finally, navigate to the tab *Impact analysis* and unfold the water use subgroups to see the AWARE results.

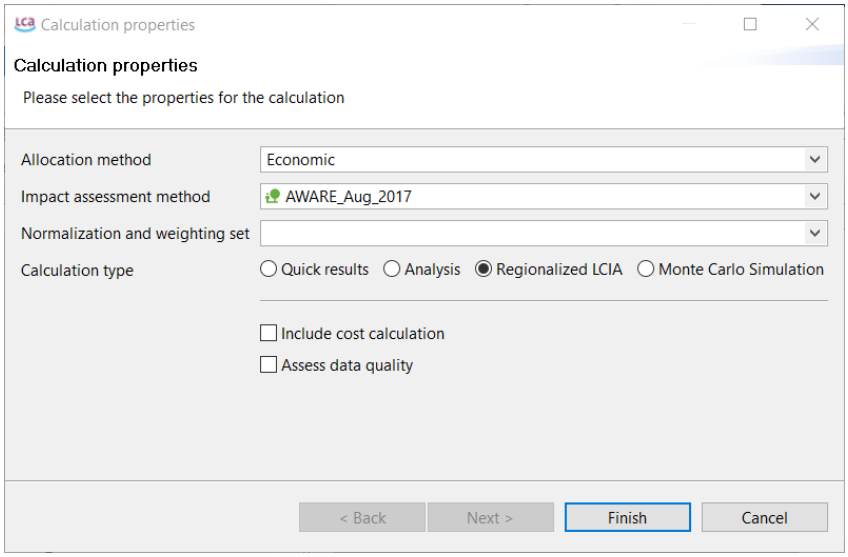

Figure 6: Applying the AWARE impact assessment method in openLCA.

3.3 Case study[5] ÞLK]ONYX rMY\\OMONA ? 6- +Å- 0]¼KZZV8ONSX YZOX6- +þ

An organic cotton production model was used to test AWARE in a full-scale application. A functional unit of 1 kg of seed cotton was adopted and the irrigation water was regionalised. The WF was calculate for Barbados, USA, Texas (US) and New Hampshire (US).

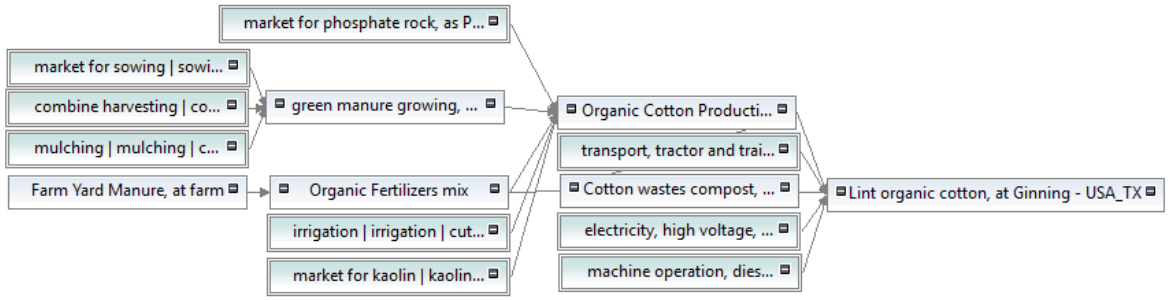

Figure 7: Graphic representation of the model in openLCA.

[5] Bizarro, D.E.G., and A. Ciroth. "Regionalized LCA in OpenLCA - AWARE Implementation." Poster presented at the ACLCA Conference Series, Portsmouth, 2017. https://www.greendelta.com/wp-content/uploads/2017/11/Implementing-AWARE-as-regionalized-LCIA-method-in-software-%E2%80%93-challenges-outcomes-findings_Bizarro_Ciroth_2017.pdf.

