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AGRIBALYSE® 3.2

THE FRENCH LCI DATABASE ON AGRICULTURE AND FOOD

Methodological report on agricultural production

FINAL REPORT

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EXPERTISES

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For previous versions of AGRIBALYSE® see previous reports:

- **Koch P. and Salou T., 2022.** AGRIBALYSE®: AGRIBALYSE®: Methodological report on agricultural production- Version 3.1 ; initial version v1.0 ; 2014. Ed ADEME, Angers, France. 342 p.
- **Koch P. and Salou T., 2020.** AGRIBALYSE®: AGRIBALYSE®: Methodological report on agricultural production- Version 3.0 ; initial version v1.0 ; 2014. Ed ADEME, Angers, France. 319 p.

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SUMMARY

AGRIBALYSE®, FROM FARM TO FINISHED PRODUCT

Since 2009, the AGRIBALYSE® program has been developing and making available an LCI database associated with methodology for French agricultural production. The beginning of 2020 marks a turning point, with an extension of the scope from upstream agriculture to the finished product now including not only French production, but also imports. Starting with version 3.0, LCI references will therefore be produced for all the main foods consumed in France.

AGRIBALYSE® v3.2 (September 2024) is built on the work of previous versions. This methodological report corresponds to the agricultural component of the v3.2 database, and to the scope of the former AGRIBALYSE® database1 . This report, focusing on the agricultural component, therefore complements the "Food products" methodological report of AGRIBALYSE® v3.2 .

AGRIBALYSE®- AGRICULTURAL DATA: DEVELOPMENTS AND ADDITIONAL SOURCES

The agricultural LCI data in the AGRIBALYSE® database come from three sources:

- data from previous versions of the AGRIBALYSE® database, which have been updated with MEANS-InOut software (updating certain emission models and correcting minor errors). These data, based on activity data deemed too old (2005-2009), are currently being updated through the InCyVie project (some updated data are already available in version 3.2 and the others will be available in the next version 3.3).
- new product LCIs (fruit and vegetables, animal feed, etc.) developed for AGRIBALYSE®, using the same methodology and calculated with MEANS-InOut. All ECO-ALIM data have been integrated and harmonized with the rest of AGRIBALYSE®.
- additional data from Ecoinvent® and the World Food LCA Database, in order of priority. These data, developed outside AGRIBALYSE®, concern imported products in particular. They follow their own methodology, similar to AGRIBALYSE® but with some variations.

This report describes only the methodology for agricultural data produced within the framework of AGRIBALYSE®. Specific documents detail AGRIBALYSE® work on certain sectors, such as fruit and vegetables or seafood products. For data from sources other than AGRIBALYSE® (e.g. Ecoinvent® and WFLDB), please refer to the methodology of these projects.

METHODOLOGY REPORT - AGRICULTURAL SECTION

General objective of the report

This report documents the methodological choices made by the program partners when establishing the AGRIBALYSE® database, for the agriculture components, or the methodological choices updated with each new version (refer to the change reports between the different versions of the database). These choices were generally approved unanimously, if not by a majority. In addition to the metadata available for each LCI, this report ensures the transparency of the process. It presents the process and the choices made, but is not intended as a recommendation guide. It is intended to enable outsiders to assess the quality of the data provided, and to produce agricultural LCIs comparable to those produced by AGRIBALYSE®.

LCI calculation: data collection, processing chain

The inventory data describing the technical itineraries were defined by the technical institutes and entered into an input tool. Emissions models were then applied to these technical itineraries to calculate direct emissions flows and resource consumption. For AGRIBALYSE® versions 1 to 1.3, this was done in an Excel-based processing chain. Since version 3.0, this has been carried out in MEANS-InOut software (referred to as "InOut" in the following) by several of the AGRIBALYSE®

[1] Previous versions of the report are available on the REVALIM AGB dataverse: Koch and Salou 2022 .

program partners (Koch Consulting, technical institutes, INRAE, etc.). The background processes were then integrated via Simapro® software, enabling LCI and ALCI to be calculated. InOut is available under a service contract for users wishing to carry out new agricultural LCAs using the AGRIBALYSE® methodology.

Quality control

Data quality control was carried out at two levels. Firstly, the technical itinerary data provided by the technical institutes were checked by experts from outside the AGRIBALYSE® program. Secondly, the LCI data calculated by INRAE and Agroscope were checked internally by the technical institutes. In addition, the transfer of the calculation tool used for versions 1.3 and earlier to InOut enabled a global check and various corrections. These various checks have significantly improved the quality of the inventories produced.

Products studied

The main French agricultural products have been analyzed in AGRIBALYSE®, using a consistent methodology. Product groups" refer to crops or animals (e.g. wheat, corn, broiler chicken, pork, etc.). The construction of representative LCIs for France for most "product groups" was carried out by aggregating unit LCIs corresponding to contrasting systems (conventional, organic, AOC, regional variations, etc.); two average LCIs for France are intended to be proposed for all agricultural production (an average conventional product for France and an average organic product for France). This aggregation has been made and is updated on a case-by-case basis for each production by the Agricultural Technical Institutes partnering the program

Agricultural products studied in AGRIBALYSE®*	
Crops	*Oats, durum wheat, soft wheat, sugar beet, carrot, rapeseed, faba bean, maize, barley, peas, potato, sunflower, triticale, cauliflower, leek, onion, flax, hemp, soybean, sorghum*
Associated crops	*Wheat-beans, triticale-peas, wheat-peas, barley-peas, barley-beans*
Meadows/Forages	*Grass, alfalfa, corn silage, cereal-protein crop mix (meslin)*
Perennial crops: Fruit and vines	*Peach/nectarine, apple, cider apple, wine grape, walnut, pear*
Vegetables and special crops in France	*Strawberry, lettuce, tomato, zucchini, melon, endive shrub, rose*
Tropical specialty crops	*Coffee, clementine, jasmine rice, cocoa, mango, banana, pineapple*
Plant production: 49 product groups	
Cattle	*Cow's milk, beef cattle*
Sheep	*Sheep's milk, lamb*
Goats	*Goat's milk*
Poultry	*Eggs, broiler chicken, turkey, duck for roasting, duck for force-feeding*
Rabbit farming	*Rabbit*
Fish farm	*Trout, sea bass / sea bream*
Pigs	*Pigs*
Animal production: 14 product groups	

*The Organic LCA project has added products from organic farming, please refer to the dedicated report.

