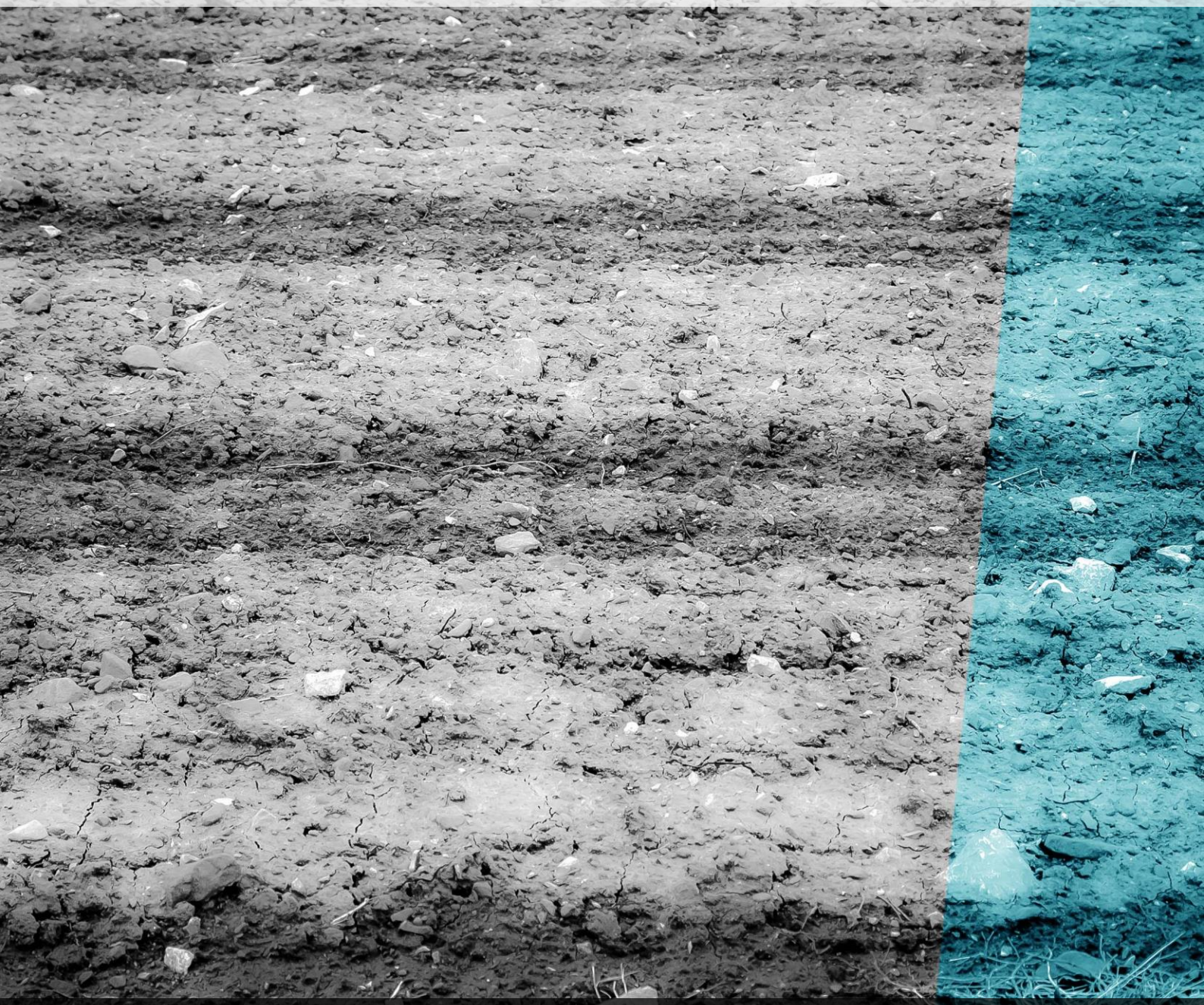
Methodology of the EC feed database.

Version 1.0 May 2017



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Date	5-4-2017
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Table of contents

1. Introduction

This document describes the methodology and data sources applied for deriving the EC feed LCI dataset (full name "feed" process-based product environmental footprint-compliant life cycle inventory datasets). It merges the methodological requirements from the EC tender specifications [ENV.A.1/SER/2016/0035VL], the most recent guidelines document (European Commission, 2017) and the latest version of the draft feed PEFCR (Technical Secretatiat for the Feed pilot, 2015).

Chapter 2 explains the generic approach and the work flow. In chapter 3 the details on the methodology applied for agricultural processes, processing of corps and processing of other products are summarized. Chapter 4 explains the method applied for deriving average market mixes and logistics and chapter 5 explains the method how new datasets are derived from existing datasets. Chapter 6 elaborates on the data quality method and how the DQR scores are calculated.

This document is a so-called living document and it will be regularly updated throughout the project. The final version will be provided as a deliverable as agreed on in the project proposal.

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2. Generic approach

2.1 Data request and data sources

The EC Feed database is generated from a selection of existing datasets that are partially remodelled to fulfil the requirements that the EC sets for drafting a PEF compliant database. This remodelling involves:

- The implementation of the EC Energy and Transport data in background processes that are used in agriculture and processing, such as fertilizers, capital goods and pesticides production. These background processes are made compliant to the modelling criteria mentioned in the tender specifications.
- The implementation of the agricultural modelling requirements as mentioned in the draft Guidance document for developing PEFCRs (European Commission, 2017)[1] in the agricultural process data.
- The alignment of data sources used for foreground processes. The main data source for foreground processes is the Agri-footprint database (1464 datasets). For France, the data request covers 64 datasets. AGRIBALYSE cultivation data will be used for France (24 datasets), see Table 2-2. For processing in France 12 datasets are used from Agribalyse (Koch & Salou, 2016), the others originate from Agri-footprint (Blonk Agri-footprint BV, 2015b), see also Table 2-1.
- The definition of proxies. 562 of the 1518 datasets are not currently available and need to be modelled in the project, either on the basis of aggregation, selecting similar datasets from other countries or generating new datasets. This concerns 228 new country datasets and 334 aggregated datasets that are requested either on EU28+EFTA level or on global level. These datasets will be generated on the basis of the available country data and their share in the EC feed consumption mix. The method that will be applied is in accordance with the approach defined in the feed PEFCR.

Table 2-1. Overview of origin of used data sets and newly developed datasets

	No of datasets requested	Data source (No)	No of newly developed for the EC database
Crops			
Country	510	AFP (486) and AGB (24)	
EU 28 +EFTA	28	Weighted average of country datasets, based on production volume	28
World	34	Weighted average of country data sets Based on production volume	34
Processed crops			
Country	636	AFP(624) and AGB (12)	
EU 28 +EFTA	142	Weighted average of processing based on country datasets, crop inputs based on EU market mix	142
World	114	Weighted average of country datasets, based on production volume.	114
Other products (animal based, (bio)chemicals, minerals			
Country	24	AFP	
EU 28 +EFTA	36	Extrapolated from AFP, data developed in screening studies of feed and beer	36
World	4	Extrapolated from AFP, data developed in screening studies of feed and beer	4

[1] Assuming that there will be consensus on the default emission factors for pesticides.

On top of the data request for cultivation of crops in specific countries cultivation data needed to be collected additionally for some other countries related to the market mix of processing of crops in the EU, see chapter 5.

Table 2-2: France cultivation data requested in feed EC tender

FAO name	Feed EC tender name	Comment
Barley grain	Barley grain, technology mix; at farm	
Green pea	Green pea; technology mix; at farm	
Maize	Maize (corn grain) production; technology mix; at farm	
Oat grain	Oat grain production; technology mix; at farm	
Rapeseed	Rapeseed; technology mix; at farm	
Rye grain	Rye grain production; technology mix; at farm	Not available in Agribalyse AFP will be used
Soybean	Soybean production; technology mix; at farm	
Starch potato	Starch potato; technology mix; at farm	
Sugar beet	Sugar beet; technology mix; at farm	
Sunflower seeds	Sunflower seeds; technology mix; at farm	
Triticale	Triticale; technology mix; at farm	
Wheat grain	Wheat grain; technology mix; at farm	

2.2 Workflow

The project consists of five main steps Figure 2-1:

1. To generate all **background process data** in accordance to the tender specifications, i.e. implementing the EC energy and transport datasets and the other data requirements set in the tender specifications (EoL formula, capital goods etc.).
2. To generate all **foreground processes** (i.e. cultivation, processing of crops and other processing) in accordance to the tender specifications.
3. To generate the **full database to be reviewed**, including linking the background and foreground data, conducting the data quality assessment and adding the meta-data.
4. The Review process.
5. Support and maintenance of the delivered feed database.

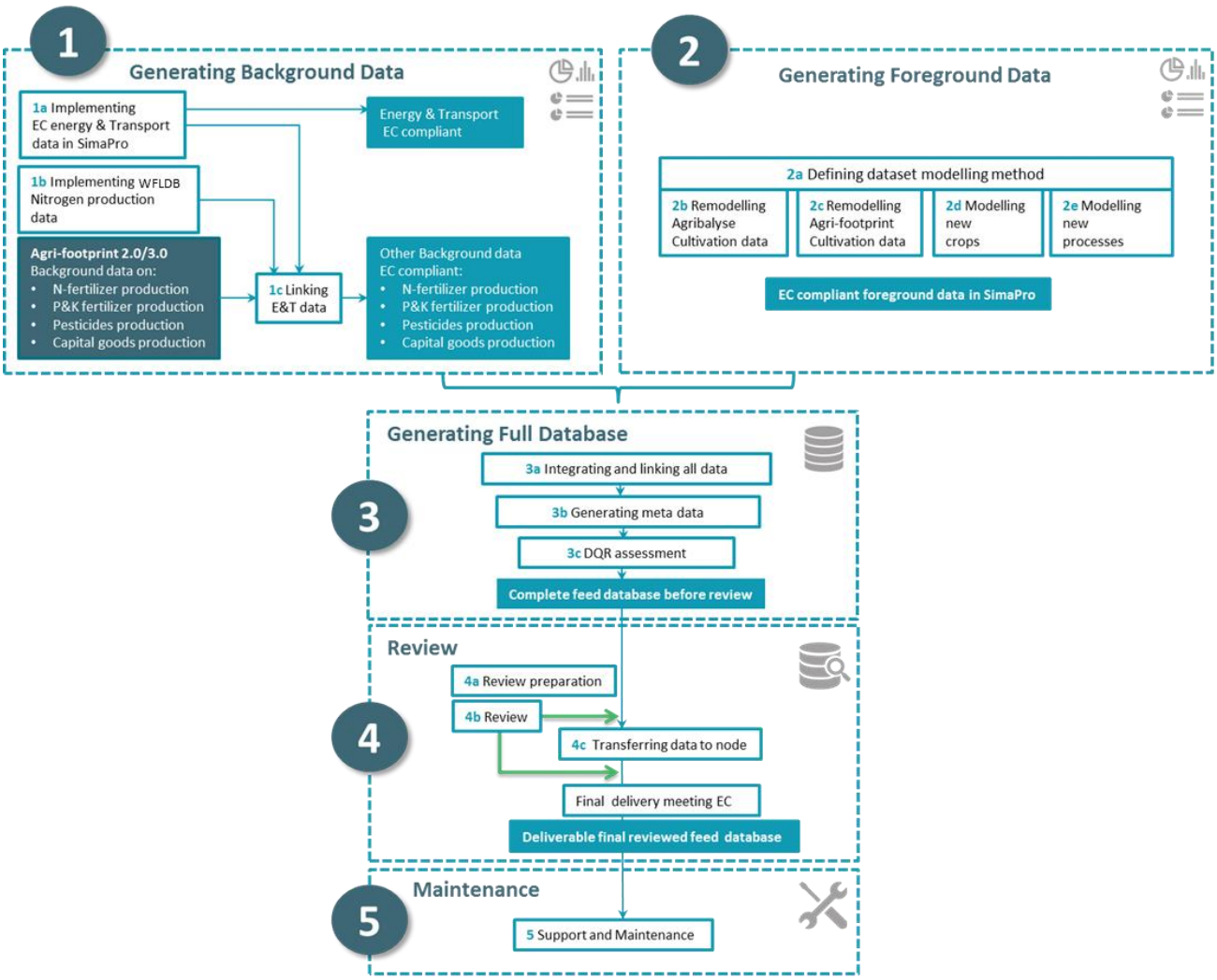

Figure 2-1 Workflow of generation of the feed LCI database, review and maintenance

3. Modelling of processes

3.1 Cradle to gate and cradle to gate TIER -1 processes

The feed datasets are provided at two levels.

