LC-Impact method documentation

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openLCA

Content

1 New Impact Method – LC-Impact

LC-Impact is a global life cycle impact assessment methodology resulting from the outcomes of the FP7-funded project LC-IMPACT. The characterization is at **endpoint level** and it covers three main areas of protection: human health, ecosystem quality and resources.

The method provides detailed spatially differentiated impact data for select categories. This is a major benefit for those categories that have local and specific impact, such as land stress and water consumption. LC-Impact provides shapefiles with geospatial data at different resolutions (e.g. watershed-level, consisting of 11.000 units for "water stress – human health") for the specific calculation of characterisation factors based on territorial attributes.

The openLCA implementation of regionalized categories (see category details on chapter 3), natively contains continent and country-level characterization factors. Additionally, for this method only, **we provide regionalization setups in JSON format**: they are based on the shapefiles provided by LC-Impact, and include the flow-binding based on the openLCA implementation of the method. These setup files allow customisable calculation of characterization factors, enhancing the accuracy of the impact assessment (refer to Chapter 3.1 for further details).

Impact category	Reference unit	Area of protection
Climate change – human health	DALY/kg	Human health
Stratospheric Ozone Depletion	DALY/kg	Human health
Ionizing radiation	DALY/kgq	Human health
Photochemical ozone formation – human health	DALY/kg	Human health
Particulate matter formation	DALY/kg	Human health
Human toxicity – carcinogenic	DALY/kg	Human health
Human toxicity – non-carcinogenic	DALY/kg	Human health
Water consumption – human health (average approach)	DALY/kg	Human health
Water consumption – human health (marginal approach)	DALY/kg	Human health
Climate change – terrestrial ecosystems	PDF*y/kg	Ecosystem quality
Climate change – freshwater ecosystems	PDF*y/kg	Ecosystem quality
Photochemical ozone formation – terrestrial ecosystems	PDF*y/kg	Ecosystem quality
Terrestrial acidification	PDF*y/kg	Ecosystem quality
Freshwater eutrophication	PDF*y/kg	Ecosystem quality
Marine eutrophication	PDF*y/kg	Ecosystem quality
Freshwater ecotoxicity	PDF*m^3*d/kg	Ecosystem quality
Marine ecotoxicity	PDF*m^3*d/kg	Ecosystem quality
Terrestrial ecotoxicity	PDF*m^3*d/kg	Ecosystem quality
Land stress (average approach)	PDF-eq*y/m2*a (occupation flows) PDF-ep*y/m2 (transformation flows)	Ecosystem quality
Land stress (marginal approach)	PDF-eq*y/m2*a (occupation flows)	Ecosystem quality

	PDF-ep*y/m2 (transformation flows)	
Water consumption - ecosystems	PDF*y/m3	Ecosystem quality
Mineral resource extraction	Kg_{ore}/kg	Resources

The reference units are this intended:

- DALY: Disability Adjusted Life Years
- PDF*year: Potentially Disappeared Fraction of species during one year
- PDF*m^3*d: Potentially Disappeared Fraction of species in a cubic meter during one day
- $Kg_{ore:}$ extra average amount of ore produced as a result of mineral resource extraction

The method does not provide normalization/weighting sets.

LC-Impact provides four sets of characterization factors, based on the impact effect certainty and time horizon:

1. All impacts, short-term: short (100 years) time horizon and high level of certainty for impact of a specific intervention
2. All impacts, long-term: long time horizon and high level of certainty for impact of a specific intervention
3. Certain impacts, short-term: short (100 years) time horizon and low level of certainty for impact of a specific intervention
4. Certain impacts, long-term: long time horizon and low level of certainty for impact of a specific intervention.

Note: It is recommended to calculate results with all sets of CFS. The two extreme scenarios are recommended as a minimum in every study:

- Core (100 years, high robustness) – it corresponds to certain impacts, 100 years
- Extended (1000 years, low robustness) – it corresponds to all impacts, infinite

Linear/average vs. marginal calculation approach:

Effect factors can be calculated either with an average/linear or a marginal approach. The marginal approach considers the influence of raising the background concentration/pressure by an incremental amount, where the background concentration, or today's situation, is the reference state and what is quantified is the additional impact of a marginal change. With the average/linear approach, instead, is calculated the average effect change per unit of change, and the reference state is the current state. For the average approach the background level is known, while for the linear approach it is assumed to be 0.5 because the actual information on background pollution level is lacking.

