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Agri-footprint 6 Methodology Report

Part 1: Methodology and basic principles
Version 3



Blonk
SUSTAINABILITY TOOLS

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About us

Agri-footprint is a high-quality, comprehensive life cycle inventory (LCI) database focused on the agriculture and food sector. It covers data on agricultural products: food, feed, and agricultural intermediate products. Since its conception in 2014, Agri-footprint has been critically reviewed and is now widely accepted by the food industry, LCA community, scientific community, and governmental institutions.

Blonk is a leading international expert in food system sustainability, inspiring and enabling the agri-food sector to give shape to sustainability. Blonk's purpose is to create a sustainable and healthy planet for current and future generations. We support organizations in understanding their environmental impact in the agri-food value chain by offering advice and developing tailored software tools based on the latest scientific developments and data.

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Part 1: Methodology and basic principles

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1. Introduction

The Agri-footprint database is a relevant source of LCA information from agricultural production and processing of commodities for a wide range of different users. Since the first release in 2014 the database has been expanded and updated 5 times to arrive at the current Agri-footprint 6 version. Now, Agri-footprint has become the core database to be used in footprinting reports and footprint declarations for several industrial sectors. It is particularly of interest for the feed sector since it's the source database for the Global Feed Lifecycle Institute (GFLI) database, the European Commission EF feed databases, and therefore for all animal sectors that want to generate compliant footprinting studies.

Agri-footprint aims to be compliant to the most widely-used methodology standards for agricultural and food LCA and footprinting by connecting to data from leading statistical institutes (such as FAO and Eurostat), industry publications, and scientific literature. For agricultural modelling the product environmental footprint calculation rules are followed as published in the latest PEF guidelines, (EU) 2021/2279 “Commission Recommendation of 15 December 2021 on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations.”

Agri-footprint is available as a library within SimaPro and for purchase on the Blonk Tools Portal and openLCA Nexus. It is expected that Agri-footprint users have a basic understanding of life cycle assessment concepts. Blonk can also provide bespoke training sessions to build capacity in other organizations at request. General information, FAQ, Update Logs, Issue Trackers, and reports are publicly available on www.agri-footprint.com. Agri-footprint users can also ask questions via this website or by sending inquiries to tools@blonksustainability.nl.

Agri-footprint is published by Agri-footprint B.V., which is an affiliate of Blonk Sustainability. More information on Blonk and Agri-footprint can be found at <https://blonksustainability.nl> and www.blonksustainability.nl/agri-footprint.

This document contains background information on the methodology, calculation rules and data that are used for the development of the data published in the Agri-footprint database. It will be updated whenever new or updated data is included in a new release of Agri-footprint.

Part 1 of the Agri-footprint methodology describes the main methodological principles for the setup, development, and maintenance of the Agri-footprint data. In Part 2, more detailed information is given on the specific methodological assumptions and data used for developing the different datasets.

2. Using the Agri-footprint data

2.1 Target users

The Agri-footprint database is useful for all parties that want to study and report on the LCA impact of products and services originating from agriculture and fisheries. This can be:

- LCA researchers and consultants, government research organizations, academia
- Operators that conduct product or company footprints, research and development
- Service providers (e.g. software developers) that develop tools for footprinting-related decision support
- Database developers that provide secondary data for certain related industries

For all use cases there are specific License Agreements. The three main license types are the Research License, Commercial License, and Developer License. More information on the license offering can be found at www.blonksustainability.nl/agri-footprint.

The Agri-footprint database contains agriculture crop data, data from fisheries, data on animal production systems, and data on products processed to commodities and ingredients. Therefore, typical users are in the agricultural industry where products are composed from multiple ingredients to a product.

2.2 Intended use

Agri-footprint aims to support both type A (“Micro-level decision support”) and C (“Accounting”) applications, including interactions with other systems (C1) as well as isolated systems (C2), as described in the ILCD guidelines (JRC-IES & European Commission, 2010). Agri-footprint is based on an attributional approach. This means that the results give an impression of the environmental impact of a product in the current situation. Agri-footprint does not aim to support type B (“Meso/macro-level decision support”), where LCI modelling exclusively refers to those processes that are affected by large-scale consequences. The processes in Agri-footprint are not modelled in a consequential way.

Agri-footprint can be used as a secondary data source to support comparisons or comparative assertions across systems (e.g. products). In case an LCA should be used to make public claims, it is the responsibility of the practitioner to ensure ISO 14040:2006/14044:2006 compliance (through an ISO review of the study). This document provides all relevant information to facilitate this process, through transparent documentation of methodological choices and through description of data sources and modelling (see Agri-footprint 6 - Part 2 – Description of data). In some comparative LCA cases, a consequential approach may be more appropriate. In that case, the user may need to modify the LCIs to accurately reflect marginal effects.

More specifically, potential applications of Agri-footprint may be:

- The identification of key environmental performance indicators of a product group
- Hotspot analysis of a specific agricultural product.
- Benchmarking of specific products against a product group average.
- To provide policy information for identifying product groups with the largest environmental impact in a certain context.
- Carbon footprints and other partial footprints
- Environmental product declarations (EPD)

Agri-footprint may also support other applications; however additional modelling (or modification of datasets) will be required:

- Strategic decision-making through forecasting and analysis of the environmental impact of raw material strategies and identification of product groups or raw materials with the largest environmental improvement potential
- Detailed product design of food products, in which the data from Agri-footprint can be used as a starting point which can be partially replaced by primary or more specific data where needed
- The development of life cycle-based Eco label criteria, but does not provide Eco label criteria directly
- Agri-footprint can be referred to as a prescribed secondary data source to be used in life cycle based environmental declarations of specific (food) products under the Product Environmental Footprint (PEF) framework, or in Product Category Rules (PCRs).

