Sphera® Managed LCA Content (MLC) Land Use LCI Modelling and Assessment 2024

Sphera Land Use LCI Modelling & Assessment (LANCA) 2024

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Introduction

About half of the global land area is heavily influenced by humans. Every day between 5,000 and 15,000 hectares of natural land are used worldwide for anthropogenic purposes (Hooke et al. 2012). In Germany, as example, about 77 hectares (more than 100 football fields) are sealed per day (Chemnitz and Weigelt 2015). Both the sealing of land by construction as well as its agricultural and forestry, infrastructural and industrial use lead to a change in the natural soil functions and thus the originally provided ecosystem services. When assessing processes caused by human activities, the impact of land use on soil functions should therefore be considered. Established methods and tools such as life cycle assessment, which holistically investigates the environmental impact of products, processes, or services, are in between expanded to include land use aspects.

LANCA®

At the University of Stuttgart, Institute for Acoustics and Building Physics, Department of Life Cycle Engineering, the method LANCA® (Land Use Indicator Value Calculation in Life Cycle Assessment) was developed and operationalized (Bos et al. 2016, Beck et al. 2010, Baitz 2002). Using this method, country specific and land use type specific characterization factors have been calculated for different land use related impact categories. With the update LANCA® v.2022.1, the following categories are considered:

1. Erosion resistance: The capacity of the natural environment to prevent erosion beyond the naturally occurring erosion.
2. Mechanical filtration: The ability of a soil to filter a suspension by mechanically binding pollutants to soil particles.
3. Physicochemical filtration: The ability of a soil to bind dissolved substances from the soil solution and thus prevent them from entering the groundwater.
4. Groundwater regeneration: The ability of a soil to contribute to groundwater recharge.
5. Soil organic carbon: The deviation of soil organic carbon under land use.
6. Biodiversity: The effects of land use on biological diversity.

Table 1 shows the impact categories with its respective characterization factors and category indicators for occupation and transformation.

Impact Category	Characterization Factor	Category Indicator Occupation	Category Indicator Transformation
Erosion Resistance	Erosion potential of each land use type in each country [kg_{soil}/(m²*a)]	Additional soil loss due to water erosion from land occupation [kg/m²]	Additional annual soil loss due to water erosion from land transformation [kg/(m²*a)]
Mechanical Filtration	Infiltration reduction potential of each land use type in each country [m³water/(m²*a)]	Additional infiltration reduction from land occupation [m³/m²]	Additional annual infiltration reduction from land transformation [m³/(m²*a)]
Physicochemical Filtration	Physicochemical filtration reduction potential of each land use type in each country [mol/m²]	Physicochemical filtration capacity loss from land occupation [mol*a/m²]	Annual physicochemical capacity filtration loss from land transformation [mol/m²]
Groundwater Regeneration	Groundwater regeneration reduction potential of each land use type in each country [m³groundwater/(m²*a)]	Additional groundwater regeneration loss from land occupation [m³/m²]	Additional annual groundwater regeneration loss from land transformation [m³/(m²*a)]
Soil Organic Carbon	Soil organic carbon loss potential of each land use type in each country [kg_{soil} organic carbon /(m²*a)]	Additional soil organic carbon loss from land occupation [kg/m²]	Additional soil organic carbon loss from land transformation [kg/(m²*a)]
Biodiversity	Potential biodiversity risk of each land use type in each country [PBR/(m²*a)]	Potential biodiversity risk from land occupation [PBR/ m²]	Potential biodiversity risk from land transformation [PBR/(m²*a)]

Table 1: Land use related impact categories and definitions

During the last 20 years, many approaches to integrate land use aspects into life cycle assessment have been developed and published. However, only the LANCA® method has been selected and recommended by the European Commission to be used under its Environmental Footprint (EF) (also PEF/OEF, Product Environmental Footprint / Organization Environmental Footprint) initiative. LANCA® is therefore considered internationally accepted and recognized. It is therefore recommended to be used for land use impact assessment in LCA for Experts software and served by the inventory data in all Sphera Managed LCA Content.

LANCA® in LCA for Experts

Sphera's LCA for Experts software and Managed LCA content have integrated the EF elementary flows for land use (e.g., *arable, intensive* or *forest, natural*) and provides characterization factors for the LANCA® indicators in the impact assessment for more than 60 countries. A comprehensive overview of the LANCA® method and the characterization factors can be found here:

- https://www.bookshop.fraunhofer.de/buch/LANCA/244600 and;
- https://www.bookshop.fraunhofer.de/buch/234460

A distinction is made between land occupation and land transformation. For this purpose, the flows "Occupation" [m² * a], "Transformation from" [m²] and "Transformation to" [m²] are used specifically for country and land use type in the inventory and are then characterized in the impact assessment. Occupation describes the land quality difference between the actual land use and a reference situation. For example, the land use quality difference between a mineral extraction site and forest, primary. Transformation means the (semi-)permanent changes in land quality due to a certain land use regarding the situation before the actual land use takes place and after a regeneration time. If, for example, the studied land was pasture/meadow before, then a mineral extraction site and after a regeneration phase it is shrub land. The Transformation impact is the quality difference between the land quality of the shrub land and the pasture/meadow. If the land quality is higher after the regeneration of the used land, the impact is negative, that means it poses a benefit for the environment.

Since the integration of the characterization factors V2.5 (Horn and Maier 2018) in LCA FE with the release 2020, SP 40, all relevant reference situations per country are used to calculate the characterization factors (CF). The respective reference situations are derived from Olson et al. 2001. This is described in De Laurentiis et al. 2019. For country specific CFs for agricultural and forest-related land uses, types CFs are calculated without using the reference land use types "boreal tundra woodland", "polar", "subtropical desert", "temperate desert" and "tropical desert". The reason for this is the assumption that agriculture and forestry cannot be carried out on these five types of land use.

The most recent implemented version that has been released now with CUP 2023.1 is LANCA® V2022.1. As improvement to LANCA® V2.5, the net primary production indicator was replaced by soil organic carbon (De Laurentiis et al., submitted), and a new indicator on biodiversity (based on Maier 2023) was added.

CFs are regularly updated and can be found here; they are integrated and updated by Sphera also in the MLC Databases: http://publica.fraunhofer.de/documents/N-379310.html.

In the foreground system, the user enters the inventory information using the specific land use flows presenting the land use types and respective areas that are occupied and transformed for a given process in [m²*a] and [m²].

For the following process groups land use inventory information has been implemented on a country specific, regionalized level in the background processes:

- Agricultural processes
- Forest processes
- Open pit mining processes (incl. bauxite, copper, ore, sand, gravel etc.)
- Hard coal
- Lignite

The respective occupied and transformed areas for the land use processes are depending on the yields and growth rates for the respective agrarian and forestry processes.

For lignite and hard coal productivity information [m²/kg lignite] and [m²/kg hard coal] is taken from Weyer 2001, for bauxite the information is derived from Mori and Adelhardt 1998.

The productivity for all other mining products is taken from BGR 2016, BGR 2017, Rio Tinto 2006, Rio Tinto 2008, Xstrata 2005, Xstrata 2007. The respective ore content is taken in consideration when calculating the land use value in [m²/kg mining product] for the inventory flows.

For the foreground system, site specific land use indicators can be calculated by our partner at Fraunhofer Institute for Building Physics IBP, department GaBi. Please contact Rafael.Horn@ibp.fraunhofer.de.

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