AGRIBALYSE also includes agricultural/aquaculture production data created by contributors to the database updates, which are not described in this report: please refer to the dedicated reports available on the agribalyse documentation website:

- Specific reports on 7 agricultural production inventories, Gastaldi Gentiane, 2022
    - Juice beet
    - Pepper
    - Endive root
    - Grapefruit juice
    - Kiwi
    - Quinoa France
    - Farmed salmon
- Specific report on the creation of inventories for the publication of Agribalyse 3.0, Asselin-Balençon et al. 2020

- Green bean
- Cherry
- Mould
- Seaweed
- Shrimp

Finally, there is a specific methodological report on fishery products (LCI Fishery project).

Representativeness

The initial aim of AGRIBALYSE®-agriculture report was to obtain LCIs for agricultural products representative of the French market. However, given the variability of practices and soil and climate conditions across the country, it is often difficult to construct a relevant agronomic description of an average French product. Agronomically relevant regional variations, or variations by production method, have therefore been defined, enabling us to construct an average French product.

Subsequently, different production methods for the same crop were studied in various projects (ECO-ALIM, fruit and vegetables, organic LCA, etc.). These LCIs are provided in AGRIBALYSE® but do not represent "average" practices. The use of AGRIBALYSE® LCIs must therefore take into account their representativeness.

System limits (spatial/temporal)

The system considered for AGRIBALYSE®'s agricultural LCIs is from cradle to grave (for crop production inventories) or from production plant to production plant (for animal production inventories). For crop production, this implies the integration of all upstream processes (input manufacturing) and field processes (cultivation operations), but excluding post-harvest processes that may take place on the farm (e.g. potato storage, cereal drying). Animal workshops are to be considered in the strict sense of the term. All processes required to run the workshop (livestock buildings, on-farm feed storage and production, milking parlour and milk tank operation, etc.) are included, but food processing operations (cheese processing, etc.) are treated separately from the agricultural phase. The reference period used for the initial construction of the data was 2005-2009. More recently integrated data have a more recent reference period (e.g. 2011-2015). The reference period of each LCI is indicated in the metadata.

Direct emissions associated with animal and plant production on the production site were modeled (see next point), while indirect emissions linked to the production of inputs used on the production site were integrated using data from pre-existing inventory databases, mainly Ecoinvent® . Specific work has been carried out on animal feed (Appendix II

Models for calculating direct emissions

Agricultural production activities generate direct emissions (e.g. CO_2, NH_3, ETM, P, phytosanitary molecules, etc.) as well as the consumption of resources required for production processes (water consumption, land use, etc.). These flows emitted into the various compartments (water, soil, air) were calculated using models. Each substance flow was modeled by a specific model, which was chosen as being the most suitable in relation to the objectives of the AGRIBALYSE® program. The**Table11** presents the emissions and consumption selected, the items considered and the models used.

Allocation

The procedure for managing allocations complies with international standards. For plant-based products, co-products are often generated during the agro-industrial transformation of the raw agricultural product. This point is therefore covered by processing data (from ACYVIA and World Food) for the majority of plant products. For animal products leaving the farm, a so-called "biophysical" allocation has been implemented. In the first instance, allocation is avoided by breaking down the system into classes of animals managed in a similar way. Secondly, for phases where allocation cannot be avoided (e.g. dairy cow production phase), impacts are allocated between the various co-products in proportion to the energy required to produce them. The environmental impacts of animal classes producing a single product are fully allocated to that product. For example, the impacts of a "dairy heifer" class will be allocated to the "cull cow" product.

ABSTRACT

AGRIBALYSE® v3.2, FROM FARM TO FOOD PRODUCT

Since 2009, the AGRIBALYSE® program has been developing and making available an LCI database and the associated methodology for French agricultural production. 2020 marks a turning point, with an extension of the scope from agriculture to food products, now including French production but also imports. From this version 3.0 onwards, LCI references will therefore be produced for all the main feedstFUfs consumed in France.

The AGRIBALYSE® v3.2 version (September 2024) is based on the previous work and versions. This methodological report corresponds to the agricultural section of the v3.0 database, and to the scope of the former AGRIBALYSE® database. This report, which focuses on the agricultural component, therefore complements the "Food Products" methodological report of AGRIBALYSE® v3.2 (Cornelus et al., 2024).

AGRIBALYSE® v3.2 - AGRICULTURAL DATA: DEVELOPMENTS AND COMPLEMENTARY SOURCES

The AGRIBALYSE® v3.2 Agricultural LCI data come from three sources:

- the former AGRIBALYSE® v1.3 data which were updated with the MEANS-InOut software (updating of some emission models and correction of minor errors). These data, based on activity data deemed too old (2005-2009), are currently being updated through the InCyVie project (some updated data are already available in version 3.2 and others will be available in the next version 3.3).
- new LCIs of products (fruits and vegetables, animal feed, etc.) developed in AGRIBALYSE®, following the same methodology and calculated with MEANS-InOut. All ECO-ALIM data have been integrated and harmonized with the rest of AGRIBALYSE®.
- additional data from Ecoinvent® and the World Food LCA Database in order of priority. These data developed outside AGRIBALYSE® address in particular imported products. They follow their own methodology, similar to AGRIBALYSE® but with some variations.

This report only describes the methodology for agricultural data produced within the framework of AGRIBALYSE®. Specific documents detail AGRIBALYSE®'s work on certain sectors, such as fruit and vegetables or seafood products. For data from sources other than AGRIBALYSE® (e.g. Ecoinvent®), please refer to the methodology of these projects.

THE METHODOLOGICAL REPORT - AGRICULTURAL COMPONENT

General aim of the report

This document presents the methodological choices made by the partners during construction of the agricultural component of AGRIBALYSE® database or the methodological choices updated with each new version (refer to the change reports between the various versions of the database). Most choices were adopted unanimously, the rest by a majority. Complementing the metadata provided with each LCI, this document ensures transparency of the approach followed by AGRIBALYSE®. It describes in detail the choices made but has not been designed as a manual. It should help LCA practitioners assess the quality of the AGRIBALYSE® database and create LCIs comparable to those of the AGRIBALYSE® database.