- Cradle to gate system processes and (aggregated)
- Cradle to gate system processes TIER -1 (partially aggregated)

The partially aggregated datasets shall be complemented by their sub-processes aggregated datasets. Both datasets (system process and partially aggregated plus complementing aggregated sub-processes) shall deliver the same impact category indicator results. The level of aggregation shall be agreed between the contractor and the Commission before releasing the final datasets.

The level-1 aggregation dataset shall contain only the single product output flow. For datasets with originally several output products from the last process step, the following applies: for each input flows at level 1, the information is to be provided, which share of this flow has been allocated to the single product reference flow of the final dataset. All co-products shall be clearly listed in the documentation and all allocation keys shall be transparently reported. If for example the data set would be "soybean oil" (with "soybean meal" as co-product), the steam from e.g. natural gas used in the last process step at level 1 would carry the information which % of the overall steam used in that last process step has been allocated to the soybean oil (e.g. "80%") and which allocation key was used (e.g. "price", or "mixed (details of the mix)"). This information allows data set users to replace the input flows in the right amount. This information shall be stored in the dedicated ILCD format for the individual product flow in the sub-section "Allocations" in the "Exchanges" section, or in the metadata field "Use advice for data set". In case the co-products at the last step have been treated/removed via substitution, that share will be 100%, as the substitution will be fully reflected in the LCI of the main level 1 data set elementary flows. In this case, the dataset used to substitute the co-product shall be modelled as a separate aggregated dataset at level-1.

As a minimum the level 1 aggregation should be complemented by the following sub-processes (and related activity data and parameters for parametrised datasets):

- Energy input(s) (differentiated by energy carrier, including any potential energy conversion of fuels and thus direct emissions, as "steam from [name of fuel]", or "process heat from [name of fuel]");
- Transport(s) to the user of the product, differentiated by transport mode (plus values of parameters);
- In case system expansion is used as allocation: the datasets used for substitution.

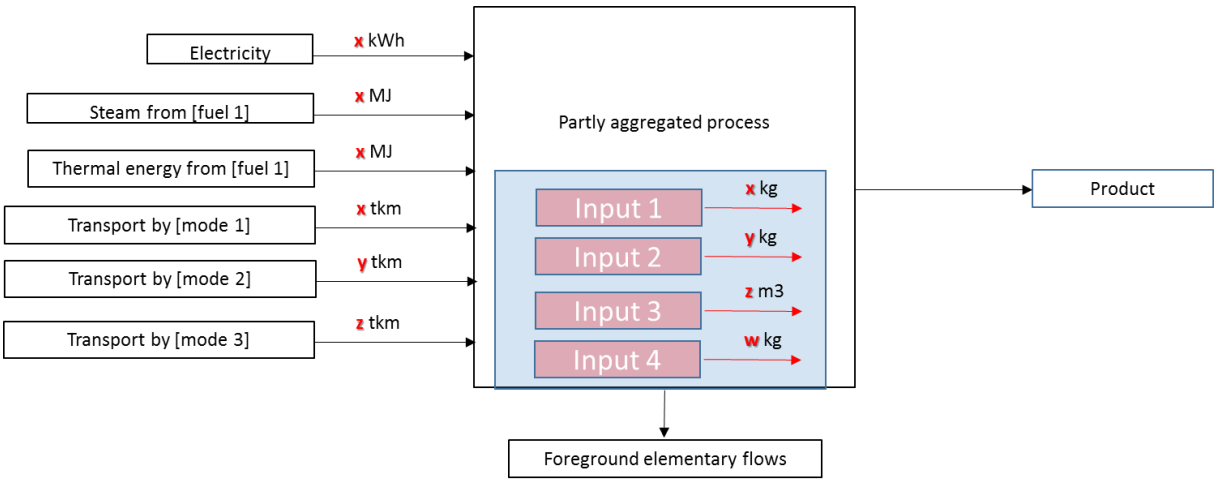

Figure 3-1: Minimum level of disaggregation requested for a dataset aggregated at level 1. The "Input" information shall be part of the data set's documentation.

In Table 3-1 an overview is given on which data will be provided for the Tier level-1 processes.

Table 3-1 Set up of Tier level 1 process data for Cultivation, Processed crops and other data

	Cultivation	Processing of crops	Other feed materials
Foreground elementary flows	Land occupation; emissions of N,P, K, Zn, Cu, Pb, active ingredients and others if relevant	Elementary flows of materials being converted and emitted (auxiliary materials, waste flows), not crops.	Elementary flows of materials being converted and emitted (auxiliary materials, waste flows), not crops.
Level -1 processes	Activity data on inputs of energy (type and quantity) and transport (means and quantity)	Activity data on inputs of energy (type and quantity) and transport (means and quantity	Activity data on inputs of energy (type and quantity) and transport (means and quantity
Aggregated process with background data (not energy and transport)	Elementary flows of Inputs of fertilizers use (type and quantity), pesticides active ingredients use (type and quantity), capital goods depreciation, seeds and other products if relevant	Elementary flows of crop raw materials.	Elementary flows of raw materials.
Documentation	Inputs of fertilizers use (type and quantity), pesticides active ingredients use (type and quantity), capital goods depreciation, seeds and other products if relevant. Relation between foreground elementary data, activity data and inputs with applied allocation	Inputs of crop raw materials and relation between foreground elementary data, activity data and inputs with applied allocation	Inputs of raw materials and relation between foreground elementary data, activity data and inputs with applied allocation

3.2 Modelling of cultivation

3.2.1 Basic approach defining process sheets for cultivation in LCI databases

The LCI elementary flows of cultivation are not measured but calculated by combining activity data and models.

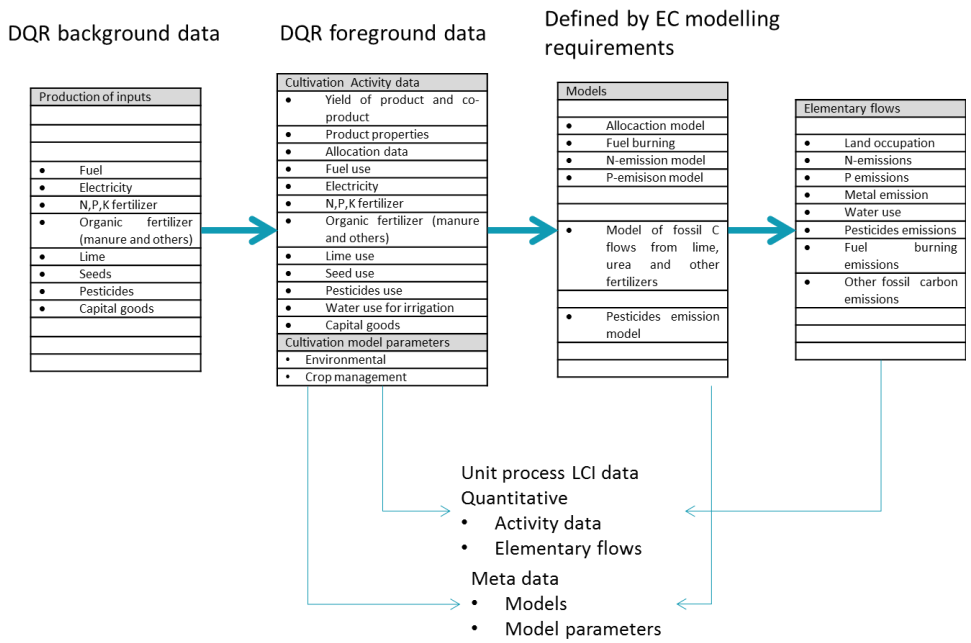

Figure 3-2 Modelling of cultivation data

The activity data as summarized in Figure 3-2 are included in the Agri-footprint and Agribalyse databases. These data are linked to LCI data (by multiplication) for the production of the inputs used at cultivation and several models that calculate emissions and resource use. Depending on the type of model and way of allocation additional information needs to be collected on:

- plant product properties, coproduct properties plant residue properties (energy content, or price when applying energy or economic allocation or N- content of plant residues for N emission modelling);
- crop rotation relationships (assigning activities that are not targeted to one crop but to maintain fields such as manure management, drainage etc.);
- management practices (soil management in relation to N2O and CO2 emissions such as tillage/ no tillage);
- environmental conditions (ground water level, soil type, water balance, etc.).

3.2.2 Harmonization: using best data available

For the modelling of cultivation, it was decided to use the "best data" available for the PEF from the existing databases. All the background processes (energy, transport, material, inputs etc.) are fully harmonized. For the direct emissions modelling, as a minimum the basic approach from PEF guidance was followed, but when more detailed modelling was available, for instance for French crops coming from AGRIBALYSE database, the choice was made not to compromise the LCIs . The idea is that more detailed modelling reflects better the effect of agronomic practices and provides more robust emission flows in France. The aim is to go towards harmonization and better overall modelling in the future.

3.2.3 System boundary and cut off

As explained in 3.2.1there is a given set of activities that form the starting point for modelling the elementary flows. Table 3-2 shows the included activity data at cultivation.

Table 3-2 Included and excluded activities and elementary flows in cultivation, processing of crops and other production

Included	Excluded
• Fuels use for all machinery used during field preparation, all crop growing stadia, harvesting and storage. • Electricity for all machinery used during field preparation, all crop growing stadia, harvesting and storage. • N,P,K Fertilizer use • Organic fertilizer (manure and others) use direct and indirect related to crop rotation • Lime use direct and indirect related to crop rotation • Seed use • Use of organic fertilizers or soil improvers direct and indirect related to crop rotation • Use of Pesticides on the field and at storage • Depreciation of capital goods for machinery and storage • Packaging of fertilizers and pesticides.	• Other consumables used during cultivation • Activities related to living at the farm • Activities related to other business (e.g. producing wind energy)

It is common practice to exclude other consumables at arable farming. This involves mostly negligible quantities in terms of environmental contributions. Activities related to living at the farm (for instance fuel and electricity use) are considered as out of scope but are sometimes hard to distinguish from cultivation related activities.

Activities related to energy production at the farm that are not related to the mass flows being generated due to cultivation (e.g. wind or solar power) are only accounted for to the level of own energy needs.