Agri-footprint is not intended to be used:

- As the only source for green public or private procurement, as Agri-footprint does not (yet) provide sufficient data on supplier or brand-specific products (although this may change in the future, as incorporation of supplier specific data is desired).
- Agri-footprint is not intended for corporate or site-specific environmental reporting or environmental certification of specific life cycles, although Agri-footprint may be used as a source for background data.

Agri-footprint provides LCI datasets which were modelled on the unit process level using models and data that were developed by Blonk. The database is available in three versions: Impact Result Level, System Process Level, and Unit Process Level. Agri-footprint unit processes are linked so that detailed, interconnected, LCI models can be applied directly as input into LCAs.

Agri-footprint uses some background data from other databases such as ecoinvent. A list of these datasets is provided in the data report (Agri-footprint 6 - Part 2 – Description of data).

3. Methodology and scope

3.1 Life Cycle Assessment (LCA) framework for agriculture

Life cycle assessment (LCA) is a methodological framework for assessing the environmental impacts that can be related to the production and use of a product or service. Examples of environmental impacts are climate change, toxicological stress on human health and ecosystems, depletion of resources, water use, and land use.

There are several LCA protocols and guidelines, such as the ISO standards, for practitioners that give directions on how to conduct an LCA.

Important LCA standards and handbooks that were used as a basis for the LCIs in Agri-footprint are:

- The ISO 14040/44 series (ISO 14040, 2006; ISO 14044, 2006, 2020)
- Product Environmental Footprint (PEF) methodology (EU 2021/2279 Commission Recommendation of 15 December 2021 on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations)
- Several Product Environmental Footprint Category Rules PEFCRs such as feed, dairy and pet-food (European Commission, 2018a)

The ISO 14040 series (ISO 14040, 2006) describe the basic requirements for performing an LCA study. This includes, among other things, directions on how to define the functional unit of a product, how to determine which processes need to be included or excluded, and how to deal with co-production situations where elementary flows need to be allocated to the different products. However, the ISO standards can still lead to different methodological decisions, depending on the LCA practitioner's interpretation. This means that applying the ISO standards may still result in different approaches and different quantitative results.

That's why the more specific methodologies as defined in the PEF framework are relevant. They define more in detail how to model emissions in agriculture and other aspects such as system boundaries and allocation. Agri-footprint aligns to these specific requirements.

3.2 Included processes

Agri-footprint contains LCIs of animal and plant agricultural production, fisheries and derived processed products. Furthermore, it contains datasets for transport, energy production, packaging and some chemicals that are used to produce these products. These unit processes are linked in Agri-footprint to produce commonly used agricultural commodities. The system boundaries are from cradle to the exit gate of the plant-based or animal-based food commodity as shown in the figures of Section 3.6 System Boundaries. Retail, preparation by the consumer, and waste treatment after use are not incorporated in Agri-footprint. Consumer and distribution packaging is not included in Agri-footprint, apart from pesticide packaging. However, for several commodities and regions Agri-footprint provides market mixes based on production and import statistics (see Agri-footprint 6 - Part 2 – Description of data).

The processes in Agri-footprint reflect an average performance for a defined region, for instance wheat cultivation in the Netherlands, or crushing of soybeans in the United States. The data description section of the report (Agri-footprint 6 - Part 2 – Description of Data) gives more detail on how the data is generated.

3.3 Consistency of methods, assumptions, and data

The data in Agri-footprint are derived from different sources. The LCIs for the animal production systems, transport, auxiliary materials, fertilizers, etc. have been developed based on own work of Blonk Sustainability. In these studies, data were collected mainly from the public domain (scientific literature, FAOstat, Eurostat, etc.) or from public or confidential research initiated by the industry and conducted by Blonk Sustainability. Where possible, the data have been reviewed by industry experts. Data gaps were filled with estimates, which were

based on industry expert opinions as much as possible. The assumptions are documented in Part 2 and clearly identified in the database.

3.4 Function, functional unit, and reference flow

Products can fulfill different functions, which depend on the context in which they are used. It is therefore not possible to define a complete functional unit for every product in the database. Rather, reference flows can be defined which can fulfill different functions in different contexts. To allow for maximum modelling flexibility, multiple properties of the reference flow are provided in the database. For example, the main reference flow for crop cultivation is 1 kg of crop, but the dry matter and energy content are given as additional properties. The general principle used in Agri-footprint is that the reference flows of products reflect 'physical' flows as accurately as possible, i.e. reference flows are expressed in kg product "as traded"; thus including moisture, formulation agents etc., with product properties listed separately in the process name and/or comment fields.

3.5 Multi-functional processes

According to the ISO14044:2006 standard (ISO 14044, 2006), allocation should be avoided whenever possible by dividing the unit multi-output process into two or more sub-processes and collecting the inventory data related to these sub-processes separately. In practice this is however not possible and therefore allocation keys are used to divide impact of the process and precursor processes in the supply chain over the co-products. Agri-footprint provides three types of allocation: *mass allocation*, *energy allocation* and *economic allocation*.

1. **Mass allocation:** For the crops and the processing of the crops, mass allocation is based on the mass of the dry matter of the products. For the animal products, mass allocation is based on the mass as traded.
2. **Gross energy allocation:** Water has a gross energy of 0 MJ/kg. The gross energy for protein, fat and carbohydrates are respectively: 23.6, 39.3 and 17.4 MJ/kg which are based on (USDA, 1973). Nutritional properties for gross energy calculations of products are based on a nutritional feed material list (Centraal veevoederbureau, 2010). For the other products, the references to the gross energy are given in the chapters on these products in in 'Agri-footprint 6 - Part 2 – Description of Data'.
3. **Economic allocation:** For the crops and the processing of the crops the economic value of the products is largely based on (Vellinga et al., 2013). For the other products, the references to the economic value are given in the chapters on these products in 'Agri-footprint 6 - Part 2 – Description of data'.