LCI calculation: data collected and calculation chain

AGRIBALYSE® identified the most appropriate calculation methods for all direct (foreground, on-farm) emissions and resource consumption and used pre-existing datasets (mainly Ecoinvent®) for calculating indirect emissions (background) associated with the production of inputs.

Data describing agricultural practices were provided by the technical institutes, into an input tool. Then, emission models were applied according to agricultural practices to calculate direct emission and resource consumption flows. For AGRIBALYSE®, from versions 1 to 1.3 this was done in an Excel-based processing chain. Since version 3.0 this has been done

in the MEANS-InOut software (referred to as "InOut" in the rest of the document) by several of the partners of the AGRIBALYSE® program (Koch Consulting, technical institutes, INRAE...). The background processes were then integrated via Simapro®, allowing the calculation of LCI. InOut is accessible under service contract conditions for users wishing to perform new agricultural LCAs according to the AGRIBALYSE® methodology.

Quality control

Quality control was considered extremely important. Quality control of agricultural system descriptions was performed by independent experts, while results calculated by INRA and Agroscope was performed by experts from the technical institutes involved in the program. This two-step inspection process was important to improve quality of the LCIs.

Products assessed

AGRIBALYSE® created LCIs of the main French agricultural products (including three imported products), organized into "product groups", following a homogeneous methodology. "Product groups" were composed of varieties of production systems (e.g., conventional, organic, regional) for individual crop or animal products. An "average French" LCI for most product group was obtained by aggregating all of its LCIs ; two average French LCIs will be proposed for all agricultural products (an average French conventional product and an average French organic product).

Products assessed in AGRIBALYSE®**.	
Annual crops	*Durum wheat, soft wheat, sugar beet, carrot, rape seed, faba bean, grain maize, barley, pea, potato, sunflower, triticale, cauliflower, cauliflower, leek, onion, flax, hemp, oat, soybean, sorghum*
Intercrops	*Faba bean-wheat, pea-triticale, pea-wheat, pea-barley, faba bean-barley*
Forage/grassland	*Grass, alfalfa, silage maize, cereal-legume intercrop harvested as silage*
Fruits and vineyard	*Peach, apple, cider apple, wine grape, walnut, pear*
Special crops	*Rose, tomato, ornamental shrubs, strawberries, lettuce, zucchini, melon, endive*
Tropical special crops	*Coffee, clementine, jasmine rice, cacao, mango, banana, pineapple*
Crop total: 49 product groups	
Cattle	*Cow milk, beef cow*
Sheep	*Sheep milk, lamb**
Goats	*Goat milk*
Poultry	*Egg, broiler, turkey, duck for roasting, fattening duck*
Rabbits	*Rabbit*
Aquaculture	*Trout, sea bass/sea bream*
Pigs	*Pig*
Animal total: 14 product groups	

* The LCA organic project has added products from organic farming, refer to the dedicated report.

AGRIBALYSE also includes agricultural production data created by contributors to database updates, which are not described in this report: refer to the dedicated reports available on the website of agribalyse:

- Specific reports on 7 agricultural production inventories, Gastaldi Gentiane, 2022
    - Beetroot for juice
    - Pepper
    - Chicory roots
    - Grapefruit for juice
    - Kiwifruit
    - Quinoa France
    - Farmed salmon
- Specific report on the creation of inventories for the publication of Agribalyse 3.0, Asselin-Balençon et al. 2020:
    - Green beans
    - Cherry
    - Mussel
    - Seaweed
    - Shrimp

Finally, there is a specific methodological report on fishery products (LCI Fishery project).

Representativeness

AGRIBALYSE® agricultural component originally aimed to provide LCIs of agricultural products representative of the French market. However, due to the variability of farmer practices, soils and climate in France, it was often difficult to describe a realistic "national average" agronomic system for products. This was one reason for creating several LCIs of the same product, differing in farmer practices or region of production. When possible, they were then aggregated to obtain "national average" products (e.g., fresh tomato = heated + non-heated tomatoes). Still, national representativeness could not be achieved for all products. Afterwards different modes of production of the same crop were studied in different projects (ECO-ALIM, fruits and vegetables etc.). These LCIs are provided in AGRIBALYSE® but do not represent "average" practices.

Representativeness should always be considered when using the LCIs.

System definition (space and time)

The system considered in AGRIBALYSE® agricultural LCIs is from cradle to field gate (for crops) or from cradle to farm gate (for animals). For crops, this implies that all up-stream processes (input production) are included but that post-harvest operations are excluded, even though they may occur on the farm (e.g., potato storage, cereal drying). For animals, all operations required for the production phase are included (e.g., animal production, fodder storage, milking room and machines), but no transformation phase is included in agricultural component of the database (e.g., slaughter, cheese making).

To create LCIs representative of current systems, the reference period chosen is from 2005 to 2009 for the first delivery of the database. Data integrated in the current version may have another reference period. Reference period is indicated in metadata of each LCI.

Direct emissions, linked to animal and crop production, happening on the farm itself were modeled in AGRIBALYSE®, whereas indirect emissions due to input production were based on pre-existing data, mainly from Ecoinvent® . Specific work was performed to estimate emissions for the production of feed ingredients (**Appendix K**).

Models used to calculate direct emissions

Farming activities cause direct emissions (e.g., CO_2, NH_3, heavy metals, P, pesticides) and use resources (e.g., water, land). Flows of pollution emitted to environmental compartments (i.e., water, soil, air) were calculated with models. Each flow was calculated with a specific model chosen as the most suitable according to the objectives and limits of the program. **Table11** shows the types of emissions and resource consumption included, their sources and the models used.

Allocation

Allocation rules follow international recommendations. For crop production, most co-products are generated in the processing phase, which is rerated in the food component of AGRIBALYSE®. For animal production, a "biophysical" allocation method was implemented. First, allocation is avoided by breaking the system down into animal classes, characterized by animal age/physiological stage and management. Then, for animal classes requiring allocation (e.g., dairy cows during milk production), allocation is based on the metabolic energy required to produce each co-product (e.g., calf, milk). In contrast, impacts of animal classes producing a single product are fully allocated to this product. For example, impacts of the "dairy heifer" class are allocated to the "cull cow" product.