3.2.4 (Steady state) average situation

Cultivation data are collected over a period of time sufficient to provide an average assessment of the life cycle inventory associated with the inputs and outputs of cultivation that will offset fluctuations due to seasonal differences. Table 3-3 gives an overview how the EC tender requirements are applied in the data collection process of the main data sources:

Table 3-3 Implementation of the (steady state) average requirement in the source databases used for the EC feed database

Requirement	Implementation in Agrifootprint	Implementation in Agribalyse
1. For **annual crops**, an assessment period of at least three years shall be used (to level out differences in crop yields related to fluctuations in growing conditions over the years such as climate, pests and diseases, et cetera). Where data covering a three-year period is not available i.e. due to starting up a new production system (e.g. new greenhouse, newly cleared land, shift to other crop), the assessment may be conducted over a shorter period, but shall be not less than 1 year. Crops/plants grown in greenhouses shall be considered as annual crops/plants, unless the cultivation cycle is significantly shorter than a year and another crop is cultivated consecutively within that year .	Yields, manure application, water use are 3 to 5 year averages All other activity data (Fuels use; Electricity; N,P,K Fertilizer use; Lime use; Peat use; Seed use; Use of Pesticides; Use of water for irrigation and other blue water use; depreciation of capital goods) are collected for 1 recent and representative year since fertilization and land management practices are fairly constant in 3 years. Pesticides use may vary considerably depending on plagues. However data are often lacking to define multiple year averages.	All activity data for arable crop are based on the 2005-2009 period, using olympic means (i.e. remove maximum and lower values).
2. For **perennial plants** (including entire plants and edible portions of perennial plants) a steady state situation (i.e. where all development stages are proportionally represented in the studied time period) shall be assumed and a three-year period shall be used to estimate the inputs and outputs. Where the different stages in the cultivation cycle are known to be disproportional, a correction shall be made by adjusting the crop areas allocated to different development stages in proportion to the crop areas expected in a theoretical steady state. The application of such correction shall be justified and recorded.	This is relevant for palm fruit; sugar cane and coconuts. Same approach as for annual crops and the modelling of the steady state is done in accordance to the EC requirements.	Not applicable since all French crops are arable crops
3. For **crops** that are grown and harvested in **less than one year** (e.g. lettuce produced in 2 to 4 months) data shall be gathered in relation to the specific time period for production of a single crop, from at least three recent consecutive cycles .	In Agri-footprint all arable crops are considered as annual crops although the time period of production can sometimes be slightly different than a year. A specific case is double cropping of soy maize in Brazil and other tropical regions. For this no correction has been made in the EC feed database. A first estimate of the impact is that for soy from Brazil the land occupation would reduce 15.	In Agribalyse the exact time period of the cultivation cycle of a crop has been taken into account for So if this is 0.9 year on a ha land occupation is 0.9 yr*ha. This has been set on 1.0 to make the LUC calculations consistent and in accordance to PAS2050-2011/1

3.2.5 Assigning inputs and outputs to crops and allocation of crop co-products

At an arable farm mostly different crops are grown in a certain sequence (crop rotation) and also quite often livestock is produced at the same farm. Furthermore harvested plants can generate multiple co-products such as seeds and straw. To assign the different activities and inputs to specific crops and co-products the LEAP feed guidelines (FAO LEAP, 2015) are followed (Figure 7 page 37) as well as possible. Table 3-4 shows how the different allocation topics are handled in both databases. Agribalyse has a quite detailed method on allocation of nutrients in organic fertilizers to the crops in the rotation scheme. In Agri-footprint a more basic approach has been used.

Table 3-4. Handling of allocation topics in the source databases

Allocation topic	Agri-footprint	Agribalyse
Activities related to crop rotation		
• **Organic fertilizer application (manure and others)**	Nutrient content of manure application per year on arable land is divided over all crops on the basis of surface contribution. No division is made in the mineral and organic fraction in manure.	Organic fertilizer application is determined by the sum of available Nitrogen (from manure) and P directly applied on the crop and N (not directly available) in organic fertilizers from the previous year on the basis of the share of preceding crops and their organic fertilizer application
• **Energy production from co-products from farming**	Relevant for palm fruit bunches and sugar cane bagasse. Energy recovery has been accounted for in reduction of fossil energy use during production	Not applicable
• **Straw from cereals**	Allocation has been applied on the basis of three different keys (economic, energy content and mass). For the PEF we use economic allocation.	Economic allocation is preferred option, although because of a lack of price information no allocation has been applied between grains and co-products.

3.2.6 Modelling of N-flows

The N flows modelling in Agri-footprint is in accordance to baseline modelling as being defined in the PEFCR guidance document 6.0, see Agri-footprint methodology document 2.0 for further explanation

For the 12 French crops from Agribalyse a more detailed N-modelling has been be applied. A description of this modelling can be found in the Agribalyse method 1.3.

In Table 3-5 the difference between the emissions calculated according to the baseline modelling and the modelling on the basis of the Agribalyse method 1.3 is illustrated. The differences between N_2O and NH_3 are mainly related to the use of different emission factors. The difference between NO_3^- emissions is related to a different type of modelling. According to the baseline modelling of Guidance 6.0 an emission is calculated in relation to application. In the Agribalyse model the emissions are an actual estimate of field emissions related to crop risk properties and regional environmental risks. In Agribalyse, nitrate leaching is based on summer N residues and not linear to the total N inputs, which explains the difference with Agri-footprint

The difference in results using the Agribalyse modelling and the baseline modelling will be mentioned in the metadata.

Table 3-5 Comparison between the baseline methodology on N emissions

Feed EC tender name	AGB 1.3 Process	N_2O (G6.0/AGB1.3)	NH_3 (G6.0/AGB1.3)	NO_{3-} (G6.0/AGB1.3)
Barley grain, technology mix; at farm	Winter barley, conventional malting quality, animal feed, at farm gate/FR U	134%	129%	152%
Green pea; technology mix; at farm	Spring pea, conventional, 15% moisture, animal feed, at farm gate, production/FR U	123%	134%	10%
Maize (corn grain) production; technology mix; at farm	Maize grain, conventional, 28% moisture, national average, animal feed, at farm gate/FR U	101%	101%	223%
Oat grain production; technology mix; at farm	Oat grain, national average, animal feed, at farm gate/FR U	101%	136%	140%
Rapeseed; technology mix; at farm	Rapeseed, conventional, 9% moisture, national average, animal feed, at farm gate	114%	181%	215%
Rye grain production; technology mix; at farm	NA			
Soybean production; technology mix; at farm	Soybean, national average, animal feed, at farm gate/FR U	20%	138%	12%
Starch potato; technology mix; at farm	Starch potato, conventional, national average, at farm gate/FR U	130%	126%	140%
Sugar beet; technology mix; at farm	Sugar beet roots, conventional, national average, animal feed, at farm gate, production/FR U	68%	129%	145%
Sunflower seeds; technology mix; at farm	Sunflower, conventional, 9% moisture, national average, at farm gate/FR U	93%	83%	61%
Triticale; technology mix; at farm	Triticale grain, conventional, national average, animal feed, at farm, gate, production/FR U	129%	228%	111%
Wheat grain; technology mix; at farm	Soft wheat grain, conventional, national average, animal feed, at farm gate, production/FR U	131%	131%	181%

3.2.7 Modelling of P flows

According to the guidance document 6.0, 95% of P application shall be emitted to agricultural soil and 5% to water. In Agri-footprint the application was 100% agricultural soil which equals an emission to 5% to water by the fate modelling in the impact model in Simapro. We adapted this modelling to become fully compliant with the EC guidance requirements.

In Agribalyse the emissions are modelled according to the SALCA P model which is further described in the Agribalyse method report 1.2, datasheet 11, p226.

The difference in results using the Agribalyse modelling and the EC baseline modelling are shown in Table 3-6 and will be mentioned in the metadata.

Table 3-6 Comparison between the baseline methodology on P emissions

Feed EC tender name	EU G6.0 (interpretation AFP)/AGB
Barley grain, technology mix; at farm	152%
Green pea; technology mix; at farm	113%
Maize (corn grain) production; technology mix; at farm	159%
Oat grain production; technology mix; at farm	103%
Rapeseed; technology mix; at farm	111%
Rye grain production; technology mix; at farm	
Soybean production; technology mix; at farm	51%
Starch potato; technology mix; at farm	125%
Sugar beet; technology mix; at farm	126%
Sunflower seeds; technology mix; at farm	74%
Triticale; technology mix; at farm	113%
Wheat grain; technology mix; at farm	193%

3.2.8 Modelling of metal flows

Both in Agri-footprint and Agribalyse a heavy metal emissions model is applied in accordance to the requirements set in the draft guidance document 6.1. This means that a balance is made of the application and uptake of heave metals. In both database a methodology is applied described in (Nemecek & Schnetzer, 2012). The emissions are the result of inputs of heavy metals due to fertilizer and manure application and of deposition and outputs of heavy metals due to leaching and removal of biomass.

However, there may occur differences in both datasets that are the result of the use of different background data for manure application, metals content of manure, metal uptake of corps and deposition. These differences have not been studied in details since both methodologies are compliant to the EC requirements.

3.2.9 Modelling of pesticides emissions

The paper of (Van Zelm, Larrey-Lassalle, & Roux, 2014) gives a good overview of the emission routes of pesticides and how they enter the fate modelling applied in the impact assessment method. In the current draft guidance document (v6.1), the following division of emissions is proposed:

- 90% to agricultural top soil
- 1% to fresh water
- 9% to air

It should be realized that both the 1% to water and the 9% to air can be considered as a first default estimate but actual emissions may differ greatly per type of active ingredient, environmental conditions at application, application technology, climate conditions, (existing) drainage system, crop height, local regulations on applications to reduce emissions.

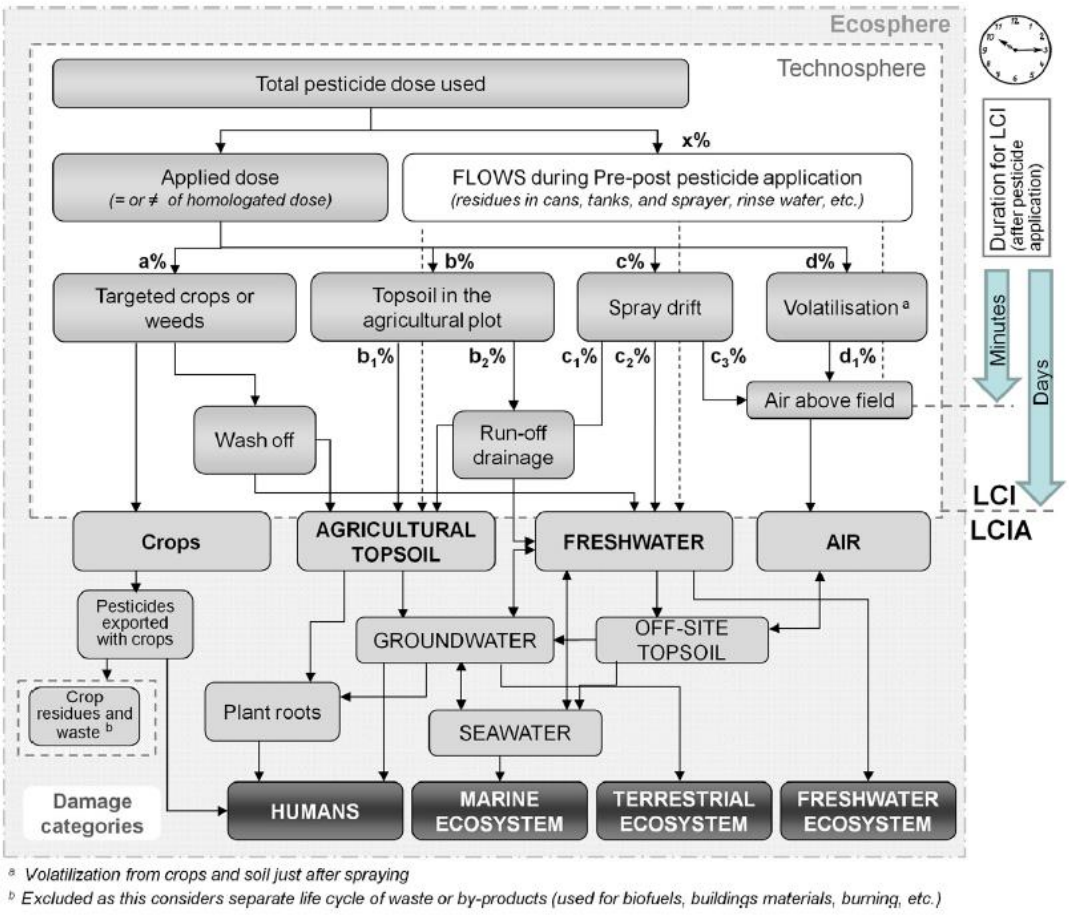

Figure 3-3 Emission routes of pesticides (Van Zelm et al 2014)

For the Netherlands we made a further check on average water emissions in relation to use. We derived the following Figure on the basis of pesticides use statistics (CBS, 2017) and emission statistics (WUR-Alterra & Deltares, 2016).