Allocation is applied without the use of cut-offs for so-called residual product streams whenever possible. There are four exceptions to this allocation rule:

- Citrus pulp
- Brewer's grains, wet
- Animal manure
- Offal, from fishery

These exceptions are according to the recommendations of the FAO LEAP (Livestock Environmental Assessment and Performance Partnership) guidelines for feed and animal systems. Citrus pulp, wet brewer's grain and manure do not include any inputs from previous life cycle stages. Dried citrus pulp only includes the energy required for drying.

Animal manure is considered a residual product of the animal production systems and does not receive part of the emissions of the animal production system¹ when animal manure is applied.

Products are considered residual when they have the following characteristics:

- Former food product for feed
- Marginal revenue share
- Production volume is independent of the demand for the rest-product

¹ The animal production systems are single farming systems and not mixed farming systems.

- Often products with limited shelflife, e.g. wet materials

3.6 System boundaries

Agri-footprint includes the interventions between technosphere and ecosphere that occur during normal operation (thus excluding accidents, spills, and other unforeseeable incidents). For agricultural soil which is partly technosphere and partly ecosphere Agri-footprint follows the definitions of the PEF impact models used for modelling ecotoxicity and eutrophication.

The LCI data is 'cradle-to-gate', where the gate is dependent on the process analysed. No data on distribution to retail, retail, consumer use or end-of-life (after the use phase) are provided (but treatment of waste generated during processing is included). All processes that are relevant for analysis on an attributional basis are included. Any omission or deviation is documented in the documentation of the specific process.

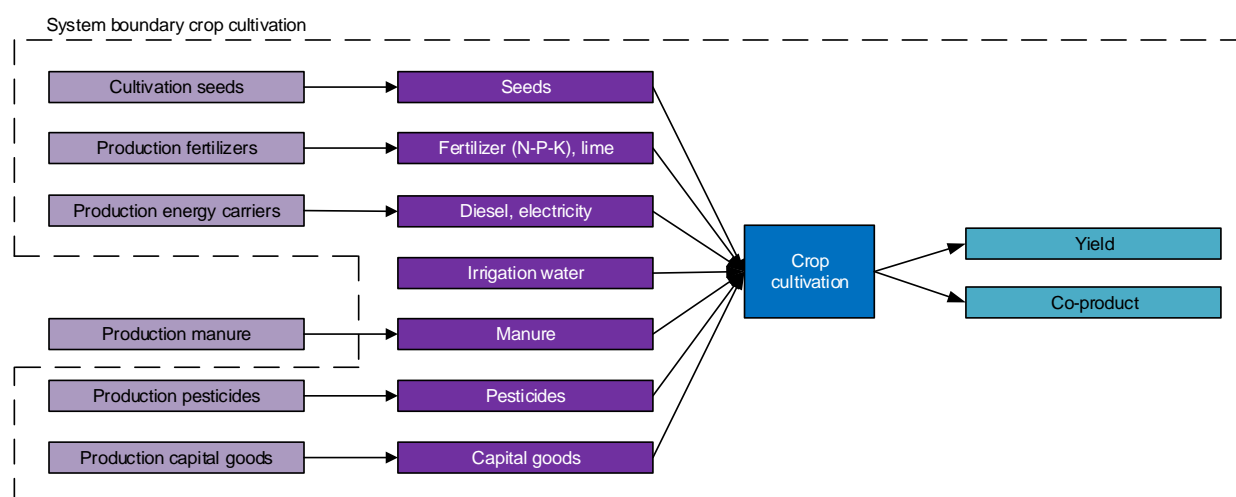


FIGURE 3-1: SYSTEM BOUNDARY FOR CROP CULTIVATION.

Crop cultivation (Figure 3-1) is modelled on the country-level (with country specific crop yields, fertilizer composition and application rates and energy use). Carbon storage in crops for feed, animals and milk are not included in Agri-footprint because this carbon is part of the short-term carbon cycle. Because of this, the carbon dioxide emissions at the end of the life cycle (e.g. emitted during fermentation or digestion) should not be modelled as a CO₂ emission contributing to climate change except when the stored carbon is released as methane due to, for instance, enteric fermentation or manure management and storage, which is inventoried as 'methane, biogenic'. After cultivation some crops undergo a country-specific processing stage (e.g. crushing of palm fruit bunches), see Figure 3-2.

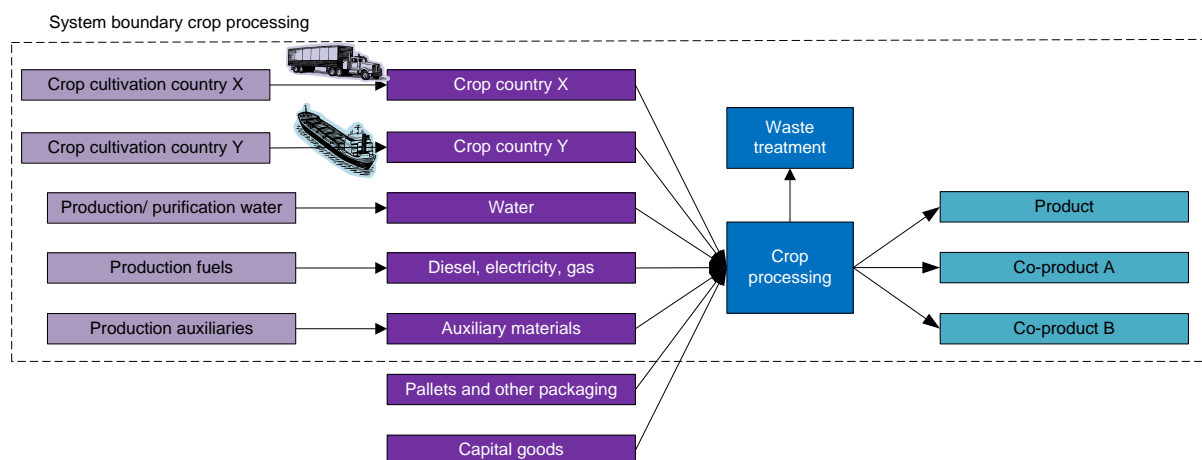


FIGURE 3-2: SYSTEM BOUNDARY FOR CROP PROCESSING.