The complete documentation for this LCIA Method can be found in the LC-Impact dedicated website.

2 openLCA implementation

The implementation in openLCA is based on LC-Impact version 1.3 and consists of **four different methods, one for every considered impacts/time horizon scenario:**

- LC-IMPACT – Certain Impacts, Short Term (100 years)
- LC-IMPACT – Certain Impacts, Long Term
- LC-IMPACT – All Impacts, Short Term (100 years)
- LC-IMPACT – All Impacts, Long Term

When both average/linear and marginal approach are available for the same impact category, they are provided differentiated (e.g. Land stress – marginal approach and Land stress – average approach).

Flow mapping:

In order to get LC-Impact working in openLCA environment (openLCA method pack, which LC-Impact if part of, is compatible with many databases on Nexus), we performed a mapping of the flows described in the method and the flows of openLCA reference data, then applied the characterisation factors (CFs) provided from the method documentation.

Below, details and characteristics of each impact category.

2.1 Climate change

Climate change category consists of three sub-categories, depending on the area of protection considered.

2.1.1 Climate change – human health

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
Both available	Both Available	Average	Not regionalized

2.1.2 Climate change – terrestrial ecosystems

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
Both available	Both available	Average	Not regionalized

2.1.3 Climate change – freshwater ecosystems

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
Both available	Only long-term available	Average	Not regionalized

2.2 Stratospheric Ozone Depletion

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
Both available	Both available	Linear	Not regionalized

2.3 Ionising Radiation

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
Both available	Both available	Linear	Not regionalized

2.4 Photochemical ozone formation

Photochemical ozone formation category consists of two sub-categories, depending on the area of protection considered.

2.4.1 Photochemical ozone formation – human health

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	No differentiation	Average	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus regionalization setups are provided for specific calculations, with a country-level spatial resolution.

2.4.2 Photochemical ozone formation – terrestrial ecosystems

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	No differentiation	Average	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus regionalization setups are provided for specific calculations, with a country-level spatial resolution.

2.5 Particulate matter formation

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
Certain impact CFs available only for PM 2.5	No differentiation	Linear	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus regionalization setups are provided for specific calculations, with a country-level spatial resolution.

2.6 Terrestrial acidification

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	No differentiation	Marginal	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus regionalization setups are provided for specific calculations (2° x 2.5° spatial resolution).

2.7 Freshwater eutrophication

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	No differentiation	Linear	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus regionalization setups are provided for specific calculations (0.5° x 0.5° spatial resolution).

2.8 Marine eutrophication

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	No differentiation	Linear	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus regionalization setups are provided for specific calculations (country to large marine ecosystems spatial resolution - 233 spatial units).

2.9 Human toxicity

Human toxicity category consists of three sub-categories, depending on the carcinogenicity of the impact factors.

2.9.1 Human toxicity – carcinogenic

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	Long-term impact CFs available for metals only	Linear	Not regionalized

2.9.2 Human toxicity – non-carcinogenic

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	Long-term impact CFs available for metals only	Linear	Not regionalized

2.10 Ecotoxicity

Ecotoxicity category consists of three sub-categories, depending on the area of protection considered.

2.10.1 Freshwater ecotoxicity

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	Long-term impact CFs available for metals only	Linear	Not regionalized

2.10.2 Marine ecotoxicity

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	Long-term impact CFs available for metals only	Linear	Not regionalized

2.10.3 Terrestrial ecotoxicity

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	Long-term impact CFs available for metals only	Linear	Not regionalized

2.11 Land Stress

Land stress category consists of two sub-categories, depending on the calculation method used to obtain the CFs.

2.11.1 Land stress (average approach)

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	No differentiation	Average	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus regionalization setups are provided for specific calculations (0.05° x 0.05° spatial resolution).

2.11.2 Land stress (marginal approach)

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	No differentiation	Marginal	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus we are working to provide regionalization setups for specific calculations (0.05° x 0.05° spatial resolution).

2.12 Water consumption

Water consumption category consists of three sub-categories, depending on the area of protection considered and, in case of human health area, on the calculation method used to obtain the CFs.