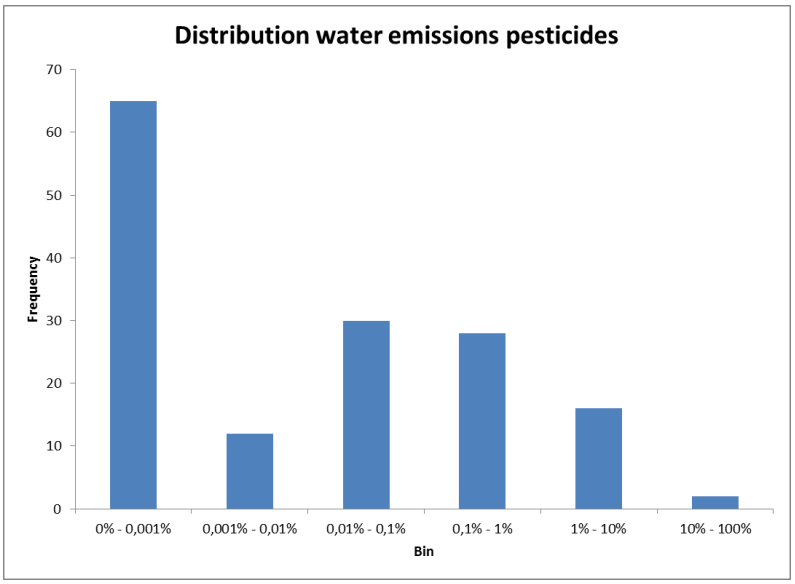

Figure 3-4 Distribution of faction of use emitted to water in the Netherlands anno 2010.

3.2.10 Drying and storage of crops

Drying and storage of crops and the involved transport has been included in the cultivation stage according to the guidance document. Both the Agri-footprint and the Agribalyse methodology is based on a calculation for evaporation of water and thus related to drying energy efficiency and moisture contents.

3.2.11 Linking to LCI data of production of inputs

Table 3-7 gives an overview of the data sources used for the production of inputs up to the farm gate used in cultivation. Agri-footprint 2.0 refer to existing datasets available in the Agri-footprint database that users can access. Agri-footprint 3.0 datasets are datasets that were constructed for the update of Agri-footprint to be released in March 2017. Chapter 3.5 gives a further explanation of used data sources.

Table 3-7.Background data used for production of inputs used in cultivation

Input	Assigned dataset by EC for production LCI	Non EC datasets	Comments
Fuels	EC tender data energy and transport		
Electricity	EC tender data energy and transport		
N-production		World Food Lifecycle Database	Remodelled by connecting to EC Energy and Transport E&T
P and K production		Agri-footprint 2.0	Remodelled by connecting to EC E&T
Manure and other fertilizers		Agri-footprint 2.0	Remodelled by connecting to EC E&T
Lime		Agri-footprint 2.0	Remodelled by connecting to EC E&T
Seeds		Agri-footprint 3.0	Remodelled by connecting to EC E&T
Pesticides		Agri-footprint 3.0	Remodelled by connecting to EC E&T
Capital goods		Agri-footprint 3.0	Remodelled by connecting to EC E&T

3.2.12 Overview of adaptations in Agri-footprint and Agribalyse cultivation data

Table 3-8 summarizes the necessary adaptations for both AFP and AGB datasets.

Table 3-8.Adaptations to Agri-footprint and Agribalyse data to comply to EC requirements

Agri-footprint cultivation data	Agribalyse cultivation data
1. Change of LCI data of inputs a. Energy and transport b. N-fertilizer production 2. Pesticides emissions → breakdown soil, water and air	1. Change of LCI data of inputs a. Energy and transport b. N-fertilizer production c. P,K fertilizer production d. Manure transport e. Pesticides production f. Capital goods/machinery production 2. Pesticides emissions → breakdown soil, water and air 3. Land occupation and LUC emissions 4. Addition of energy use for drying and storage

3.3 Modelling of processed farm products

The majority of the processed feed ingredients are crops from cultivation split into different co-products in a processing plant, such as wet and dry milling of grains, pressing and crushing of oil seeds and soy beans, sugar production and so on to bulk products. A limited set of requested feed ingredients concern (co-)products from further refining.

Overall the processing of crops to feed ingredients are characterized to large scale processing facilities with limited input of other raw materials needed for processing. Also the need for packaging materials is very low since the products are sold in bulk. This makes the energy inputs the predominant activity data during processing except from some specific production routes such as wat milling and sugar production.

3.3.1 System boundaries and cut off

The following inputs and outputs are included in the process sheets

Table 3-9 System boundaries for processing of crops

Included	Excluded
• Fuels use for all plant processing operations • Electricity for all plant processing operations • Water use • Waste water treatment only for wet processes • Auxiliary materials (processing aids)	• Raw materials adding up to less than 1% of mass contribution • Consumables used at the plant not used as a raw material or auxiliary material • Packaging if occurring

3.3.2 Assigning inputs and outputs (allocation) to co-products

Economic allocation is default approach.

3.3.3 Use and adaptation of Agribalyse processing data

We made an inventory of the French data sets for processing of crops in France in Agribalyse and compared the data sources to the data sources used in Agri-footprint. If data were not specific for France and data quality of the data sources used in Agri-footprint was higher, Agri-footprint data were used. The table below gives an overview of the results of this assessment.

Table 3-10. Selection of datasets for processing in France

Dataset number	Indicative name of the dataset	Indicative description of content	Data to be used
127	Crude rapeseed oil (solvent)	Crude rapeseed (canola) oil; from crushing including further extraction of the oil using hexane as a solvent; production mix; at plant	**Agribalyse (AGB) activity data**
183	Crude sunflower oil (solvent extraction)	Crude sunflower oil; from crushing (pressing and solvent extraction); at plant	**AGB activity data**
399	Maize flour	Maize flour, from dry milling, at plant	**AFP data, since no AGB data are available**
427	Maize middlings	Maize middlings, from dry milling, at plant	**AFP data, since no AGB data are available**
631	Rapeseed meal (solvent)	Rapeseed expeller; from crushing (extraction with solvent); production mix, at plant	**Agribalyse (AGB) activity data**
817	Soybean expeller (pressing)	Soybean expeller; from crushing (pressing); at plant	**AFP data, since no AGB data are available**
839	Soybean hulls (solvent)	Soybean hulls; from crushing (extraction with solvent); at plant	**AFP data, since no AGB data are available**

863	Soybean meal (solvent)	Soybean meal; from crushing (pressing and extraction with solvent); at plant	**AFP crushing data based on FEDIOL since data sources used in AGB are not specific for France and are older**
885	Soybean molasses (solvent)	Soybean molasses; from crushing (extraction with solvent); at plant	**AFP data, since no AGB data are available**
959	Sugar (from sugar beet)	Sugar, from sugar beet, from sugar production, at plant	**AFP beet sugar data for EU since data sources used in AGB are not specific for France and are older**
1033	Sugar beet molasses	Sugar beet molasses, from sugar production, at plant	**AFP beet sugar data for EU since data sources used in AGB are not specific for France and are older**
1055	Sugar beet pulp (wet)	Sugar beet pulp, wet, from sugar production, at plant	**AFP beet sugar data for EU since data sources used in AGB are not specific for France and are older**
1119	Sunflower seed dehulled	Sunflower seed dehulled; technology mix; at plant	**Agribalyse (AGB) activity data**
1145	Sunflower seed expelled dehulled (pressing)	Sunflower seed expelled dehulled; from crushing (pressing); at plant	**AFP data**
1171	Sunflower seed meal (solvent)	Sunflower seed meal; from crushing (pressing and extraction with solvent); at plant	**Agribalyse (AGB) activity data**
1197	Sunflower seed partly dehulled	Sunflower seed partly dehulled; technology mix; at plant	**Agribalyse (AGB) activity data**
1367	Wheat gluten feed	Wheat gluten feed, from wet milling, at plant	**AFP data**
1385	Wheat gluten meal	Wheat gluten meal, from wet milling, at plant	**AFP data**
1473	Wheat middlings and feed	Wheat middlings & feed, from dry milling, at plant	**AFP data**
1499	Wheat starch	Wheat starch, from wet milling, at plant	**AFP data**

3.4 Modelling of non-vegetable feed ingredients

Most of the non-vegetable processed products relate to animal production and are either co-products of rendering of slaughter co-products resulting in meals and fats, rendering of fish, also resulting in meals and fats and products from dairy industry. Next to that there are two products from mostly non biogenic sources, mineral pre-mixes and vitamin pre-mixes.

3.4.1 Rendering of animal products

Rendered animal products are all requested for on the level “EU 28 and EFTA”. The data used for the animal farming and the slaughtering will come from Agri-footprint 2.0 and are representative for the Netherlands. These data will be used as an EU average where the transport and energy data are replaced. The use of Dutch data as an EU average reduces the DQR score which will be further explained in chapter 6.

3.4.2 Rendering of fish

Rendered fish products involve products per country and for Chile, Germany, Denmark, Norway, Peru and United Kingdom and for the regions EU-28 + EFTA and world. The activity data originate from Agri-footprint 3.0 and involves both data from industry fish and by-catch. The aggregation on EU and world level will be done on the basis of shares of countries in market and production mixes (see chapter 5).

3.4.3 Liquid whey

Liquid whey cones from cheese production and will be based on Agri-footprint 2.0 data for the Dutch situation. These data will be used as an EU average where the transport and energy data are replaced. The use of Dutch data as an EU average reduces the DQR score which will be further explained in chapter 6.

It should be noted that liquid whey is not an ingredient for compound feed.

3.4.4 Pre mixes

The pre-mix data for minerals and vitamins originate from the screening study for feed.

Table 3-11Average composition of mineral premix (not animal specific)

Component	contr.	Commenst and Sources
L-Lysine HCl	9.2%	(Mosnier, van der Werf, Boissy, & Dourmad, 2011)
DL-Methionine	1.5%	(Mosnier et al., 2011)
L-Threonine	3.1%	(Mosnier et al., 2011)
L-Tryptophan	0.3%	(Liedke & Deimling, 2014)
Calcium carbonate	45.0%	ELCD
Mono calcium phosphate	7.0%	Agri-footprint v2.0, Production of super triple phosphate used as proxy
Sodium chloride	9.5%	ELCD
Sodium carbonate	0.3%	ELCD
Phythase	0.3%	Tryptophan used as proxy
Trace elements premix	23.9%	consists of 0.11% metal minerals (water excluded) of which 24.4% ZnO, 48.3% ZnSO4, 27.3% CuSO4
Total	100.0%	

3.5 Background data for production of goods and services

3.5.1 Energy and transport

Description of the energy and transport data and the potential adaptations needed to enable implementation will be completed after data are fully implemented in SimaPro. Point of concern is the matching of available transport data for sea, inland water and rail where the available EC dataset has its limitations.

3.5.2 Fertilizers production

Description of applied fertiliser data and the potential adaptations needed to enable implementation will be added later on.