Production of fuels, auxiliaries, and transport of crops and materials to the crop processing site are included. Intermediate packaging and capital goods are excluded from the system boundaries. The partially processed

product may then be exported to another country for further processing or be processed further domestically (e.g. palm oil refining). After this second processing step, country-specific crop product mixes may flow into various feed ration mixes (e.g. cattle feed compound). The feeds are an input for the animal husbandry, see Figure 3-3.

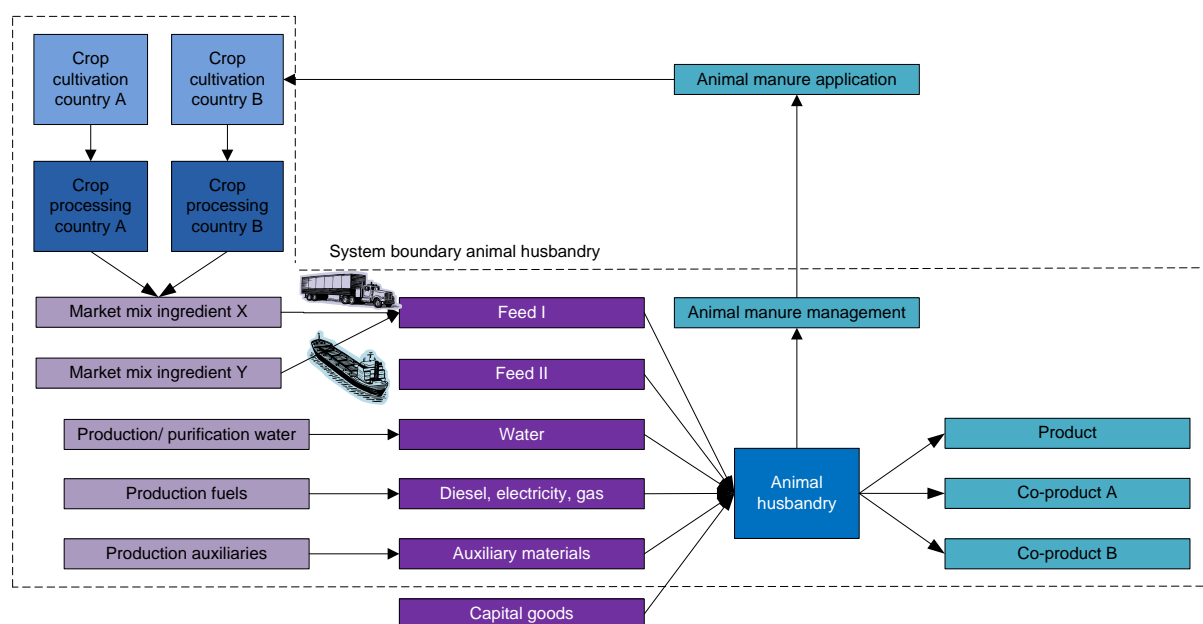


FIGURE 3-3: SYSTEM BOUNDARIES FOR ANIMAL HUSBANDRY.

In Agri-footprint market mixes are derived for many feed materials that are used for the compound feeds fed to chicken, pigs and cattle. Emissions due to the management of manure on the farm are included within the system boundaries, but the emissions due to application of manure are attributed to the crop cultivation stage. This is not done via a loop, but when a crop is cultivated using manure this is modelled within the crop cultivation itself, not taking into account any emissions from the animal husbandry. So, the manure is treated via a cut-off. Emissions due to animal manure transport to the field are 100% allocated to crop cultivation.

Plant and animal products can be further processed into food ingredients, see Figure 3-4. For food ingredients that originate from processing of crops, the system boundary is drawn after the processing into 'generic' ingredients (e.g. into starch, sugar, vegetable oil etc.). These products are often processed further into food products (e.g. bread, soft drinks). This further processing is not included in Agri-footprint.

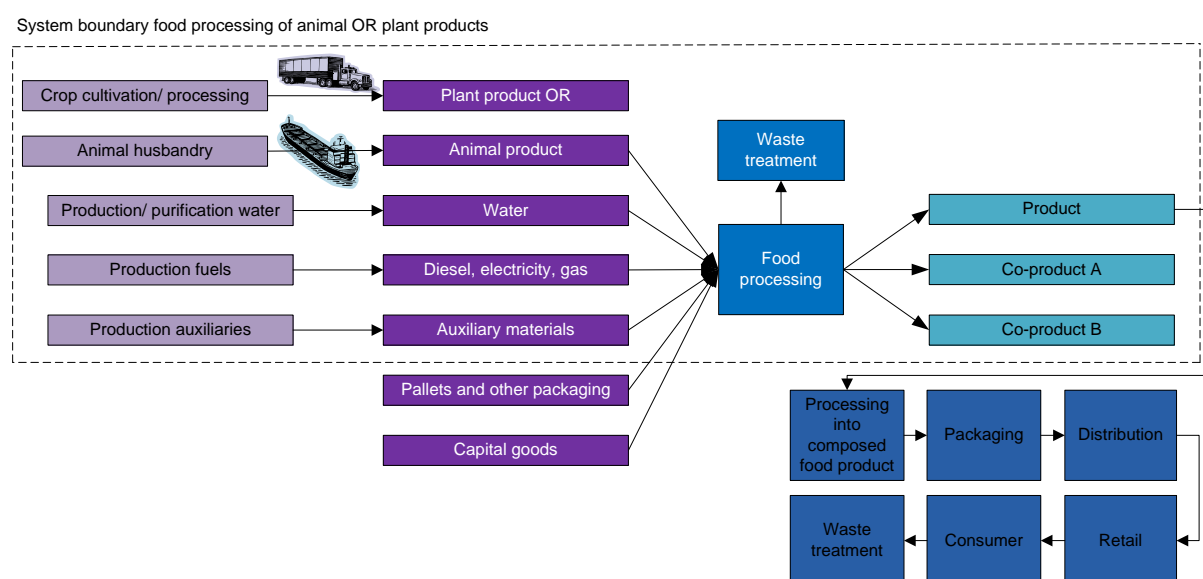


FIGURE 3-4: SYSTEM BOUNDARIES FOR FOOD PROCESSING.