INTRODUCTION

CONTEXT AND OBJECTIVES OF THE METHODOLOGICAL REPORT

Carrying out Life Cycle Assessments (LCA) of agricultural processes requires numerous methodological choices concerning the definition of the systems studied, functional units (FU), system boundaries and temporal limits, as well as models for calculating direct emissions (of primary importance) and their parameterization, impact indicators and characterization methods. The aim of this methodological report is to detail the choices made within the framework of the AGRIBALYSE®, agricultural program. It does not constitute a guide specifying mandatory and optional data for different uses, and its content therefore has no value as a recommendation.

The methodologies reported here have been used to produce Life Cycle Inventories (LCIs) for French agricultural production in mainland France and for certain overseas crops as part of the AGRIBALYSE® program.

This report is intended for anyone wishing to carry out an LCI using the AGRIBALYSE® methodology.

This report has been structured according to the four phases of the LCA methodology defined in ISO 14040/44 (ISO, 2006a and ISO, 2006b).

THE LIFE CYCLE ASSESSMENT APPROACH

LCA is a method for the environmental assessment of a product or service throughout its life cycle. LCA is a four-stage process used to compare different products and identify opportunities for improving their environmental performance. According to ISO standards (2006a and 2006b), the four phases are:

1. Defining the objectives and scope of the study. This phase enables us to set out the problem and define the objectives and scope of the study.
2. Inventory of inputs (resource extraction, means of production) and outputs (emissions, products) required to perform the system function under study.
3. Assessing the impact of previously inventoried flows
4. Interpretation, in which the results obtained in the previous phases are analyzed, along with any uncertainties.

1. Defining the objectives and scope of the study

1.1. Objectives

1.1.1. Background to the AGRIBALYSE program®

Since 2009, the AGRIBALYSE® program has been developing and making available an LCI database and associated methodologies for French agricultural production. The beginning of 2020 marks a turning point, with an extension of the scope from upstream agriculture to the finished product. Starting with version 3.0, LCI references will therefore be produced for all the main foods consumed in France.

The AGRIBALYSE® v3.2 version (September 2024) builds on the work and previous versions. This methodological report corresponds to the agricultural component of the v3.2 database, and to the scope of the initial AGRIBALYSE® database. This report, focusing on the agricultural component, therefore complements the overall AGRIBALYSE® v3.2 methodological report (Asselin-Balençon et al., 2020).

The AGRIBALYSE® agricultural program was launched in 2013. This methodological report was one of the major deliverables. It documents the choices made by the 14 partners in the AGRIBALYSE® program over the last ten years, when establishing the AGRIBALYSE® database. It has been adapted to take account of progressive updates and the extension of the scope.

This report presents:

- The requirements, recommendations and considerations stipulated in the AGRIBALYSE® Collection Guide,
- Decisions taken at AGRIBALYSE® Steering Committee meetings on methodological issues,
- Evaluations carried out and decisions taken at seminars dedicated to "methods for calculating direct emissions" and "quality control of results".

1.1.2. Deliverables

The AGRIBALYSE® v3.2 database provides LCIs for around 2,500 foods, in line with the CIQUAL nutritional database (cf. Asselin-Balençon et al., 2020). These food LCIs result from the aggregation of several thousand data points, to cover every stage in the production chain. The data are made available in aggregated Excel format and in disaggregated unit process format via LCA software (e.g. SimaPro, OpenLCA). Access to the AGRIBALYSE® 3.2 database via LCA software is conditional on access to the Ecoinvent® database used in the background, via an appropriate License, insofar as the entire database is available in disaggregated version.

All agricultural LCIs produced in AGRIBALYSE® are made available to users via LCA software. Average data for France are used for final food LCIs, but this is not the case for declinations (organic, specific technical itineraries, etc.). These LCIs are available and can be used to specify/substitute average LCIs for users with precise data, particularly in eco-design and agricultural system improvement projects.

1.2. Scope of study

Defining the scope of the study ensures that the scale, depth and level of detail of the study are compatible with, and meet, the study objectives. The following chapters detail the elements stipulated by international standards ISO 14040 and 14044 (ISO, 2006a and ISO, 2006b). The definition of the scope of the LCA study must take into account and clearly describe the following elements:

- Product systems to be studied (see A.2.1)
- The functions of the systems studied (see A.2.1)
- Functional units (See A.2.1)
- The system boundary (see A.2.2)
- Data requirements (see A.2.3)
- Data quality requirements (see A.2.4)
- Type of critical review (see A.2.5)
- Type and format of report specified for the study (See A.2.6)
- Allocation rules (see B.3)
- Life cycle impact assessment methodology and types of impact (see Part C).

1.2.1. Product systems analyzed and their functions

1.2.1.1. Systems analyzed

This report applies to the agricultural part of AGRIBALYSE®, which focuses on agricultural product systems located in mainland France, as well as a few imported products of tropical origin. ISO 14044 (ISO, 2006b) and the ILCD standard (JRC and IES 2010a) both give a very broad definition of the notion of product. Indeed, when applying the ISO/ILCD definitions of "product", each AGRIBALYSE® inventory represents a product.

Given the great diversity of agricultural product systems, AGRIBALYSE® has introduced a generic categorization to enable simpler communication of results. The notions of "**product group**" and "**declination**" have been introduced and defined as follows:

- A "product group" brings together comparable products through the notion of **declination**.
- The variations enable us to distinguish production systems that contrast in terms of specific parameters, such as production region, technical itinerary or production method.

The choice of product groups was based on an analysis of the agricultural products most frequently consumed in France (BIO IS, 2010). Declinations were made according to the following three criteria: (1) representative production system, (2) contrasting production system or (3) innovative production system. The declinations were selected by each technical institute according to its expertise and resources within the program, then discussed and validated with the project leaders and ADEME.

Using this terminology, the agricultural production systems presented in**Table1** were analyzed.

Table1: Agricultural products studied in AGRIBALYSE®.