3.5.3 Capital goods and machinery production

The following categories of capital goods are included at cultivation

Table 3-12 List of capital goods and machinery included in the farm LCIs

Category	Exclusions
1. Production and maintenance of tractors, machines and other energy using equipment on the farm, crop specific	Except for consumables to maintain these goods (however motor oil is included at fuels use)
2. Production and maintenance of goods used for storage, crop specific	Except for consumables to maintain these goods
3. Production and maintenance of infrastructure; buildings, roads and pavements	Except for consumables to maintain these goods and infrastructure needed for drainage or irrigation

Category 1 Tractors and other machinery for field operations

The activity data for depreciation of tractors and machinery is derived according to two methods:

- AFP 3.0 method, based on a constant that connects materials use to fuel use in machinery. This method is based on the assumption that the total fuel use in farm equipment for field operations is correlated with the size and life span of equipment.
- AGB method. Based on hours used. This method is applied for the 11 Agribalyse datasets for cultivation.

AFP method 3.0 method.

Based on a literature review of Dutch farming practises we determined that the average material use from depreciation of machinery for arable farming equals 0.37 kg per litre diesel used at a farm. The average was constructed using twelve different arable crops. The average material use of depreciation of machinery was determined using the mass of machine (Williams, Audsley, & Sandars, 2006), repair factors for various machinery (Nemecek & Kägi, 2007), economic lifetime and utilisation rates of machinery (Wageningen UR, 2015a). Tillage determines two/third of the material use. In a Brazilian study on no tillage farming of soy beans an average was found of 0.11 kg materials use for depreciation of capital goods (Andrea, Romanelli, & Molin, 2016). The same analysis revealed that 27% of the capital goods are a results of tractor usage, the remaining 73% are a result of various machinery, mainly ploughing equipment.

The average material composition is determined on the basis of an estimate of the average composition of a tractor and the average composition of other machinery. The average composition of a tractor is derived on the basis of data for production of a truck and scaled to the tractor dimensions. (see Table 3-13) which is assumed to have a similar material composition as tractors.

The average composition in other machinery is assumed to be equal to the tractor, except for materials needed for batteries, windows, anti-freeze and wood, which are removed from the materials balance. Using the mass of machinery, repair factors for various machinery, economic lifetime and utilisation rates of machinery, the amount of capital good for tractors and machinery has been calculated. Then the average material composition for tractor and machinery use combined could be calculated.

Table 3-13: Material composition of the average tractor and machinery

	Unit				Comment
Products					
Type		*Tractor (27%)*	*Machinery (73%)*	*Average composition (%)*	
Materials/fuels [ELCD background processes]					
Steel hot rolled coil, blast furnace route, prod. mix, thickness 2-7 mm, width 600-2100 mm RER S	*kg*	*5442*	*5442*	*79.9%*	*For all steel and iron components*
Aluminium sheet, primary prod., prod. mix, aluminium semi-finished sheet product RER S	*kg*	*201*	*201*	*2.9%*	
Lead, primary, consumption mix, at plant DE S	*kg*	*95*	*-*	*0.4%*	*Battery*
Copper wire, technology mix, consumption mix, at plant, cross section 1 mm² EU-15 S	*kg*	*79*	*79*	*1.2%*	*For copper, brass and electronics*
Steel hot dip galvanized, including recycling, blast furnace route, production mix, at plant, 1kg, typical thickness between 0.3 - 3 mm. typical width between 600 - 2100 mm. GLO S	*kg*	*37*	*37*	*0.5%*	*Stainless steel & brake pads*
Polyethylene high density granulate (PE-HD), production mix, at plant RER	*kg*	*413*	*413*	*6.1%*	*Thermoplastics*
Polybutadiene granulate (PB), production mix, at plant RER	*kg*	*465*	*465*	*6.8%*	*Tires*
Container glass (delivered to the end user of the contained product, reuse rate: 7%), technology mix, production mix at plant RER S	*kg*	*60*	*-*	*0.2%*	*Windows*
Polyethylene terephthalate fibres (PET), via dimethyl terephthalate (DMT), prod. mix, EU-27 S	*kg*	*57*	*57*	*0.8%*	*Textile*
Naphtha, from crude oil, consumption mix, at refinery EU-15 S	*kg*	*62*	*62*	*0.9%*	*Proxy for lubricant*
Sulfuric acid (98% H2SO4), at plant/RER Mass	*kg*	*36*	*-*	*0.1%*	*Battery*
Spruce wood, timber, production mix, at saw mill, 40% water content DE S	*kg*	*11*	*-*	*0.0%*	*Wood*
Ethanol, from ethene, at plant/RER Economic	*kg*	*21*	*-*	*0.1%*	*Anti-freeze*
Electricity/heat					
Electricity mix, AC, consumption mix, at consumer, < 1kV EU-27 S System - Copied from ELCD	*MWh*	*20*			*Renewable and non-renewable electricity combined*
Process steam from natural gas, heat plant, consumption mix, at plant, MJ EU-27 S	*MWh*	*69*			*Other renewable and non-renewabole energy combined*

The capital good is linked to the diesel use. First needs to be determined how much diesel is consumed during a tractors lifetime. Based on an economic lifetime of 7200 hours, average diesel consumption of 12.5 l/hour and 0.832 kg/l diesel, total amount of diesel use is 75,000 kg. 1 kg diesel produces 44.8 MJ work and requires 1/75000 part of the tractor.

Category 2 storage: grain silo

Material composition of grain silo is based on the most commonly applied type of grain silo in the Netherlands, which is the NBIN200WU type grain silo. From the product manual the main characteristics and weights were extracted: 4735 kg steel elements and 3575 kg concrete elements enough to provide 347 m^3 of storage or 260 ton of grain stored. Average lifetime of the silo is estimated to be 35 years. Material requirements per ton of stored product are 0.52 kg steel and 0.39 kg concrete.

Category 3 general: basic infrastructure at farm level

The assumption is that 30 m^2 of roads and pavements are applied per hectare. Using concrete slabs, 15 cm thick, lifetime of 33.3 years (Wageningen UR, 2015a) and density of 2400 kg/m^3, the total concrete input for basic infrastructure can be determined, which is 327.27 kg concrete per hectare.

3.5.4 Pesticides production

For Pesticides production the newly developed Agri-footprint 3.0 data are used. Pesticides constitute of the following components:

- Active Ingredients (AI)
- Inert Materials (IM)
    - Oil based solvents
    - Adjuvants
    - Minerals
    - Water as a solvent

The functional unit is the amount of active ingredient plus the additional other components. The amount of additional other Inert Materials is determined

Inert Materials[g] = (1/Active Ingredient Concentration)-1)*Active Ingredient [g]

The Active Ingredient Concentration is an average from often used formulations (see new Agri-footprint methodology 3.0 document)

For the inert materials an equal share per type of ingredient has been assumed.

Process used to model inert ingredients	Type of inert ingredient	Share of specific inert compound to the inerts composition
Benzene, prod. mix, liquid EU-27 S & Naphtha, from crude oil, consumption mix, at refinery EU-15 S	Oil-based solvent	25%
Soap stock (coconut oil refining)	Adjuvant	25%
Kaolin coarse filler , production, at plant EU-27 S	Mineral solvent	25%
Drinking water, water purification treatment, production mix, at plant, from surface water RER S	Inorganic solvent	25%

The production of pesticides includes the following processes:

- Energy use and emissions of production of active ingredients (this also includes minor losses of active ingredients during production)
- The production and emissions of the inert materials

3.5.5 Seeding rates and seed production

Seeding rates for various crops are determined using a number of sources. In order of preference these are:

- FAOstat online data on seeding rates specific crops and countries, using most recent data based on 5 year average (2009-2013). When this is known, this number will be used.
- Seeding rates for specific crops and country from “Technical Conversion Factors for Agricultural Commodities” document (FAOSTAT, 2000). When this is known, this number will be used.
- In case none of these two sources provide crop and country specific data, an average of seeding rates from other countries from both sources for the same crop will be used.

The production of the seeds, are assumed to be exactly the same as the cultivation of the specific crop, meaning that the cultivation of the crop and the seed are exactly the same. The only adjustment is that the yield of the seeds cultivation process is 80% of the crop cultivation process.

For propagated crop like sugar cane and cassava, seeding rates cannot be determined and the influence of propagation is neglected. For palm oil plants a specific LCI is used to determine the environmental impact of palm nursery based on Malaysian data (Halimah, Hashim, & May, 2010).

4. Modelling of market mixes and logistics

4.1 Origin of raw materials mix to be processed

Processing data sets contain activity data on the mix of origin of raw materials. These mixes are determined on country level and EU level and global level.

On country level the origin of raw materials to be processed has been determined on the basis of statistics on production, import and export per country (Eurostat, 2016; FAO, 2016). For Agri-footprint a tool has been developed to derive these crop mixes automatically from the FAOstat database. Five year averages are used and updated every year. The EU28+ EFTA crop mix is determined in the same way but than on EU28+EFTA level instead of country level.

This method gives a good estimate for the origin of materials being processed in a country but do not differentiate to the type of processing, so there is no difference in for instance the mix of dry milling or wet milling of a grain in a country.

For global processing we assume that the global production mix of crops is equal to the mix of products being processed.

4.2 Logistics of raw materials to be processed

The logistics from cultivation to processing are as a baseline determined on the basis of the country mixes combined with method described in the Agri-footprint 2.0 methodology report (Blonk Agri-footprint BV, 2015a). For some country crop combinations more specific transport scenarios are defined such as soy beans for soy bean meal processing in Brazil.

4.2.1 Transport model

The transport model consists of two parts. First the distance within the country of origin (where the crop is cultivated) is estimated, it is assumed that the crops are transported from cultivation areas to central collection hubs. From there, the crops are subsequently transported to the processing country.

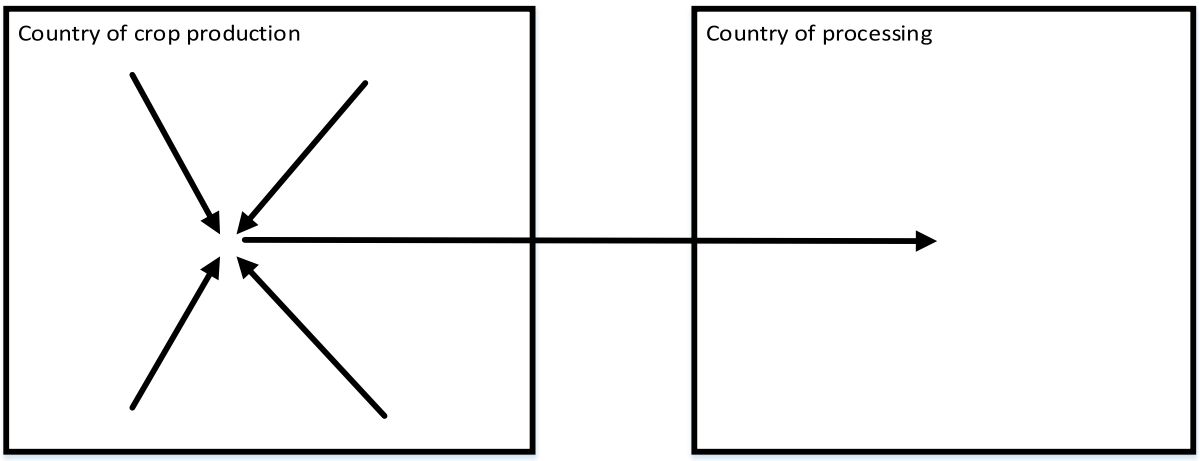

Figure 4-1: Generic transport model from a central hub in land of cultivation to the location in a processing country.

4.2.1.1 Data collection

The transport model of Feedprint (Vellinga et al., 2013) has been used as a basis but has been updated and extended to cover all relevant transport flows for EC feed tender database.

The transport distance has been estimated using the following principles:

Domestic distances based on transport mix from EuroStat (tkm travelled per mode for domestic transport tasks).