For meat, for instance, the processing to fresh product means that the animal is slaughtered and fresh meat is produced, but further processing into specific meat products and packaging for retail is not included. Agri-footprint excludes packaging, distribution, retail, consumer handling and waste treatment of the final product.

Some processes may be excluded from the system, because there is only a remote relation to the most important processes in the lifecycle of the product. A key consideration here is the use of capital goods (e.g. tractors, barns, farmstead, processing plants, mills, trucks, ships). The energy and materials production in the supply chain of capital goods often make a negligible (not substantial or significant) contribution to the LCA results and have not been incorporated into Agri-footprint.

3.7 Cut-off

The cut-off criteria for the inclusion of inputs and outputs were based on mass and/or energy consumption. It is estimated that elementary flows representing not more than 2% of the cumulative mass and energy flows were omitted.

3.8 Basis for impact assessment

The LCIA methods ReCiPe 2016 v1.1 (M. Huijbregts et al., 2016) and the (SimaPro adapted) EF method were taken into account when developing Agri-footprint, but Agri-footprint may also support other impact assessment methods.

In Agri-footprint, climate change due to land use change has been modelled separately in the emissions to air: Carbon dioxide, land transformation. This makes it possible to report on the effects of land use change separately. Land use change is also modelled in m² land transformation in the known inputs from nature. Although m² land transformation contributes to other environmental indicators than carbon dioxide, please keep in mind that double counting of the impact of land use change should be avoided.

Agri-footprint makes use of other databases like ecoinvent to provide data for some background processes. If LCIs of other databases are used, it is possible that errors have occurred during the implementation of those datasets into third party LCA-software. It remains to the user of Agri-footprint to select the impact categories that are environmentally relevant for the analysed products or systems and to check which impact categories are endorsed by other bodies of the relevant region. The inventories in Agri-footprint support the calculation of the midpoint impact categories being proposed in the EU PEF.

3.9 Treatment of uncertainty

Uncertainty in inventory data exists in many ways and there are many factors determining the level of uncertainty in LCA (M. A. J. Huijbregts et al., 2001). Most of the inventory data in Agri-footprint are not the result of actual measurements but of models that compute inventory data in relation to activity data that are on its turn measured or estimated. We use the following classification derived from (M. A. J. Huijbregts, 2001) to explain the different types of uncertainties and how we have treated and estimated uncertainties:

1. Uncertainty due to LC modelling choices which are related to the simplifications made in modelling the lifecycles, for instance by using cut off rules for marginal inputs and outputs or excluding not common situations in defining the average lifecycle;
2. Data uncertainty which encompasses inaccuracy of data and lack of (representative) data;
3. Emission model and parameter uncertainty which refers to the many emissions which are calculated by combining primary activity data with an emission factor that is the result of a parameterized model;
4. Spatial variability refers to the variation in conditions (soil, climate) and applied technologies (age, type, abatement techniques, etc.) the region under study
5. Temporal variability refers to variation in time related to variation in natural conditions over the years (climate, pests, capacity usage, calamities, et cetera).

3.9.1 Which uncertainty types are included and how

In Agri-footprint, uncertainty distributions are defined for specific input or output data of LCI processes that incorporate some main factors defining uncertainty and variability around the average. There we focus on key parameters related to the average efficiency of processes in the regions for which average process data are derived. This overall distribution combines the variability in technology, processing conditions and management, which may have a spatial correlation in that region (see Table 3-1 for further explanation).

TABLE 3-1: OVERVIEW OF APPLIED UNCERTAINTY MODELS AND PARAMETERS IN AGRI-FOOTPRINT

Process group	Parameters that define process efficiency	Explanation
Cultivation	Yield (kg crop/ha)	In a defined cropping system where agricultural practice is more or less the same (for instance conventional winter wheat grown in the Netherlands), the differences in emissions and resource use per unit product are strongly related to differences in yield. Yields vary in relation to differences in climate and local growing conditions with same inputs and related emissions per hectare (at least if we assume that emissions are not related to factors that also explain the variation in yield, e.g. rainfall can effect yields but also runoff of N-fertilizer). Of course yields are also correlated with agronomic inputs such as fertilizers. This change in yields per hectare caused by a change in inputs per hectare causes mostly a smaller effect on emissions and resource use per kg product, because the yield responses to marginal inputs. Since emissions in cultivation are all related to agronomic inputs and these inputs are on its turn related to yield we decided not to introduce variations on inputs and yields at the same time. The distribution around the average yield gives a first proxy for many of the inputs and related emissions.
Transport	Performance (tkm) per unit fuel	Also here many factors determine emissions and resource use of a specific transport modality over a certain distance. Similar to cultivation there are many interrelations between inputs emissions and performance. In this version of Agri-footprint we only set a distribution on the fuel efficiency (same as yield in cultivation).
Processing of food crops	Energy use per unit production	LCA contribution analysis of processing show that energy use is for many environmental impacts the most important contributor. From our industry assessments of variation in energy use in European sectors we know that a factor 2 difference between the best and worst performing factories is quite common. This variation is explained by the applied technology, age

		of equipment, plant management and capacity/production rate. All these factors can differ considerably. In Agri-footprint we do not include uncertainty estimates but explain in the meta information the representativeness of the data.
Production of fertilizers	Energy use per unit production	The average LCA impact of fertilizer production is mainly determined by energy use, type of energy source and efficiency of production of this energy source and N ₂ O emissions. Before we included uncertainty for energy use. Now we have regionalized the N-production and we did not add uncertainty data
Animal production	Yield (kg milk/cow; piglets/sow; kg pig/kg feed; kg broilers/feed, number of eggs/kg feed)	The main parameter explaining environmental performance of animal production systems is the Feed Conversion Rate, how efficient feed inputs are transferred to the animal product. We do not add uncertainty data on feed conversion ration in Agri-footprint 6 . We expanded the amount of regional production types instead.t

4. Data development and procedure

A three -stage data development procedure is used for the development of the Agri-footprint database. Each stage of the procedure focusses on different aspects, to ensure an efficient but at the same time robust work procedure. Each step of the procedure.