Table 3: Results of WF calculation for the organic cotton model, the resulting WF was calculated by multiplying the water usage from the foreground system by the aggregated CF and multiplying the water usage from the background system by standard CF values (on "corrected WULCA" CFs for AWARE, applied in openLCA**).**

Selected region	Inventory (irrigation)		aggCF (irrigation)	irrigation WF (m3 world eq.)	Inventory (m3)	Total WF (m3 world eq.)
BB	0.1286	m3	17.51102	2.251392106	0.15342	2.361
US	0.1286	m3	36.21656	4.656363667	0.15342	4.788
US-TX	0.1286	m3	19.07326	2.452249326	0.15342	2.570
US-NH	0.1286	m3	0.623	0.080099119	0.15342	0.181

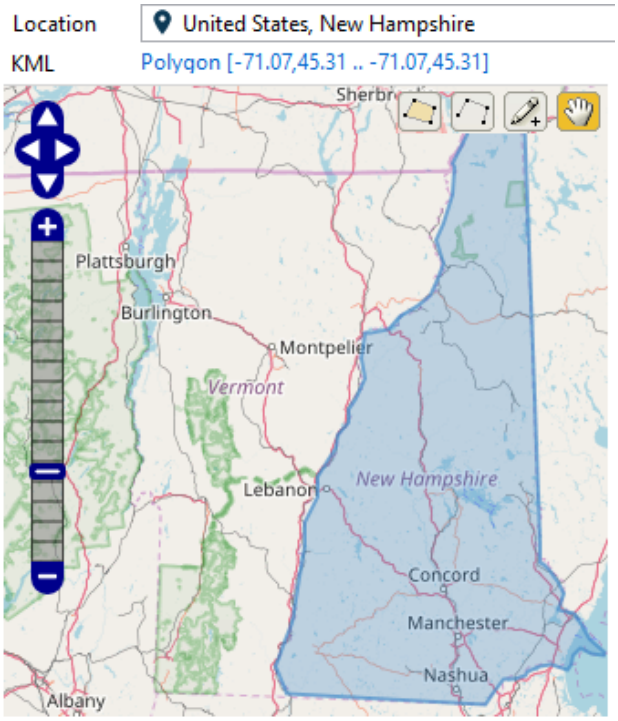

Figure 8: New Hampshire polygon used for the regionalization of irrigation water usage in openLCA KML editor.

AWARE normalized WF is the result in m^3 world eq. of the inventoried water times the CF. Thus, the case study shows that 0.1531 m^3 inventoried water is equivalent to the consumption of 0.152 m^3 in NH-USA and 4.257 m^3 in TX-USA due to the different water scarcity in those regions.

4 Conclusion & Outlook

This improved AWARE_Country_2.0 allows for a more representative country aggregation of the native AWARE CF compared to the country values originally calculated. It should be noted that the native CF (at the watershed scale, monthly or annual) remain unchanged and are still the ones to favour over a country-wide assessment (Jolliet et al, 2017)[6].

Additional regions and, possibly, input data with an even higher spatial resolution, would further enhance the results of AWARE.

We are currently creating factors for new locations for AWARE and look forward to publishing these shortly, in collaboration with the WULCA group.

Besides AWARE, other regionalised LCIA methods would allow more accurate impact assessments also regarding other impact categories.

The AWARE LCIA for openLCA can be downloaded via http://www.openlca.org/download/ (under *impact methods*). Use instructions are provided in section 3.2.6 of this document.

[6] with contributions of the other workshop participants, Olivier Jolliet, Rolf Frischknecht, Jane Bare, Anne-Marie Boulay, Cecile Bulle, Peter Fantke, et al. 2014. "Erratum to: Global Guidance on Environmental Life Cycle Impact Assessment Indicators: Findings of the Scoping Phase." *The International Journal of Life Cycle Assessment* 19 (8): 1566–1566. https://doi.org/10.1007/s11367-014-0763-9.

5 Feedback & Contact

If you have other questions not addressed by this document, or should you need further clarifications on any of the points commented, then please contact us:

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