2.12.1 Water consumption – human health (average approach)

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	No differentiation	Average	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus regionalization setups are provided for specific calculations (watersheds-level spatial resolution - 11'000 units).

2.12.2 Water consumption – human health (marginal approach)

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	No differentiation	Average	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus regionalization setups are provided for specific calculations (watersheds-level spatial resolution - 11'000 units).

2.12.3 Water consumption – ecosystems

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
Both available	No differentiation	Marginal	Regionalized

Regionalization specifics: continental and country-level values are immediately available, plus we are working to provide regionalization setup for specific calculations (0.05° x 0.05° spatial resolution).

2.13 Mineral Resources Scarcity

Certain/all impacts	Long/short-term impact	Calculation method	Regionalization
No differentiation	No differentiation	Linear	Not regionalized

3 Get and use the method

LC-impact method is available on Nexus and the impact directions are set. To import it on openLCA follow the instruction on the openLCA manual at this link. For this method, you can also download the regionalization setups in JSON format.

Databases from Nexus that are compatible with this method include ecoinvent 3.6, 3.7, 3.7.1, 3.8, 3.9.1, 3.10 | Agribalyse 3.0, 3.01, 3.1 | Agrifootprint 5.0, 6.3 | OzLCI 2019.

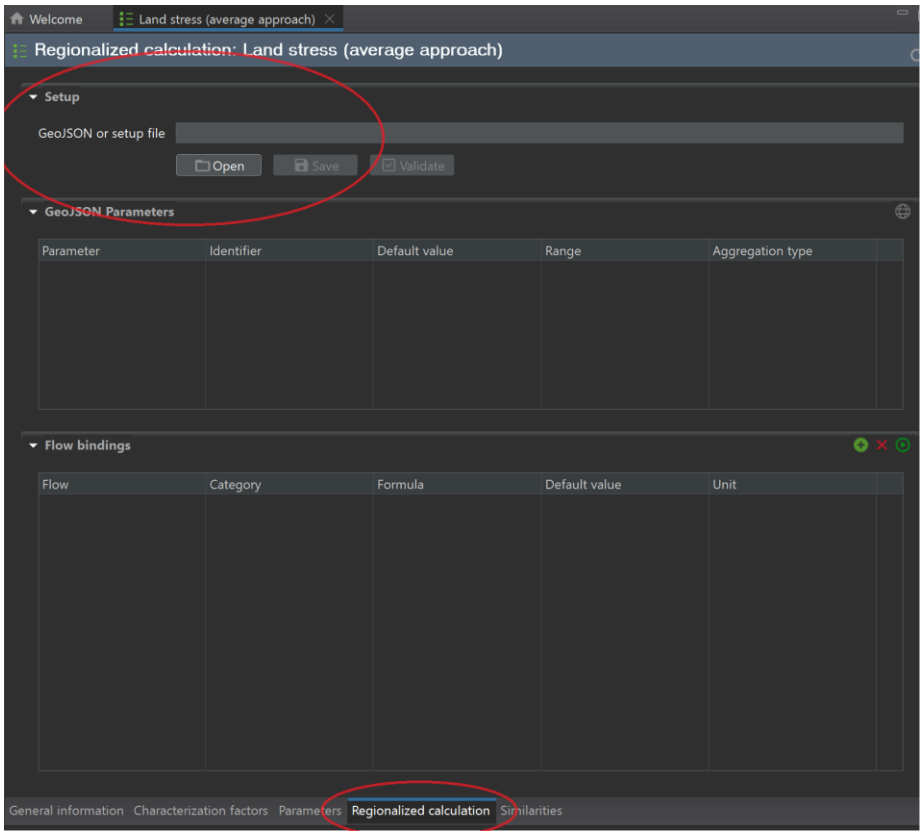
3.1 *NEW!* Regionalized calculations

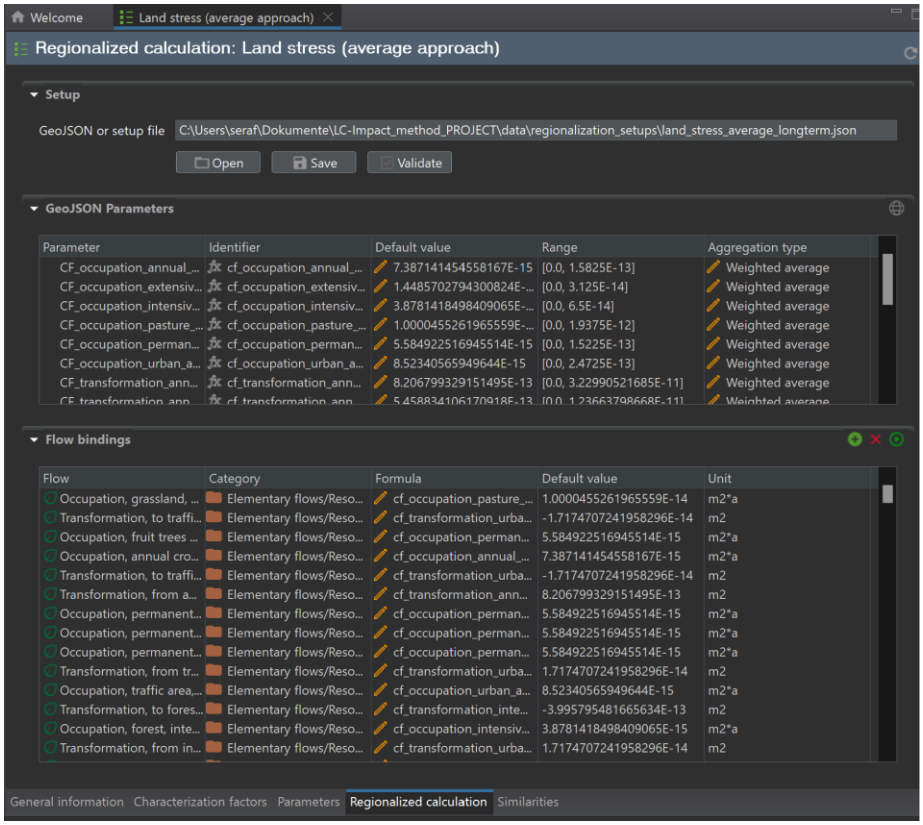
LC-Impact is a regionalized method, that means that can be used to perform regionalized impact assessment, accounting for specific conditions and characteristics of the location where the processes occur. Regional characteristics and information about geographic locations are contained in GeoJSON files that can be imported into

openLCA. For details, you can check the dedicated section of the openLCA manual (there you can see how to use a GeoJSON file in openLCA, and also how to work with locations, for example adding new ones to the database you are working with). In the case of LC-Impact, we already provide setup files on Nexus in GeoJSON format, where the flow binding has already been performed.

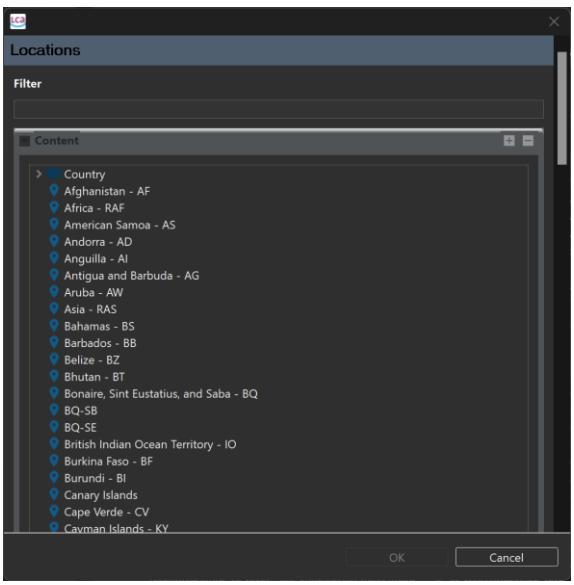
Note: regionalized calculation is an advanced form of impact calculation. It is more resource consuming that a normal impact calculation and it is needed to be handled carefully. We advise to allocate enough memory for the calculations, to perform it using a regionalized database, and to check that the locations of processes are the intended ones along the whole supply chain.