1. Establish the unit process baseline model
2. Identify data sources and aggregation level of data
3. Fill data gaps with best available data
4. Consistency checks

4.1 Establish the unit process baseline model

For all processes we use a default model consisting of calculation rules that transfer the input data into the interventions. Together they form the unit process. In Agri-footprint the unit process data are not pre-allocated and allow the user to adapt the allocation factors. These models have been developed in the past and are compliant to the PEF methodology and the GFLI handbook (European Commission, 2018b; GFLI, 2020a, 2020b).

Agri-footprint contains attributional LCIs, so generally average mixes are considered that are representative for the specific crop, process, transport modality, product or location.

4.2 Selection of data sources and aggregation of data

For Agri-footprint we aim to use consistent data for all crops and regions covered. For example, all fertilizer application rates, fertilizer types, water use etc. is based on the same methodologies and data sources for all crops.

The main baseline data source is statistics available in the public domain (Scientific literature, FAOstat, Eurostat, etc.). Data from the public domain are assessed based on representativeness (time-related coverage, technical coverage and geographical coverage), completeness, consistency and reproducibility. For a part of the data, we cannot rely on statistics. There we use literature data and models developed by Blonk (for instance for energy use at the farm). For processing, we rely on literature and industry data (either published or collected by Blonk). Where possible, the data have been reviewed by industry experts.

Fertilizers production was modeled based on the latest available literature and the modeling of a specific fertilizer product was based on primary data from a large Dutch fertilizer producer (Calcium Ammonium Nitrate produced by OCI Nitrogen in the Netherlands). Auxiliary materials were based on the Ecoinvent database or literature sources.

Processing inventories were initially drawn from the feedprint study (Vellinga et al., 2013). These inventories are generic for all provided countries and regions. These processes are either largely similar between countries or the data available was not specific enough to create country/ region specific processes. These generic processes are regionalised by adapting the inputs for energy consumption to the country or region where the processing takes place. This means that the processing (mass balances, inputs etc.) is the same for all regions. Therefore, the representativeness may have decreased for these processes (as the geography of the data is “other region assumed similar”). During the development of Agri-footprint releases, many of these ‘feedprint’ processes have been replaced by higher quality processes using region specific / higher quality data (see Part 2 of the report).

Transport distances and modes from and to the processing plant are also country specific. We connect her to the modelling rules as defined in the Feed PEFCR (European Commission, 2018b).

The aim for the LCI data is to be as recent as possible, which means that when better quality data or statistics on the processes/ systems are available, these will be incorporated in Agri-footprint, generally using five-year averages. To ensure the best time related representativeness, data will be updated regularly.

4.3 Filling data gaps using best available data

LCLs have been developed specifically for Agri-footprint or as part of previous confidential or public studies conducted by Blonk Consultants. These LCLs are fully reported or referred to in part 2.

Data gaps are filled with estimates, which are as much as possible based on expert opinions and previous experiences. The assumptions are documented in part 2, and clearly identified in the database. When fit, the uncertainty range reflects the fact that assumptions have been made.

Many unit processes require energy consumption (e.g. natural gas), fertilizers (e.g. Calcium Ammonium Nitrate) or auxiliary materials (e.g. hexane). Energy related LCLs are taken from the Ecoinvent database. These are consumption mixes for specific countries or regions.

4.4 Data quality checks during modelling

As the original data has been compiled in different software programs and data structures, it is important to check consistency and correctness of all the data during the implementation process (the migration to a SimaPro database). Quality checking has been done iteratively. (Parts of) the database was exported to SimaPro, checked, errors or inconsistencies corrected, and data gaps identified. When identified issues were resolved, a new SimaPro export was made, this was again checked. This process continues until all identified errors and data gaps were resolved. The checking process involves:

- Check naming
- Remove duplicate processes, or processes that were very similar (e.g. wheat starch slurries with slightly different starch contents).
- Check correct linking
- Remove empty processes whenever possible
- Check if newly added processes or flows are applied consistently throughout the database.
- Mass balances
 - Balances; the amount of dry matter going in should be the same as dry matter going out as product or waste/emission. The total matter 'as is' should be balanced as well. Sometimes it was possible to also calculate balances of substances (e.g. hexane make-up should be balanced by hexane emissions during crushing).
 - Appropriate waste flows
- Transport included in all processes
- Logical differences between countries (yields, fertilizer application rates, et cetera)
- Consistent calculation methodology
- Compare results to existing data from other sources.

4.5 Data Quality Ratings (DQR)

The DQR for processing of feed materials is consistent with the approach being described in the PEFCR for feed (European Commission, 2018c). The four data quality indicators for feed materials are:

- Technological representativeness (TeR)
- Geographical representativeness (GR)
- Time representativeness (TiR)
- Precision (P)

To evaluate the DQR a division needs to be made in type of data and how they are interrelated. Moreover, the data quality shall be applied on a cradle to gate process while taking into account the contribution of data points to the overall environmental impact. Or as stated in the tender specifications:

"The quantification of parameters TeR, GR, TiR, and P shall be based on the results of a contribution analysis carried out on the proposed dataset. The TeR, GR, TiR, and P values for the dataset shall be assigned as weighted average of

the corresponding values for the unit processes contributing cumulatively to at least to 80% of the total environmental impact (per impact category) based on characterised and normalized results “.