Distance between EU countries based on country midpoint to midpoint, using international transport mode mix from EuroStat

Distance between European countries and countries outside Europe based on transoceanic freight distances using http://www.searates.com/reference/portdistance/

Distance in US based on GREET model assumption (50 miles = 80 km by truck from field to processor)

4.2.1.2 Transport of crops from cultivation areas to central hubs

Within the EU, EuroStat (European Commission, 2014) provides detailed statistics for average transport modes and distances for goods within a country. These data have been used as proxy for the average distance and mode of transport of crops. For the United states, the average distance and transport mix is based on the GREET model (Elgowainy et al., 2013). For countries outside the EU, distances are based on literature when available or expert judgment based on past experience (these distances have often been carried over from the Feedprint method (Vellinga et al., 2013).

4.2.1.3 Transport from country of cultivation to processing country

If the processing country is the same as the country of cultivation (e.g. sugar beets from Germany are processed in Germany) no additional transport is modelled. If transport occurs between countries in the EU, data on the transport mix from EuroStat (European Commission, 2014) were used (modal split; e.g 10% of goods is transported by truck, 50% rail, 30% inland waterways, 10% short sea shipping). The transport distance is estimated using google maps (the distance between geometric centres of countries). For transport of crops from outside the EU to processing countries within the EU, the default mode of transport is transoceanic freight. The distance is calculated using shipping distance calculation tools (Searates.com, 2013).

5. Deriving datasets from other datasets

5.1 Method for deriving EU28+EFTA and world averages

5.1.1 Crops

The LCIs for the regional "EU28 + EFTA" and "world" production averages are derived from the country LCI data according to the following stepwise procedure:

1. Determine the average weighted contribution of countries to the regional production volume on the basis of mass share over a five years period.
2. Combine the country contribution table with the LCI data per country
3. This average will be applied for the total region. The coverage (on volume basis) of countries for which LCIs were available will be used for the DQR estimation in combination with a penalty for the part that is not covered.

5.1.2 Processed products

Raw material input for processed crops will be based on the market shares of the specific crop (own production + imports) for the specific country or region of processing (similar approach as in 5.1.1, but including imports from other countries). Energy and material effects for these processes will be based on country specific data if available, or else European background processes will be used. This same approach is used for "EU28 + EFTA" and "World" processed crops. In both regions impact of energy and material input will be based on European background datasets.

6. Data quality assessment method

6.1 Data quality system and indicators

The DQR for feed materials is consistent with the approach being described in the tender specifications except that the DQR 'use of the EoL formula' is excluded due to either cut off (processing) or the insignificancy of the use of the EoL formula on the results[2]. So for the DQR measurement 4 DQI's remain:

- Precision
- Time representativeness
- Technological representativeness
- Geographical representativeness

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 taking into account the contribution of data points to the overall environmental impact. Or as the tender specifications state:

"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 normalised 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 6-1 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
Production data transport and energy supplied by EC	Average DQR of the EC dataset
Other production data	TiR
	TeR
Combustion or other conversion data	TiR
	TeR

ANNEX 1 gives the overview of the full DQR matrix which is compiled from the guidance document and the tender terms of reference.

[2] *At Cultivation the only waste flows that could be subject of the eol formula are: depreciated capital goods (concrete, metals and plastics) and packaging of fertilizers and pesticides (plastic or paper). Regarding these materials and their EOL impact: concrete has the highest environmental impact but is not a recyclable material (due to the chemical reduction of CaO), all the other materials are based on ELCD LCI process data using the production mix of primary and secondary material. There is no end of life included in the paper and plastics data. Cultivation of crops may result in biogenic co-products being used for energy purposes (bagasse and empty fruit bunches). These flows are considered co-products and treated according to allocation rules (system expansion)*
Processing of crops and other agricultural crops do normally not generate any waste flows that are subject of the EOL formula. In all sources for process data that we use no waste flows are specified.

6.2 Data quality of agricultural processes

The approach for agriculture is closely related to how LCI data are generated for cultivation. The DQR of cultivation as a cradle to gate process can be defined as a function of the DQR of background data (production of goods & combustion of fuels) activity data and modelling elementary flows. We only look to the DQR of the activity data in combination with its background data and not to modelling. The agricultural modelling method is defined by EC requirements (Guidance document 6.0) and falls outside the scope of the DQR.

Figure 6-1 shows the list of activity (foreground and background) data to be evaluated.

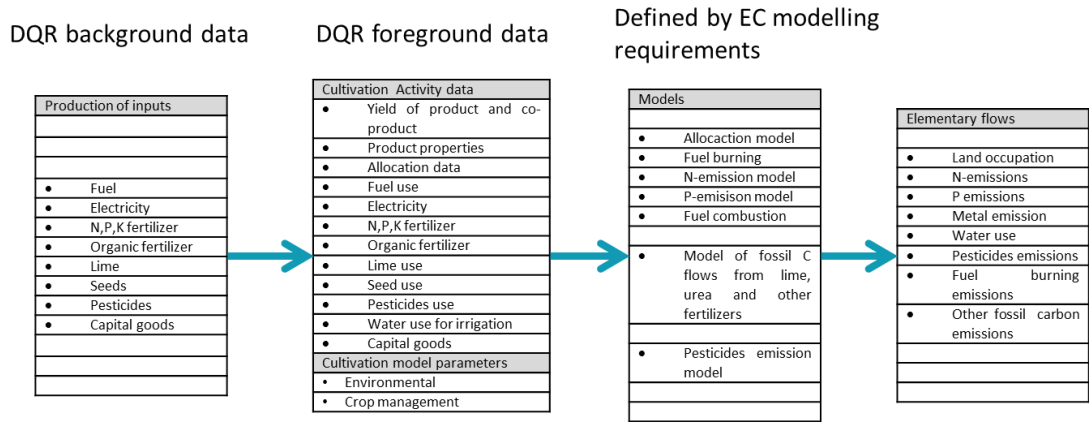

Figure 6-1 Basic scheme to evaluate the DQR of agricultural processes

Activity data for agriculture can be split into:

- Data that determine the quantity of elementary flows per baseline production unit (hectare)
- Data that are used for the scaling of the baseline production unit to the product (yield and allocation)

So the environmental impact of cultivation can be written as follows

$$ENVIMPcul = \sum Fu.Eu.F.Fo.L.Su.Pu.Wu.CG * \frac{1}{yield} * Allocationfactor$$

Table 6-2 Activity data mentioned in the Formula and how they relate to environmental impact and DQR

Abbr	Name	Environmental impact	DQR
Fu	Fuel use [kg/l per ha]	Quantity in combination with production and combustion determines total impact. Production data come from EC T&E dataset. Combustion in agricultural machinery comes from AFP/AGB datasets.	Mathematical average of: 1. Production (1.5) 2. Use quantity (Ter.Tir. Gr. P) 3. Combustion data (Ter. Tir)
Eu	Electricity use [kwh/ha]	Quantity times production data (country specific)	Mathematical average of: 1. Production (1.5) 2. Use quantity (Ter.Tir. Gr. P)
F	Fertilizer use [kg product/ha]	Quantity times production data (AFP data sets and ELCD datasets)	Mathematical average of: 1. Production (Ter.Tir) 2. Use quantity (Ter.Tir. Gr. P)
Fo	Organic fertilizer use kg product/ha]	Quantity times production data (AFP data set)	Mathematical average of: 1. Production (Ter.Tir) 2. Use quantity (Ter.Tir. Gr. P)
L	Lime use kg CACO3/ha]	Quantity times production data (ELCD data set)	Mathematical average of: 1. Production (Ter.Tir) 2. Use quantity (Ter.Tir. Gr. P)
Su	Seed use	Quantity times production data (AFP)	Mathematical average of: 3. Production (Ter.Tir)

			1. Use quantity (Ter.Tir. Gr. P)
Pu	Pesticides use	Quantity times production data (AFP)	Mathematical average of: 3. Production (Ter.Tir) 1. Use quantity (Ter.Tir. Gr. P)
Wu	Water use	Quantity	1. Use quantity
CG	Capital Goods depreciation	Quantity times production data (AFP)	Mathematical average of: 1. Production (Ter.Tir) 2. Use quantity (Ter.Tir. Gr. P)
Yield	Yield [kg/ha]	Quantity	Quantity
Allocation data	Mass* value Crop rotation	Allocation fractions derived from several data	Quantity

To determine the relevant importance of the activity data (and its related production/combustion data) amongst each other and to yield and allocation a contribution analysis has been conducted for four main crops with datasets of which we know they are relatively complete: wheat UK; Soy BR. Maize FR and Rapeseed DE. The impact of allocation has been set on default on 2.5% (allocation involves co-product allocation and crop rotation allocation). The impact of yield is set equal to land occupation plus the impact of crop residues and is on average 12.5%. 100% of the impacts and elementary flows are included instead of 80% contribution as being suggested by the EC (draft EC guidance document 6.1).

Table 6-3 Contribution of environmental impacts related to activity data and connected production and combustion

	Wheat UK	***Soybean BR***	***Rapeseed DE***	***Maize FR***	***average contribution 13 ILCD categories equally weighted.***
Yield	10.8	18.9	9.9	10.5	**12.5**
Allocation	2.5	2.5	2.5	2.5	**2.5**
Activity data (quantity and composition combined with production and combustion basis for DQR)					
Fuel Use	13.1	12.1	7.4	13.0	**11.4**
Electricity	6.1	3.7	0.0	17.0	**6.7**
NPK	52.0	25.2	57.3	40.2	**43.7**
Organic fertilizer	6.9	14.7	10.0	4.8	**9.1**
Lime use	2.2	3.9	2.9	1.4	**2.6**
Seed use	1.5	1.4	0.1	0.6	**0.9**
Pesticides use	2.7	7.3	4.2	0.4	**3.7**
Water use for irrigation	0.1	0.0	0.0	7.1	**1.8**
Capital goods	2.1	10.3	5.7	2.5	**5.1**
	100.0	100.0	100.0	100.0	**100.0**

The average contribution of activity data of these four crops has been applied for all crops as an average "expected" DQR contribution. We chose these crops because we have fairly complete and accurate datasets available. So we are confident that the results give an accurate estimate of the relevant importance of the lifecycle impact related to the activity data..

Using the above described method for the 510 country data sets for agriculture gives a DQR of 1.85 for cultivation. For Agribalyse we assumed an overall DQR of 1.5 since the data are collected specifically for the France situation. To simplify the further calculations of the DQR we assumed a worst case DQR for all crops of 1.81.

The DQR of the 28 EU + EFTA datasets is determined according to the following formula:

$$\sum DQRcountry * PRODSHAREcountry \ + \ 3 * (1 - \sum PRODSHAREcountries)).$$

where *PRODSHAREcountry* is the relative share of a country in the EU production volume of a crop. We use the average of covered cultivation in EU28 + EFTA as overall average and penalize the not covered share by using a DQR of 3. The minimum acceptable coverage for EU+EFTA data is set at 75%.

The DQR for the EU + EFTA datasets vary then from 1.85 to 2.40 Seen annex 2 for details on the calculation

For the 34 global averages we applied the same method. The minimum acceptable coverage for EU+EFTA data is set at 50%.The DQR varies from 1.93 to 2.42.

Table 6-4. Preliminary average contribution analyses for activity use data

	DQR	
AFP cultivation country baseline	1.85	Calculation in Annex A1
AGB cultivation country (France)	1.5	Country specific best data
AFP cultivation EU28 + EFTA (production mix)	1.85-2.40	Range from best to worst DQR
AFP cultivation world (production mix)	1.93-2.42	Range from best to worst DQR

6.3 Data quality of processing agricultural products

The environmental impact of processing of a crop is determined by 9 activity data of which 4 data points can be seen as scaling or context data such as the mass balance, allocation data, crop mix and transport modalities mix. The other activity data, such as use of crops, energy, water and other raw materials are directly related to the type of crop extraction/splitting technology.

