Sphera® GaBi Document for Land Use Inventory in GaBi 2022

Documentation for Land Use Inventory in GaBi 2022

February 23, 2022

Customer Care

For assistance or inquiries regarding GaBi, contact Customer Care:

- Visit the Sphera Customer Network (SCN) at SCN.Spherasolutions.com. To access frequently asked questions and to report any issues using the SCN, you must request a user name and password.
- Send an email to customercare@sphera.com

Table of Contents

Land use in life cycle assessment

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, 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, needs to be 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 the following land use related impact categories:

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 to the groundwater.
4. Groundwater regeneration: The ability of a soil to contribute to groundwater recharge.
5. Biotic production: The ability of an ecosystem to produce biomass.

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 [$kg_{soil}/(m^2*a)$]	Additional soil loss due to water erosion from land occupation [kg/m^2]	Additional annual soil loss due to water erosion from land transformation [$kg/(m^2*a)$]
Mechanical Filtration	Infiltration reduction potential of each land use type in each country [$m^3_{water}/(m^2*a)$]	Additional infiltration reduction from land occupation [m^3/m^2]	Additional annual infiltration reduction from land transformation [$m^3/(m^2*a)$]
Physicochemical Filtration	Physicochemical filtration reduction potential of each land use type in each country [mol/m^2]	Physicochemical filtration capacity loss from land occupation [$mol*a/m^2$]	Annual physicochemical capacity filtration loss from land transformation [mol/m^2]
Groundwater Regeneration	Groundwater regeneration reduction potential of each land use type in each country [$m^3_{groundwater}/(m^2*a)$]	Additional groundwater regeneration loss from land occupation [m^3/m^2]	Additional annual groundwater regeneration loss from land transformation [$m^3/(m^2*a)$]
Biotic Production	Biotic production loss potential of each land use type in each country [$kg_{biotic\ production}/(m^2*a)$]	Additional biotic production loss from land occupation [kg/m^2]	Additional biotic production loss from land transformation [$kg/(m^2*a)$]

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 PEF/OEF (Product Environmental Footprint / Organisation Environmental Footprint) initiative. LANCA® is therefore considered internationally accepted and recognized. It is therefore recommended to be used for land use impact assessment in GaBi.

LANCA® in GaBi

The GaBi software and database system has 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 GaBi coming 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.

CFs are regularly updated and can be found here; they are integrated and updated by Sphera also in the GaBi 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 Matthias.Fischer@ibp.fraunhofer.de.

Literature

Baitz 2002	Baitz, M. (2002): Die Bedeutung der funktionsbasierten Charakterisierung von Flächen-Inanspruchnahmen in industriellen Prozesskettenanalysen. Ein Beitrag zur ganzheitlichen Bilanzierung. Dissertation. Shaker (Berichte aus der Umwelttechnik), Aachen.
Beck et al. 2010	Beck, T. et al. (2010): LANCA® – Calculation of Land Use Indicator Values in Life Cycle Assessment, Fraunhofer Verlag, Stuttgart.
BGR 2016	Bundesanstalt für Geowissenschaften und Rohstoffe (Hg.) (2016): Deutschland – Rohstoffsituation 2015, ISBN: 978-3-943566-78-9 (Druckversion) 978-3-943566-79-6 (PDF).
BGR 2017	Bundesanstalt für Geowissenschaften und Rohstoffe (Hg.) (2017): Deutschland – Rohstoffsituation 2016, ISBN: 978-3-943566-42-0 (Druckversion) 978-3-943566-43-7 (PDF).
Bos et Al. 2016	Bos, U. et al. (2016): LANCA® Characterization Factors for Life Cycle Impact Assessment Version 2.0, Fraunhofer Verlag, Stuttgart.
Chemnitz and Weigelt 2015	Chemnitz, C. and Weigelt, J. (2015): Bodenatlas. Daten und Fakten über Acker, Land und Erde.
De Laurentiis et al. 2019	De Laurentiis, V., Secchi, M., Bos, U., Horn, R., Laurent, A., Sala, S. (2019): Soil quality index: exploring options for a comprehensive assessment of land use impacts in LCA. Journal of Cleaner Production, Volume 215.
Hooke et al. 2012	Hooke, R. L.; Martín-Duque, J. F.; Pedraza, J. (2012): Land transformation by humans: A review. GSA Today, 22(2), 4-10, ISSN 10525173.
Horn and Maier 2018	Horn, R., Maier, S. (2018): Updated Characterization Factors (Version 2.5), https://www.bookshop.fraunhofer.de/buch/LANCA/244600.
Mori and Adelhardt 1998	Mori, G.; Adelhardt, W. (1998): Stoffmengenflüsse und Energiebedarf bei der Gewinnung ausgewählter mineralischer Rohstoffe. Teilstudie Aluminium. Geoökologisches Jahrbuch, H. Reihe H, Heft SH2.
Olson et al. 2001	Olson et al. (2001): Terrestrial Ecoregions of the World: A New Map of Life on Earth: BioScience, 51(11), 933-938.
Rio Tinto 2006	Rio Tinto Iron Ore (2006): Pilbara Operations Sustainable Development Summary report 20006. More value with less impact.
Rio Tinto 2008	Rio Tinto Iron Ore (2008): Rio Tinto Iron Ore Information.

Weyer 2001 — Weyer, T. (2001): Abschlußbericht der Untersuchung über Flächeninanspruchnahmen durch Aktivitäten des Steinkohlenbergbaus. Institut für Bergbaukunde 1 der Rheinisch-Westfälischen Technischen Hochschule Aachen.

Xstrata 2005 — Xstrata (Hg.) (2005): 2005 Group and Commodity Business Sustainability Data Summary Sheet.

Xstrata 2007 — Xstrata (Hg.) (2007): Xstrata Annual Report 2004. Operating Review – Copper.