The DQR evaluation includes activity data and the background data they relate with, being production of goods such as transport and electricity and combustion of fuels or other chemical conversion during processing. This gives the following set of evaluation points.

TABLE 4-1 DQR CRITERIA USED IN CONNECTION TO ACTIVITY DATA AND BACKGROUND DATA FOR PRODUCTION AND COMBUSTION/CONVERSION

Data type	DQR criterion
Activity data	Precision: P
	Time Representativeness: TiR
	Technology Representativeness: TeR
	Geographical Representativeness: GR
Electricity and energy data from ELCD	Average DQR of the ELCD dataset
Other production data	TiR
	TeR
Combustion or other conversion data	TiR
	TeR

4.5.1 Technological Representativeness (TeR)

The Technological Representativeness (TeR) of a data set is defined by the ILCD as “the degree to which the data set reflects the true population of interest regarding technology, including for included background data sets, if any.” For Agri-footprint we operationalized this indicator by defining 5 levels of technological foreground representativeness and 5 levels of technological background representativeness. The DQR system for TeR can be found in Appendix I.

4.5.2 Geographical Representativeness (GeR)

The Geographical Representativeness (GR) of a data set is defined by the ILCD as “the degree to which the data set reflects the true population of interest regarding geography, including for included background data sets, if any.” For Agri-footprint we operationalized this indicator by defining 5 levels of geographical foreground representativeness and 5 levels of geographical background representativeness. The DQR system for GeR can be found in Appendix I.

More information about the contribution analysis and DQR settings can be found in Agri-footprint 6 – Part 2.

4.5.3 Time-related Representativeness (TiR)

The Time-related Representativeness (TiR) of a data set is defined by the ILCD as “the degree to which the data set reflects the true population of interest regarding time / age of the data, including for included background data sets, if any.” For Agri-footprint we operationalized this indicator by defining 5 levels of time-related foreground representativeness and 5 levels of time-related background representativeness. The DQR system for TiR can be found in Appendix I.

4.5.4 Precision Representativeness (P)

The DQR Parameter precision (P) of a data set is defined by the ILCD as a “measure of the variability of the data values for each data expressed (e.g. low variance = high precision). Note that for product and waste flows this needs to be judged on a system's level.” For Agri-footprint we operationalized this indicator by defining 5 levels of uncertainty in accordance with the PEFCR for Feed (European Commission, 2018a). The DQR system for P can be found in Appendix I.

4.6 External Review

Agri-footprint 1.0 was externally reviewed on ILCD requirements by the Centre for Design and Society, RMIT University, Melbourne, Australia. The external reviewers checked the consistency and transparency of the methodology applied and completeness and transparency of data documentation.

Agri-footprint 2.0 is reviewed by RIVM (Dutch National Institute for Public Health and the Environment). This critical review is performed to ensure compliance with ISO 14040 (ISO, 2006a), 14044 (ISO, 2006b) on the following points:

- the methods used for the LCIs are consistent with this International Standard,
- the methods used for the LCIs are scientifically and technically valid,
- the data used are appropriate and reasonable in relation to the, intended goal of the LCIs.

This critical review;

- is performed at the end of Agri-footprint 2.0 development,
- includes an assessment of the LCI model,
- excludes life cycle impact assessment (LCIA).

Agri-footprint 5 and 6 were not formally reviewed in its entirety. However, it was developed in parallel to the EC Feed databases 2.x and 3.x (part of the Environmental Footprint pilot) that included a review. As there is quite some overlap between the underlying data and models used in the feed tender and Agri-footprint, the review also benefited Agri-footprint indirectly.

5. Limitations of Agri-footprint

There are a number of limitations that should be taken into account when using Agri-footprint. Some additional limitations apply to specific processes; these limitations are reported in the data description section of that specific dataset (in 'Agri-footprint 6 - Part 2 – Description of data').

Agri-footprint provides LCI data with a standard reference unit of 1 kg. It is the responsibility of the user to determine an appropriate basis for comparison (functional unit).

The impact categories of ReCiPe and EF were taken into account when developing Agri-footprint. Agri-footprint uses some background data that is sourced from Ecoinvent. Where LCIs of other databases are used, it is possible that errors have occurred during the development of those datasets or during implementation into third party LCA-software, the correction of these errors are beyond the control of the Agri-footprint development team. Naturally, errors that were discovered in those datasets were reported to the appropriate parties.

Elementary flows have been collated to align with requirements of ReCiPe and EF method. Other LCIA methods may assess substances which are not included in Agri-footprint.

There are methodological limitations of LCA, which are not specific for Agri-footprint, but which are relevant for all agricultural and food product life cycle inventories:

- Use of statistical data for crop yields, (artificial and organic) fertilizer application rates, when there is not specific data available.
- Data availability is also limited in relation to production and the use of pesticides (impacting on ecotoxicity), but an approach was developed to estimate the impact on ecotoxicity of agricultural cultivation.

The system boundaries which are supported by Agri-footprint are from cradle (cultivation) to factory or farm gate. The processes can be used to support LCAs from cultivation to end-of-life, but Agri-footprint does not contain processes for life cycle phases such as packaging, distribution and retail, consumer storage and preparation or waste treatment.