Agricultural products studied by AGRIBALYSE®*.	
Crops	*Oats, durum wheat, common wheat, sugar beet, carrot, rapeseed, faba bean, maize, barley, peas, potato, sunflower, triticale, cauliflower, leek, onion, flax, hemp, soybean, sorghum, quinoa, green bean, beet for juice, chicory root, pea. spelt, lupin*
Associated crops	*Wheat-beans, triticale-peas, wheat-peas, barley-peas, barley-beans*
Meadows/Forages	*Grass, alfalfa, corn silage, cereal-protein crop mix (meslin)*
Perennial crops: Fruit and vines	*Peach/nectarine, apple, cider apple, wine grape, walnut, pear, cherry, kiwi*
Vegetables and special crops in France	*Strawberry, lettuce, tomato, zucchini, melon, chicory shrub, rose*
Tropical specialty crops	*Coffee, clementine, cocoa, mango, banana, pineapple, pepper, grapefruit,*
Plant production: 49 product groups	
Cattle	*Cow's milk, beef cattle*
Sheep	*Sheep's milk, lamb*
Goats	*Goat's milk*
Poultry	*Eggs, broiler chicken, turkey, duck for roasting, duck for force-feeding*
Rabbit farming	*Rabbit*
Fish farm	*Trout, sea bass / sea bream, salmon*
Pigs	*Pigs*
Animal production: 14 product groups	

*AGRIBALYSE also includes agricultural production data created by contributors to the database updates, which are not described in this report: please refer to the dedicated reports.

Agricultural production systems are frequently multifunctional. It is not uncommon for a single production process to supply several co-products (e.g. milk - veal - cull cow). To allocate impacts appropriately, these production systems have been broken down into several modules. In the animal sector, animal classes were constructed (e.g. calf/heifer/cow in production for a dairy production workshop). In the plant sector, vineyards and orchards have been differentiated into production phases (e.g. nursery/ orchard phases in full production). Consequently, the LCI of an AGRIBALYSE® application can be derived from:

- A single inventory: veal veal or durum wheat
- An aggregation of several inventories (phase or internal inventories): cull dairy cow, cider apple or carrot (seeAppendix AA
- An inventory by co-product allocation: lowland cattle milk

1.2.1.2. Generic function of production systems

Given the objectives of the AGRIBALYSE® program, the function of production systems has been targeted at food, i.e. the supply of agricultural products for human and animal consumption. In general terms, the system function can be defined as "the provision of a quantity of an agricultural product (animal or plant), from the field/greenhouse/workshop, (1) at a certain precisely defined quality level, or (2) of a defined composition".

The statement "of a defined composition" is applicable to products that have been constructed as an aggregation of different production systems and therefore represent a mix of these different systems. The statement "at a certain quality level" applies to all other products (see examples below).

Specification of the quality level (sugar beet) or composition of a product (potato), documented in the summary sheet:

Example sugar beet root (special inventory): inventory of the production of 1 kg of sugar beet with a sugar content of 16%.

Example potato (aggregation): inventory of the production of 1 kg of potatoes from different ITKs, at 80% humidity. This is an aggregation of potatoes for industry (28%), potatoes for the fresh market excluding firm flesh (52%) and starch potatoes (20%).

The definition of the system's generic function is not applicable to two metropolitan specialty crops (rose, shrub): their function is not food, but correspond to the satisfaction of other customer demands.

Other functions of agricultural production systems, such as contributing to biodiversity, land management or generating income for the farmer, are not considered co-products. Consequently, none of these flows have been allocated to them.

1.2.1.3. Nomenclature convention

Inventories are named in accordance with ILCD recommendations (JRC and IES, 2010b) and GLAD recommendations[2] . The nomenclature scheme adopted is as follows (see rule 17 - JRC and IES, 2010b): "Base name; Treatment, standards, roads; Quantitative flow properties; Mix type and location type".

To name your LCI according to Agribalyse rules, an Excel file has been produced to help you: LCI name generator tool available here .

The rules below concern the structure of the process name and editorial rules:

- the nomenclature is **in English** ;
- the use of excessively long and/or unstructured names is avoided, as they are difficult to display in LCA tools;
- commercial or obsolete names must not be used;
- all information relating to the technological representativeness of the data and the age of the data are documented in the metadata and do not appear directly in the process name, unless if those ones have given definition of two separate processes.
- you can choose whether or not to export with the suffix #MEANS- Id of the step.
- users can enter a different name from the one generated by InOut (this will link with naming using agribalyse rules)
- do not add "U" at the end of the name, as this is automatically done when exporting to SimaPro

[2] Guidance on GLAD's metadata descriptors, 2023

Example of LCI naming for upstream agriculture (underlined fields are mandatory):
Raw material name, Production method, Quantitative flow properties, ITK precision, Geographical precision, Stage {Country}.

Field details by way of example:
Raw material name:= *Cherry*
Production method: *Conventional* or *Organic* or Other (under label)
Breadmaking quality
Quantitative flow properties: OPTIONAL ex: *15% moisture*
ITK precision: OPTIONAL *Rainfed* or *systematic cover cropping scenario* or *Irrigated* etc...
Geographical details: OPTIONAL: *North* or *Aquitaine* or *national average*
Stage*: at farm gate*
{Country}: Country of production *FR* or *TH* or others with ISO 3166-1 alpha-2 country codes.

Naming examples

- Cherry, conventional, national average, at farm gate {FR} U
- Cherry, organic, national average, at farm gate {FR} U
- Soft wheat grain, conventional, breadmaking quality, 15% moisture, at farm gate {FR} U
- Soybean grain, organic, system number 3, at farm gate {FR} U
- Grain maize, basis scenario without lever, at farm gate {FR} U
- Spring barley, organic, system number 2, at farm gate {FR} U
- French bean, conventional, national average, at farm gate {FR} U
- Soft wheat grain, systematic cover cropping scenario, at farm gate {FR} U
- Sunflower grain, systematic covercropping scenario, at farm gate {FR} U

1.2.1.4. Functional unit (FU)

The FU is the quantity quantifying the system's function and performance characteristics. Its purpose is to provide a reference against which inputs and outputs are normalized (in the mathematical sense).

In line with the function (see chapter A.2.1), the FUs of AGRIBALYSE® inventories have mainly been defined as a unit of mass or volume (provided the density is specified): 1 kilogram or 1 liter of product. Depending on the nature of the product, the necessary details have been documented (e.g. definition of the product's moisture content or fat content), in the LCI name and in the metadata.

The selected FUs are:

- For crop production: kg of raw material in compliance with standards (moisture, sugar, protein) for field-grown product.
- For animal production:
  - for animals: kg live weight
  - for milk: kg of corrected milk (4% fat and 3.3% protein)
- - for eggs and wool: kg

A different functional unit had to be selected in the following cases:

- When the common market unit is not weight:

1. Shrub: the functional unit of the shrub is "1 container shrub".
2. Rose: the functional unit is "100 stems of cut flower rose" (corresponding to an average yield per m²).