Table 6-5 Activity data of crop processing

Activity data	Relation to elementary flows and impact
Mass balance	Scales and divides over co-products
Allocation data	Divides over co-products
Crop mix	Determines which crops and their impacts are taken into account and scales the relative impact of contribution of crops
Transport modalities mix	Determines the environmental intensity of transport
Production of crops	Quantity and Connection to background data
Transport	Quantity and Connection to background data
Fuel use	Quantity and Connection to background data
Electricity use	Quantity and Connection to background data
Water use	Quantity and Connection to background data
Other raw materials use	Quantity and Connection to background data

Mass balance data of crop processing can vary due to the composition of the raw materials and technology parameters. For instance the mass balance of dry milling is dependent on the grain constitution and the average amount of grinding runs. Both the composition of the grain and the amount of grinding runs can vary over time. The composition of grains relates to climate conditions and the amount of runs relates to market conditions. The information on mass balances is often collected as a specific data point and separately maintained from other data points such as energy use.

Allocation data points are prices or energy values by which the masses of co-products are multiplied. Energy content values can vary in relation to the composition of the incoming crops and the technology parameters. Prices vary on top of that in relation to market conditions. Prices of co-products are also dependent on the location of production. The bigger the distance to international harbours and export markets the lower the price for the co-product at location of production. Allocation prices are therefore standardized and reflect an average situation relevant for the EU market. Prices for economic allocation need to be updated regularly. The allocation data used are from the (FAO LEAP, 2015) and refer to a period of 2008-2012.

Both the mass balance and the price scale the amount of elementary flows assigned to a certain co-product.

Crop mixes and transport modality mixes are also not technology dependent but defined by the location of processing and the market of supply of crops. Some processing facilities are quite nearby located to the crop. This is mostly the case when the crop is voluminous or contains considerable water amounts so that transport is expensive. Examples are sugar beets, cane, potatoes and other crops such as seeds, bones and grains can be transported long distances for processing. The data of origin of crops are important due to the variability environmental impacts of crops. These data are derived by analysis of production, import and export statistics. This also holds for the scenarios of transport distances and transport modalities. The baseline approach is a statistical analysis. For several processes more accurate data are collected from country statistics or literature.

Table 6-6 Average contribution of environmental impacts of processing activity data and connected production and combustion data

Activity data	Contribution	
Mass balance	2.5%	
Allocation data	10.0%	
Crop mix	5.0%	
Transport modalities mix	2.5%	
Production of crops	61.9%	Non covered countries in the mix are accounted for with DQR 3 (times share not covered) (see Annex 3 for coverage information)
Transport	3.6%	
Fuel use	3.7%	
Electricity use	7.9%	
Water use	0.1%	
Other raw materials use	1.0%	
Waste water	1.7%	

Using the above described method for the 636 country data sets for crop processing gives a range in DQR of 1.7 to 2.5. For Agribalyse we assumed an overall DQR of 1.5 since the data are collected specifically for the French situation.

The DQR of the 142 EU + EFTA datasets is determined according to the following formula:

$$\sum DQRreference * PRODSHAREreference \;\; + \;\; 3 * (1 - \sum PRODSHAREreference)).$$

where DQRreference is the reference process data that is used as representative for EU28+EFTA. The reference process can be a country or a region (eg. EU or EU9). *PRODSHAREreference* is the relative share of the reference in the EU production volume of a processed feed ingredient. We use the average of the covered processing in EU28 + EFTA as overall average and penalize the not covered share by using a DQR of 3.

For the 118 global averages we assume that the available information is accurate enough for scoring a DQR of 3.

6.4 Data quality of other processes

The DQR of the production of animal based products is based on the same methodology as for processed crops. Where the following activity data and its production processes are evaluated.

Table 6-7 Activity data of animal processing

Activity data	Relation to elementary flows and impact
Mass balance	Scales and divides over co-products
Allocation data	Divides over co-products
Origin mix of animal raw materials	Defines relative impact of animal production/ fishing
Transport modalities mix	Determines the environmental intensity of transport
Production of animal products (fishing included)	Quantity and Connection to background data
Transport	Quantity and Connection to background data
Fuel use	Quantity and Connection to background data
Electricity use	Quantity and Connection to background data
Water use (if relevant)	Quantity and Connection to background data
Other raw materials use (if relevant)	Quantity and Connection to background data

6.4.1 Rendering of animal products

Rendered animal products are all requested for on the level "EU 28 and EFTA". The data used for the animal farming and the slaughtering will come from Agri-footprint 2.0 and are representative for the Netherlands.

The DQR of the 28 EU + EFTA datasets is determined according to the following formula:

$$\sum DQRcountry * PRODSHAREcountry \ + \ 3 * (1 - \sum PRODSHAREcountries)).$$

where *PRODSHAREcountry* is the relative share of the country (NL in this case) in the EU production volume of the animal product. We use the average of covered cultivation in EU28 + EFTA as overall average but penalize the not covered share by using a DQR of 3.

6.4.2 Rendering of fish

Rendered fish products involve products per country and for Chile. Germany. Denmark. Norway. Peru and United Kingdom and for the regions EU-28 + EFTA and world. The activity data originate from Agri-gootprint 3.0 and involves both data from industry fish and by-catch.

The DQR of the 28 EU + EFTA datasets is determined according to the following formula:

$$\sum DQRcountry * PRODSHAREcountry \ + \ 3 * (1 - \sum PRODSHAREcountries)).$$

where *PRODSHAREcountry* is the relative share of the country in the EU production volume of the animal product. We use the average of covered cultivation in EU28 + EFTA as overall average but penalize the not covered share by using a DQR of 3.

6.4.3 Liquid whey

Liquid whey cones from cheese production and will be based on Agri-footprint 2.0 data for the Dutch situation. These data will be used as an EU average where the transport and energy data are replaced. The use of Dutch data as an EU average reduces the DQR score which will be further explained in chapter 6.

It should be noted that liquid whey is not an ingredient for compound feed.

The same method as mentioned in 6.4.1 is applied for determining the DQR of EU28 + EFTA.

6.4.4 Pre mixes

The pre-mix data for minerals and vitamins originate from the screening study for feed. The DQR is considered to be 3.

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Annex 1. DQR criteria matrix

Table A1.1 DQR criteria matrix

	Activity data				Production		Combustion/Conversion	
Score	P	TiR	TeR	GeR	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 electricity grid mix profile.	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.
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

Annex 2. DQR rating of cultivation

DQR of country data sets

Table A2.1 Rating of cultivation activity data from AFP for countries (except France)

	Source	P	TiR	TeR	GeR
Yield	Based on most recent data available from FAOstat (5 years average). 2010-2014. (http://www.fao.org/faostat/en/#data/QC)	Data are considered to be measured and reviewed on plausibility by countries that provide them: → 2	Most recent data maximum 2 years old with respect to reference year of 2016. ➔ 1	Data fully comply to meta data description ➔ 1	Data are representative for countries and specific regions ➔ 1
Allocation	FAO LEAP feed guidelines 2014. original data are collected over period 2007-2011. p95	LEAP report is externally reviewed ➔ 2	Data concern 2007-2011 ➔ 2	Data fully comply to meta data description 1	Data are well representative for countries although collected on higher scale level →2
Fuel use	From different sources. Feed print cultivation documents (2012) and additional work thereafter Energy use was calculated based on data from farm simulation tool MEBOT (Schreuder. Dijk. Asperen. Boer. & Schoot. 2008)	Measured/calculated per crop. Data not checked by reviewer → 3	Most data are collected based on a model of 2008 and therefore 8 years old with respect to reference year → 4. Some datasets use more recent data. Best score is 1	Fuels is similar to meta description but merits improvements → 3 Some data concern more precise measurement of actual fuel use (1/2)	Data are representative for countries and specific regions ➔ 1
Electricity	From different sources. Feed print cultivation documents (2012) and additional work thereafter	Qualified estimate → 4. Some data sets are measured/calculated per crop 2/3	Data are deemed representative for around 2010 ➔ 3	Data are similar to meta description but merits improvements → 3	The processes are sufficiently representative ➔ 3
Fertilizer use	Fertilizer use is a combination of three types of information. 1. Fertilizer application rates per crop country. from Pailliere 2011. Rosas 2011 and Fertistat FAO 2011; 2 Fertilizer types (e.g e.g. Urea. NPK compounds. super triple phosphate etc.) per country IDA 2012.. 3. Heavy metals composition of fertilizers are from literature (Mels et al 2008) (Does not concern use	All data sources are measured/calculated or from literature and plausibility checked ➔ 2	Collected data from 2011-2015. 1 to 5 years from reference year ➔ 2	Data fully comply to meta data description → 1	Data are well representative for countries although the allocation to crops could be improved ➔ 2

	right? Or is the effect included?) 4. N2O emissions based on IPCC (2006)				
Organic fertilizer use	1. Manure application rates per country come from FAO stat. based on 5 year average (2010-2014) 2. Heavy metals composition of manure are from literature (Amlinger et al 2014)	Data are considered to be measured and reviewed on plausibility by countries that provide them: → 2	Data collected from 2014. 2 years from reference year → 1	Data fully comply to meta data description Although need for improving the allocation to different crops → 2	Data are representative and specific for all countries and regions → 1
Lime use	From different sources. Feed print cultivation documents (2012) and additional work thereafter. Heavy metals composition of lime is from literature (Mels et al 2008). Carbon dioxide emissions based on IPCC (2006)	Based on qualified estimations → 4	Data from 2012 and 2008. on average 6 years from reference year → 3	Technology aspects similar as described in the metadata → 2	The lime processes are sufficiently representative for the geographical locations → 3
Seed use	Seed application rates per country from FAO stat. based on 5 year average (2010-2014). Other sources are used as well	Data are considered to be measured and reviewed on plausibility by countries that provide them: → 2	Most recent data from 2014. 2 years older than reference years, other sources → 3	Technology aspects similar as described in the metadata. → 3	Seeding rates are fully representative for the geography stated in the location → 1
Pesticides use	Diverse specific literature. usually based on recommended application rates or specific LCA studies.	Most data from specific literature concerning specific crop and country. → 3	Data collected on pesticides application rates over many years (1997-2016). Median data point at year → 3	Technology are similar as described in the metadata. → 2	Most application rates for pesticides are country specific. In some cases proxies are use due to lack of data. → 3
Water use for irrigation	Water use for irrigation is based on the "Blue water footprint" (Mekonnen & Hoekstra. 2010)	Water footprint data from literature concerning specific crop and country. Plausibly checked by reviewer. → 2	Data from 2005. 10 years older than reference year → 5	Blue water footprint very similar to what described in metadata with limited need for improvements → 2	All water footprints are country and region specific and therefore fully representative → 1
Depreciation capital goods	Depreciation of capital goods derived from various capital goods. using Dutch data (Wageningen UR, 2015b)	Depreciation of capital goods form literature possibly not checked by reviewer → 3	Data from 2015. 1 year older than reference year → 1	Technology aspects are very similar to what described in the meta data → 2	The processes included in the dataset are sufficiently representative for various geographies → 3

Rating of production data of AFP

Table A2.2 Rating of cultivation activity data from AFP for countries (except France)