6. References

- Centraal veevoederbureau. (2010). *Grondstoffenlijst CVB*.
- European Commission. (2018a). *PEFCR Feed for food producing animals*.
- European Commission. (2018b). *PEFCR Feed for food producing animals*.
http://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_feed.pdf
- European Commission. (2018c). *PEFCR Feed for food producing animals*.
- Federal Office for the Environment. (2009). *The Ecological Scarcity Method – Eco-Factors 2006*.
- GFLI. (2020a). *GFLI methodology and project guidelines*. <https://globalfeedlca.org/wp-content/uploads/2020/11/GFLI-Methodology-and-Project-Guidelines-October-28-2020.pdf>
- GFLI. (2020b). *GFLI procedures for data collection*. October.
- Hoekstra, A. Y., & et al. (2011). *The Water Footprint Assessment Manual*. The Water Footprint Network.
- Huijbregts, M. A. J. (2001). *Uncertainty and variability in environmental life-cycle assessment door*. Universiteit van Amsterdam.
- Huijbregts, M. A. J., Norris, G., Bretz, R., Citroth, A., Maurice, B., von Bahr, B., & Weidema, B. (2001). Framework for modelling data uncertainty in life cycle inventories. *International Journal of Life Cycle Assessment*, 127–132.
- Huijbregts, M., Steinmann, Z. J. N., Elshout, P. M. F., Stam, G., Verones, F., Vieira, M., Hollander, A., Zijp, M., & Zelm, R. Van. (2016). *ReCiPe 2016: A harmonized life cycle impact assessment method at midpoint and endpoint level Report I: Characterization*.
- ISO 14040. (2006). *ISO 14040 Environmental management — Life cycle assessment — Principles and framework*.
- ISO 14044. (2006). *ISO 14044 - Environmental management — Life cycle assessment — Requirements and guidelines*. ISO.
- ISO 14044. (2020). *ISO 14044 - Amendment 2*.
- Pfister, S., Koehler, A., & Hellweg, S. (2009). Assessing the environmental impacts of freshwater consumption in LCA. *Environmental Science & Technology*, 43(11), 4098–4104.
- USDA. (1973). *Energy value of foods*.
- Vellinga, T., Blonk, H., Marinussen, M., Zeist, W. J. Van, Boer, I. J. M. De, & Starmans, D. (2013). *Methodology used in feedprint: a tool quantifying greenhouse gas emissions of feed production and utilization* (Issue March).

Appendix I DQR Rating

TABLE 6-1: DQR LEGEND TABLE

Score	Activity data				Production		Combustion/Conversion	
	P	TiR	TeR	GR	Tir	Ter	Tir	Ter
1	Measured/calculated and verified	The data (collection date) can be maximum 2 years old with respect to the "reference year" of the dataset.	Technology aspects have been modelled exactly as described in the title and metadata. without any significant need for improvement	The processes included in the dataset are fully representative for the geography stated in the "location" indicated in the metadata	The "reference year" of the tendered dataset falls within the time validity of the secondary dataset	Technology aspects have been modelled exactly as described in the title and metadata. without any significant need for improvement	The "reference year" of the tendered dataset falls within the time validity of the secondary dataset	Technology aspects have been modelled exactly as described in the title and metadata. without any significant need for improvement
2	Measured/calculated/literature and plausibility checked by reviewer	The data (collection date) can be maximum 4 years old with respect to the "reference year" of the dataset.	Technology aspects are very similar to what described in the title and metadata with need for limited improvements. For example: use of generic technologies' data instead of modelling all the single plants.	The processes included in the dataset are well representative for the geography stated in the "location" indicated in the metadata	The "reference year" of the tendered dataset is maximum 2 years beyond the time validity of the secondary dataset	Technology aspects are very similar to what described in the title and metadata with need for limited improvements. For example: use of generic technologies' data instead of modelling all the single plants.	The "reference year" of the tendered dataset is maximum 2 years beyond the time validity of the secondary dataset	Technology aspects are very similar to what described in the title and metadata with need for limited improvements. For example: use of generic technologies' data instead of modelling all the single plants.
3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer	The data (collection date) can be maximum 6 years old with respect to the "reference year" of the dataset.	Technology aspects are similar to what described in the title and metadata but merits improvements. Some of the relevant processes are not modelled with specific data but using proxies.	The processes included in the dataset are sufficiently representative for the geography stated in the "location" indicated in the metadata. E.g. the represented country differs but has a very similar	The "reference year" of the tendered dataset is maximum 3 years beyond the time validity of the secondary dataset	Technology aspects are similar to what described in the title and metadata but merits improvements. Some of the relevant processes are not modelled with specific data but using proxies.	The "reference year" of the tendered dataset is maximum 3 years beyond the time validity of the secondary dataset	Technology aspects are similar to what described in the title and metadata but merits improvements. Some of the relevant processes are not modelled with specific data but using proxies.

				electricity grid mix profile.				
4	Qualified estimate based on calculations. plausibility not checked by reviewer	The data (collection date) can be maximum 8 years old with respect to the "reference year" of the dataset.	Technology aspects are different from what described in the title and metadata. Requires major improvements.	The processes included in the dataset are only partly representative for the geography stated in the "location" indicated in the metadata. E.g. the represented country differs and has a substantially different electricity grid mix profile	The "reference year" of the tendered dataset is maximum 4 years beyond the time validity of the secondary dataset	Technology aspects are different from what described in the title and metadata. Requires major improvements.	The "reference year" of the tendered dataset is maximum 4 years beyond the time validity of the secondary dataset	Technology aspects are different from what described in the title and metadata. Requires major improvements.
5	Rough estimate with known deficits	The data (collection date) is older than 8 years with respect to the "reference year" of the dataset.	Technology aspects are completely different from what described in the title and metadata. Substantial improvement is necessary	The processes included in the dataset are not representative for the geography stated in the "location" indicated in the metadata.	The "reference year" of the tendered dataset is more than 4 years beyond the time validity of the secondary dataset	Technology aspects are completely different from what described in the title and metadata. Substantial improvement is necessary	The "reference year" of the tendered dataset is more than 4 years beyond the time validity of the secondary dataset	Technology aspects are completely different from what described in the title and metadata. Substantial improvement is necessary



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