- When the calculation unit used is dry matter (forage).

1. Grassland respectively mown grass: the FU is 1 kg of dry matter after deduction of harvesting losses (mowing and collection, detailsTable150 enAppendix II). The FU of grazed grass is 1 kg of dry matter, without harvest losses.

2. Alfalfa and corn silage: FU is 1 kg of dry matter.

- Special cases:

1. Coffee: The functional unit is 1 kg of green coffee raw material after drying and pulp removal, as most statistical data use this reference.
2. Carrots and fruit: the FU is 1 kg of raw product marketed for fresh consumption (1st choice) or for processing (2nd choice).
3. Clementine: The functional unit is 1 kg of raw material for the export market.

1.2.2.System boundary

The AGRIBALYSE® database must meet the requirements of ISO 14040 (ISO, 2006a) and the ILCD guide (JRC and IES, 2010a). The recommendations of the ILCD guide vary according to the purpose and main use of the LCA study (what is defined as a "situation"). The agricultural component of the AGRIBALYSE® database falls into situation A "microlevel-LCI datasets" (JRC and IES, 2010a).

1.2.2.1. Main rule: cradle to farm gate

For the agricultural stage, the **main rule** of the AGRIBALYSE® LCIs is to consider the "cradle *to gate*" system, i.e. from the cradle to the **exit of the field** (for crop production inventories) **or the production workshop** (for animal production inventories: the farm gate is equivalent **to the exit of live animals from the farm before their transport**).

This means that for **crop production** (produced in mainland France or abroad for tropical crops), any post-harvest processes carried out on the farm (such as potato storage or cereal drying) are not taken into account here.

In order to be consistent across all productions, transport between the field and on-farm storage has been taken into account for crops and orchards, with the exception of vineyards and beet, whose products generally do not transit through the farm (the storage site may be on the farm or off-site, with no transit through the farm).

1.2.2.1.1. Processes included

In AGRIBALYSE®, each inventory takes into account all the processes and inputs required to produce an agricultural product, within the limits "from cradle to field/workshop gate". This perimeter definition is in line with those defined in GESTIM (Gac *et al*, 2010) and Ecoinvent® (Nemecek and Kägi, 2007).

The processes considered are:

- For crop production:
    - Seed and plant production (vegetable and fruit plant nursery)
    - Production and supply of active substances through plant protection products (herbicides, fungicides, insecticides and others)
    - Production and supply of mineral fertilizers
    - The production and supply of active ingredients through plant protection products (herbicides, fungicides, insecticides and others).
    - Production and supply of mineral fertilizers
    - Application of organic fertilizers.
    - All tillage and other cultivation operations (inter-crop management, soil preparation, sowing, treatments, fertilizing, harvesting, transport, etc.) including:
    - Production of machinery and equipment (such as plastic mulching film for market gardening
    - Building construction, maintenance and equipment storage (hangar/hall/garage),
    - Shelter infrastructures (tunnel, plastic multi-chapel and glass greenhouse) and their end-of-life,
    - The fuels required for these activities. Third-party work is included in these processes.
    - Surface irrigation (equipment used (e.g. irrigation hose), water used and energy consumed,

- The water added to crop protection products in sprayers ,[3]
- Equipment cleaning water
- Transporting inputs to the farm and field,
- Where applicable, energy consumed outside farming operations
- Direct emissions.

✓ For animal production:

- The manufacture of feed (raw material production and processing) and bedding, as well as their transport to the rearing facility, whether or not they are produced on the farm.
- Production, harvesting, conservation and availability of forage.
- Use of meadows, including grazing; access to a grazing area for monogastric animals
- Watering water consumed by animals.
- Water for cleaning equipment (e.g. milking machines) and buildings, and for cooling systems.
- Breeding and production of young animals.
- Farm equipment and buildings (milking parlour, cowshed, handling equipment, building, etc.), including the production of machinery/buildings, their maintenance and storage space (shed/hall/garage).
- Energy consumed to carry out operations such as milking, handling and ventilation (i.e. fuel oil, electricity, etc.).
- Manure management (grazing, buildings, storage)
- Direct emissions (see A.2.4 Direct emissions).

Figures 1 to 9 illustrate the perimeters of the different types of systems studied in AGRIBALYSE®.

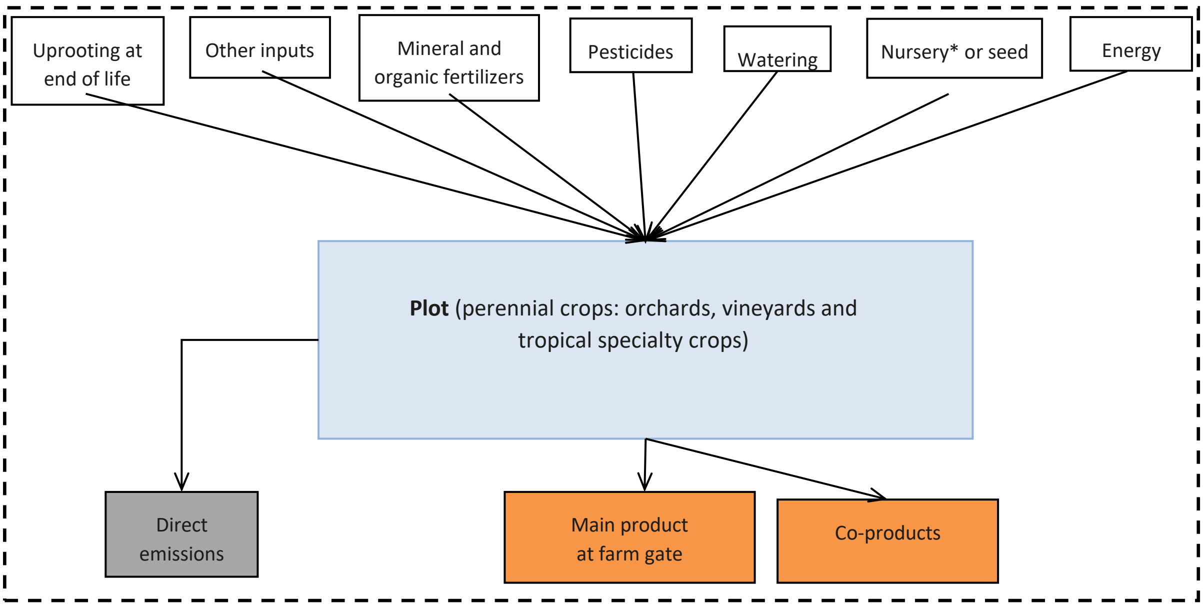

Figure1: System boundaries for perennial crops such as orchards, vines and tropical specialty crops (coffee, clementines).