	Source	TiR	TeR
Fuel production & emissions	Fuel production based on ELCD background data for diesel. Emissions based on method for calculating emissions of transport in the Netherlands (Klein et al.. 2012)	All tendered datasets on production and transportation fall within the time validity of secondary datasets. → 1	Fuel production and emissions have been modelled very similar as described by source → 2
Fertilizer production	Most important and commonly applied fertilizers from Fertilizers Europe (2014). Other minor fertilizer inputs based on older data.	Main datasets on production of fertilizers fall within the time validity of secondary datasets. Plus some additional older data. Using background database that fall within the time validity of secondary datasets. → ([2+1]/2=) 1.5	Production of fertilizers has been modelled exactly as described in title and meta data→ 1
Organic fertilizer production	Manure is considered to be a waste product. Therefore no emissions on production. Data quality on TiR and TeR are therefore not considered.	NA	NA
Lime production	Lime production is based on crushed stone process from ILCD background data only. Because of this the data quality was considered not to be relevant.	NA	NA
Seed production	Seed production based on cultivation process of that specific crop with yield correction. Data quality scores incorporated in the activity data and therefore not considered here.	NA	NA
Pesticides production	Pesticide production mainly based on Green (1987) with additional emissions to air and water.	Main data sets for the production of pesticides are from old data. Using background database that fall within the time validity of secondary datasets. → ([5+1]/2=) 3	Pesticide production has been modelled similar as described by sources but merits improvements → 3
Water use for irrigation	Water extracted from the environment and therefore no impacts assigned to the water itself.	NA	NA
Production of capital goods	Production process of tractor based on EPD Volvo truck (Volvo. 2012). Production process of other machinery based on the same process with the exclusion of some materials. Basic infrastructure based on concrete inputs.	Main data sets for the production of capital goods are from 2012. Using background database that fall within the time validity of secondary datasets. → ([2+1]/2=) 1.5	Capital good production and emissions have been modelled similar as described by sources → 2

Baseline rating cultivation

In the Table below the values are used for the baseline DQR rating of the activity data and background data of cultivation processes

Table A2.3 Baseline (worst case) rating of cultivation data for countries (except France)

		Activity data				***Production inputs***			***Combustion***			
	Weight	P	TiR	TeR	GR	Average	Tir	Ter	Tir	Ter	Average	DQR contibution weighted average
Yield	13%	2	1	1	1						1.25	0.16
Allocation	3%	2	2	1	2						1.75	0.04
Fuel Use	11%	3	4	3	1	1.5			2	2	2.36	0.27
Electricity	7%	4	3	3	3	1.5					2.90	0.19
NPK	44%	2	2	1	2		1.5	1			1.58	0.69
Organic fertilizer	9%	2	1	2	1		NA	NA			1.50	0.14
Lime use	3%	4	3	2	3		NA	NA			3.00	0.08
Seed use	1%	2	3	3	1		NA	NA			2.25	0.02
Pesticides use	4%	3	3	2	3		3	3			2.83	0.10
Water use for irrigation	2%	2	5	2	1		NA	NA			2.50	0.04
Capital goods	5%	3	1	2	3		1.5	2			2.08	0.11
DQR weighted average		2.39	2.15	1.60	1.82	1.50	1.61	1.25	2.00	2.00	1.85	1.85

DQR of EU28 + EFTA datasets

*Table A2.4 DQR rating of production mix for crops region **EU28+EFTA***

Crop	Type	Coverage	DQR
Broad beans	Production mix	0.88	1.99
Linseed	Production mix	0.52	2.40
Lupins	Production mix	0.82	2.05
Maize	Production mix	0.95	1.90
Oats	Production mix	0.96	1.89
Peas, green	Production mix	0.76	2.12
Potatoes	Production mix	0.87	1.99
Rapeseed	Production mix	0.95	1.90
Soybean	Production mix	0.75	2.13
Sugar beet	Production mix	0.95	1.90
Sunflower seed	Production mix	0.96	1.89
Triticale	Production mix	0.98	1.87
Wheat	Production mix	0.98	1.87

*Table A2.5 DQR rating of market mix for crops region **EU28+EFTA***

Crop	Type	Coverage	DQR
Barley	Market mix	1.00	1.85
Broad beans	Market mix	0.88	1.99
Lupins	Market mix	0.82	2.05
Maize	Market mix	0.90	1.96
Oats	Market mix	0.96	1.89
Peas, green	Market mix	0.72	2.16
Potatoes	Market mix	0.87	1.99
Rapeseed	Market mix	0.95	1.90
Rye	Market mix	0.92	1.94
Soybean	Market mix	0.69	2.20
Sugar beet	Market mix	0.95	1.90
Sunflower seed	Market mix	0.92	1.94
Triticale	Market mix	0.98	1.87
Wheat	Market mix	0.95	1.90

*Table A2.6 DQR rating of cultivation for crops region **world***

Crop	Type	Coverage (%)	
Coconuts	Production mix	0.74	2.12
Groundnuts	Production mix	0.67	2.20
Linseed	Production mix	0.51	2.39
Lupins	Production mix	0.81	2.03
Maize	Production mix	0.85	1.99
Oats	Production mix	0.53	2.37
Peas. green	Production mix	0.66	2.21
Rapeseed	Production mix	0.92	1.90
Rice, paddy	Production mix	0.50	2.40
Rye	Production mix	0.56	2.33
Sorghum	Production mix	0.53	2.37
Soybean	Production mix	0.91	1.91
Sugar beet	Production mix	0.50	2.40
Sugar Cane	Production mix	0.83	2.01
Sunflower seed	Production mix	0.55	2.34
Triticale	Production mix	0.73	2.13
Wheat	Production mix	0.62	2.26
Potatoes	Production mix	0.55	2.36

Annex 3. DQR rating of processing

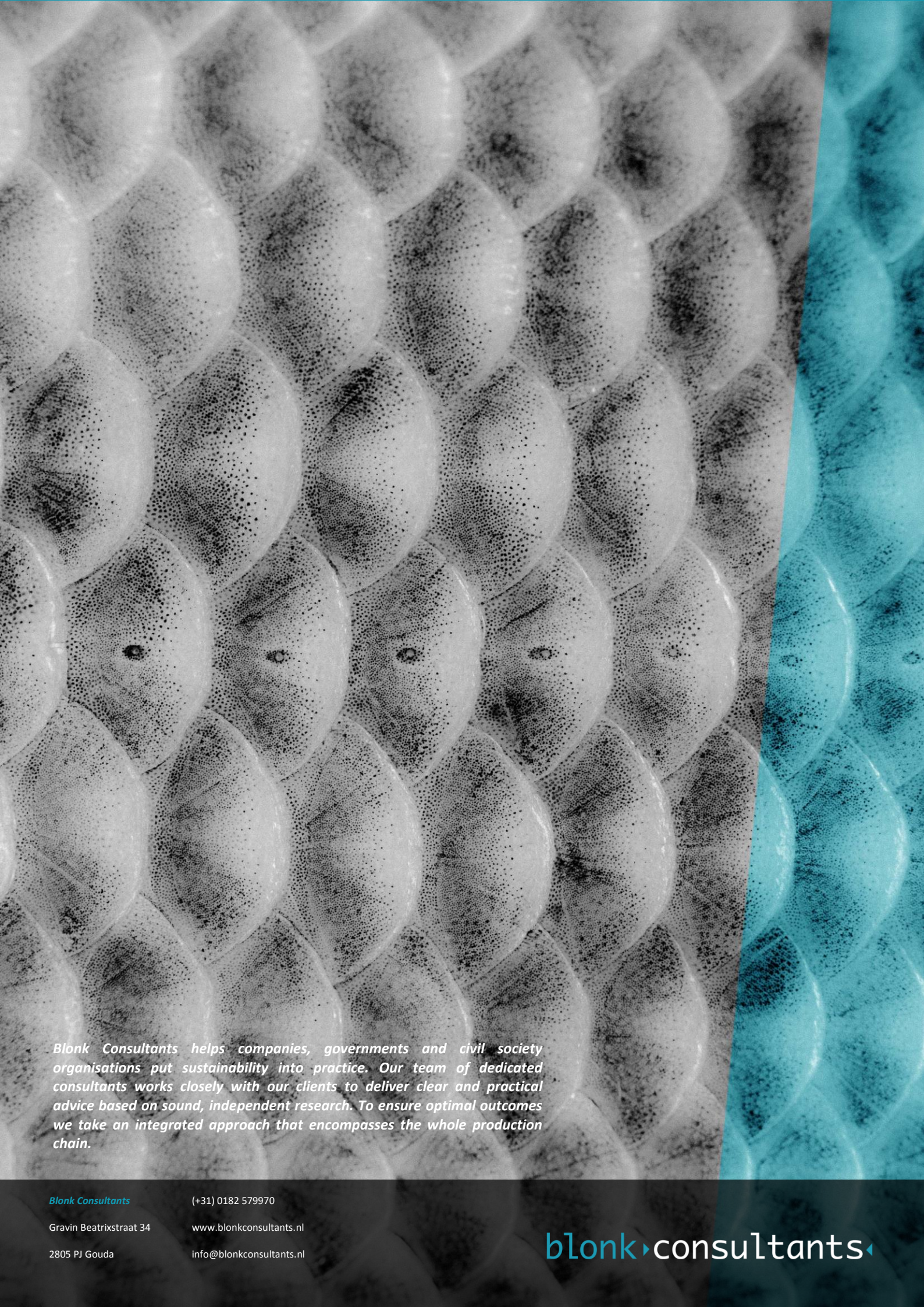
Average Contribution of activity data (related to background processes)

Table A3.1 Calculation of average contribution of activity data to total impact

	Wheat Wet milling	Maize Wet milling	Wheat Dry milling	Soybean Crushing (solvent)	Soybean Crushing (solvent)	Sugar From sugar beet	Average	Average scaled to 80%
Processing activity data	DE	FR	UK	US	RER	DE		
Production of crops	60.8	95.5	81.4	79.0	75.5	72.4	77.4	61.9%
Transport	0.4	0.3	0.7	8.3	13.9	3.5	4.5	3.6%
Fuel use	6.3	1.1	2.7	3.4	2.0	12.5	4.6	3.7%
Electricity use	24.1	2.9	14.3	4.6	5.7	7.3	9.8	7.9%
Water use	0.2	0.2	0.2	0.0	0.0	0.0	0.1	0.1%
Other raw materials	0.0	0.0	0.0	2.2	1.3	4.2	1.3	1.0%
Waste water treatment	8.1	0.0	0.7	2.5	1.6	0.0	2.2	1.7%
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	80%

Table A3.2. DQR Rating of activity data that are determined with a generic model.

	Source	P	TiR	TeR	GeR
Allocation	FAO LEAP feed guidelines 2014. original data are collected over period 2007-2011. p95 Van Zeist (2012)	LEAP report is externally reviewed. Data for economic allocation from van Zeist are externally reviewed → 2	Data concerning 2007-2011 4 years old with respect to the reference year → 2	Data fully comply to meta data description → 1	Data are well representative for countries although collected on higher scale level →2
Crop Mix	Most recent FAO trade statistics	Data are considered to be measured and reviewed on plausibility by countries that provide them: → 2	Most recent data 3 years old with respect to the reference year → 2	Data has been modelled exactly as described in the meta data → 1	The crop mix is fully representative for geography stated → 1
Transport modalities mix	Eurostat	Based on statistics from EU-28 countries, plus literature for countries outside EU. → 2	Data from 2013-2017 → 2	Data has been modelled exactly as described in metadata → 1	Geographical representativeness fully representative for countries and regions → 1
Transport distance	Google Maps, Searates.com	Based on country midpoint distances using google maps (for land based transport) and shipping distances for intercontinental transport. → 3	Data from 2017 → 1	Data has been modelled exactly as described in metadata → 1	Geographical representativeness fully representative for countries and regions → 1
Waste water use	Default approach for waste water is mass balance of the process.	Data is calculated using mass balance of the specific process → 2	Mass balance depending on the original source of the process year → 3 (1-5)	Technology aspects are similar to what described in the title year → 3	Geographical representativeness depends on the original source → 3 (1-5)



Blonk Consultants helps companies, governments and civil society organisations put sustainability into practice. Our team of dedicated consultants works closely with our clients to deliver clear and practical advice based on sound, independent research. To ensure optimal outcomes we take an integrated approach that encompasses the whole production chain.

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