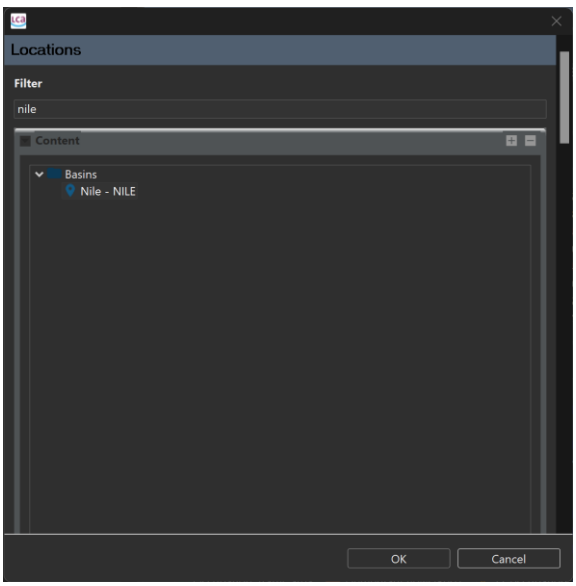
To use a setup file to calculate specific location, you can open the impact category you are interested in, go to the "Regionalized calculation" tab, and import a setup file in the "Setup" section, browsing in your computer:



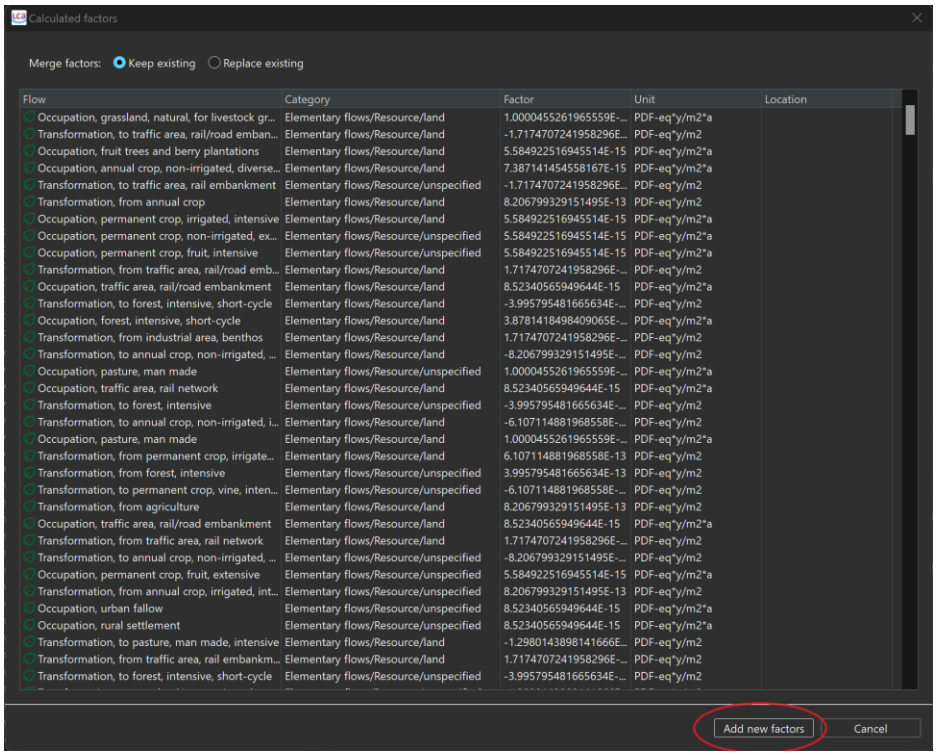


As you can see, the "Flow binding" section has already been set up, using the right formula to calculate specific CFs for every flow that is addressed by the impact category. Clicking on the play button on the right, a window will pop-up. Here you can choose a specific location for which you want to calculate the regionalized characterization factors. In this example, we want to calculate the land stress impact of a process happening in the Nile basin, therefore we need the CFs specific for the Nile location. Browse for the location you want to use, then click "OK":