[3] For example: Spray mixture consumption in liters per hectare is a data item available from SSP (Service de la Statistique et de la Prospective - Agreste) surveys.

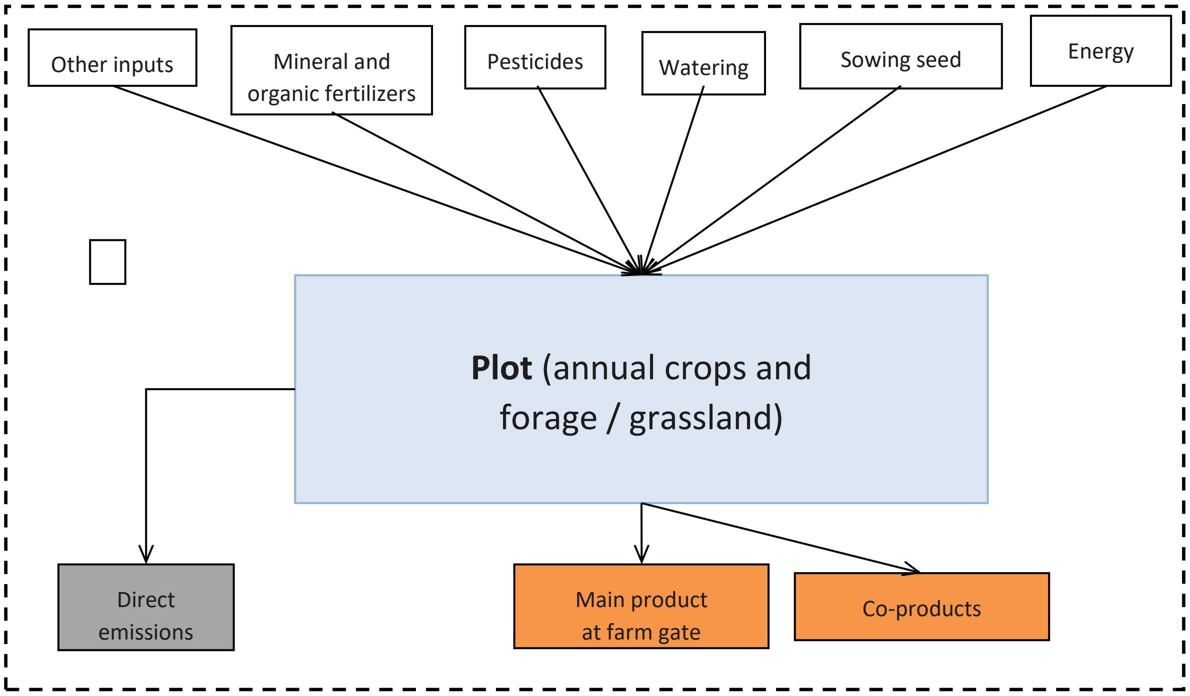

Figure2: System boundaries for annual crops, forage and grassland.

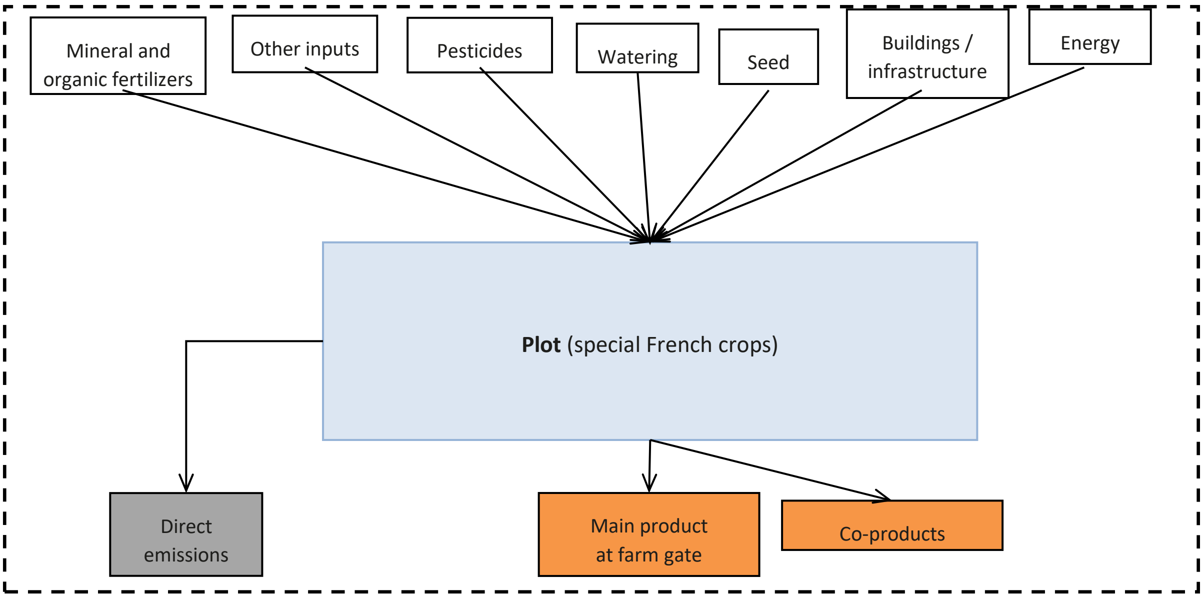

Figure3: System boundaries for metropolitan specialty crops (shrub, rose and tomato).