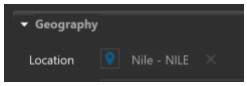




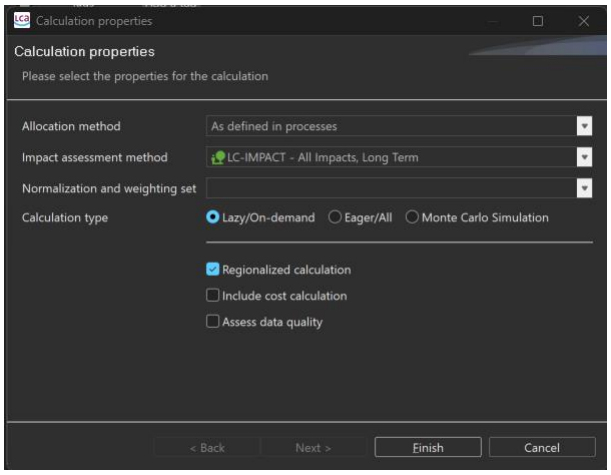
The software will calculate specific characterization factors for the impact factors of the impact category you are working with. Right know openLCA does not save the regionalization setup you imported, but the regionalized CFs can be permanently added to the impact category after the calculation, clicking on “Add new factors”:



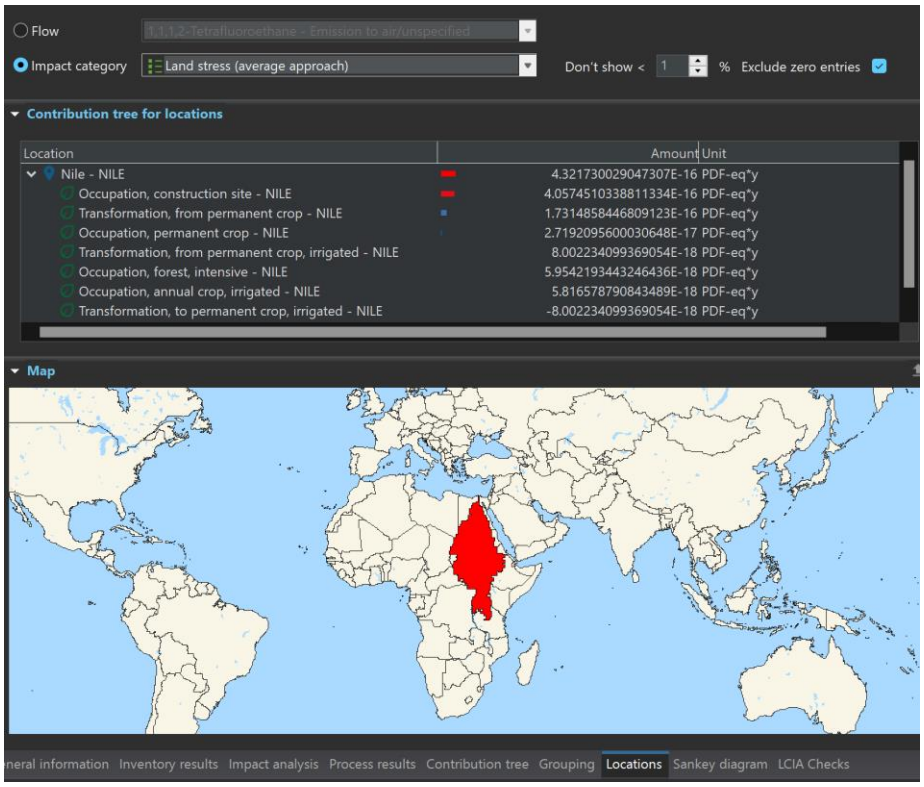
Now, make sure that the location of your process is set correctly and, if necessary, the locations of the entire supply chain (you can check this info in the general tab of each process):



Then, perform the calculations selecting the right method and checking “Regionalized calculation”:



On the “Locations” tab of the results, you can now see for each flow or impact category, where the impact is taking place:



4 Support

For any feedback, inquiry about LC-Impact implementation, or any question related to it, please contact us:

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Thank you!

GreenDelta

5 Resources

Verones, F., Hellweg, S., Azevedo, L. B., Laurent, A., Mutel, C. L., & Pfister, S. (2016). A spatially differentiated life cycle impact assessment approach. *LC-Impact Version 0.5 Report*.

Verones, F., Hellweg, S., Antón, A., Azevedo, L. B., Chaudhary, A., Cosme, N., ... & Huijbregts, M. A. (2020). LC-IMPACT: A regionalized life cycle damage assessment method. *Journal of Industrial Ecology*, *24*(6), 1201-1219.