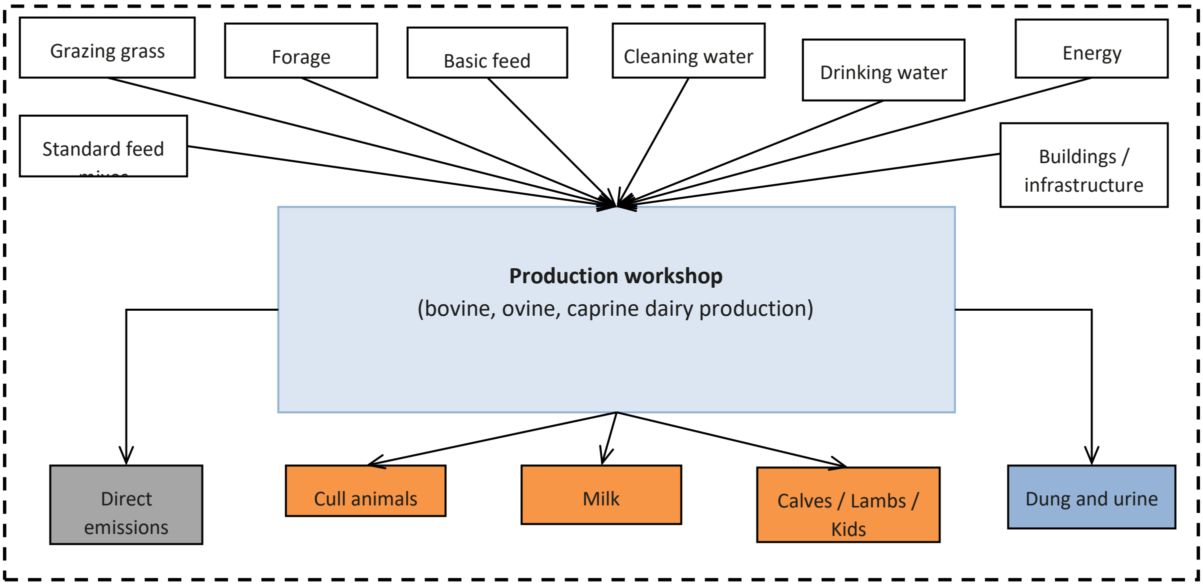

Figure4: System delimitation for dairy production (cattle, sheep, goats).

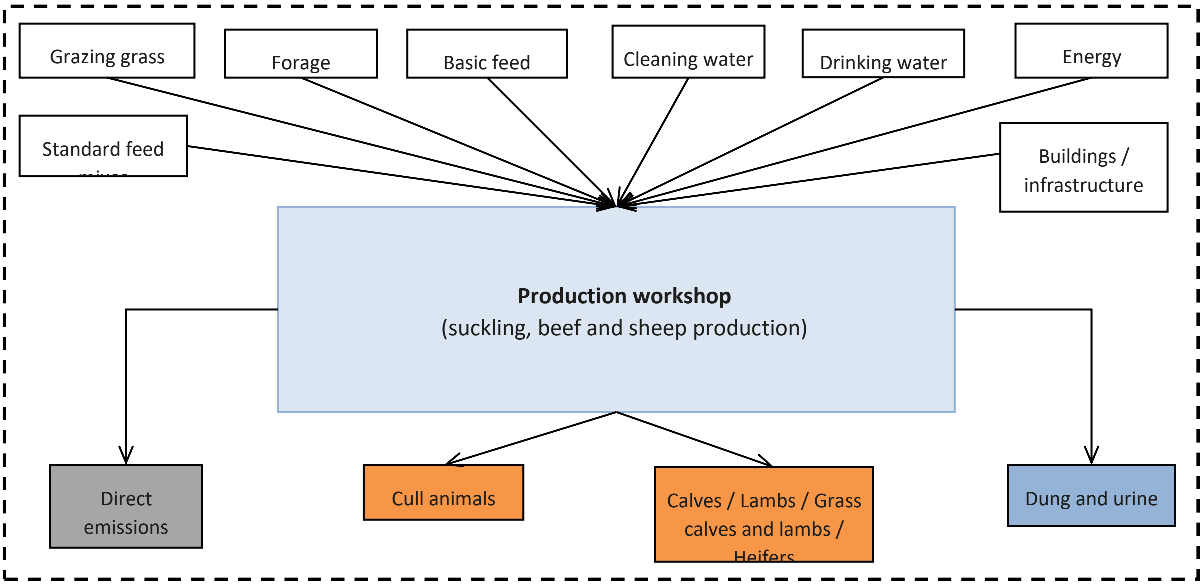

Figure5: System boundaries for beef and sheep .

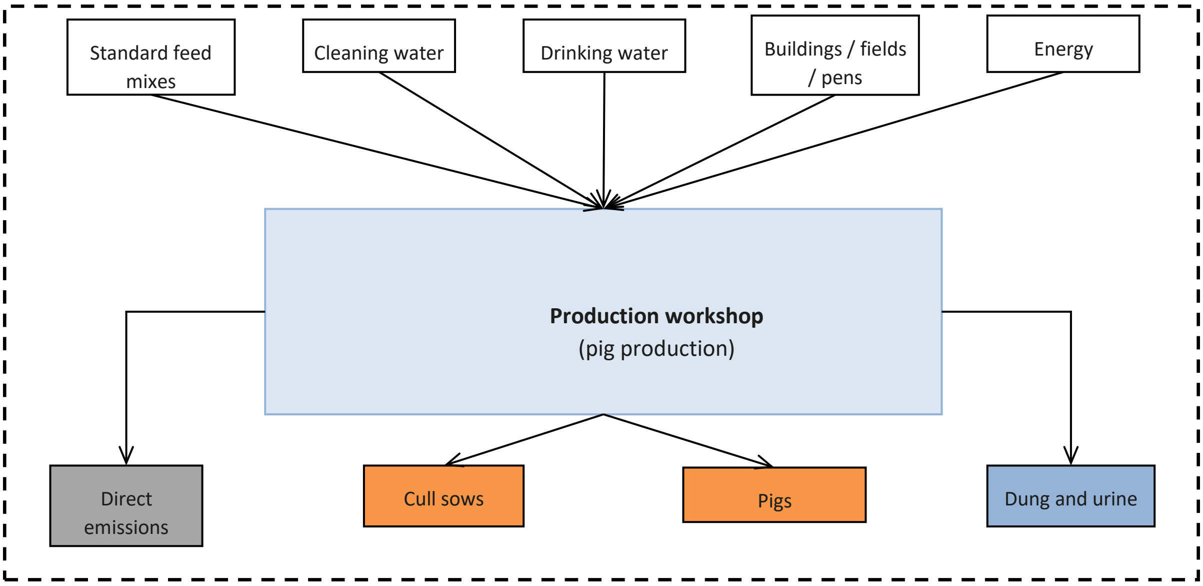

Figure6: System boundaries for pig production.

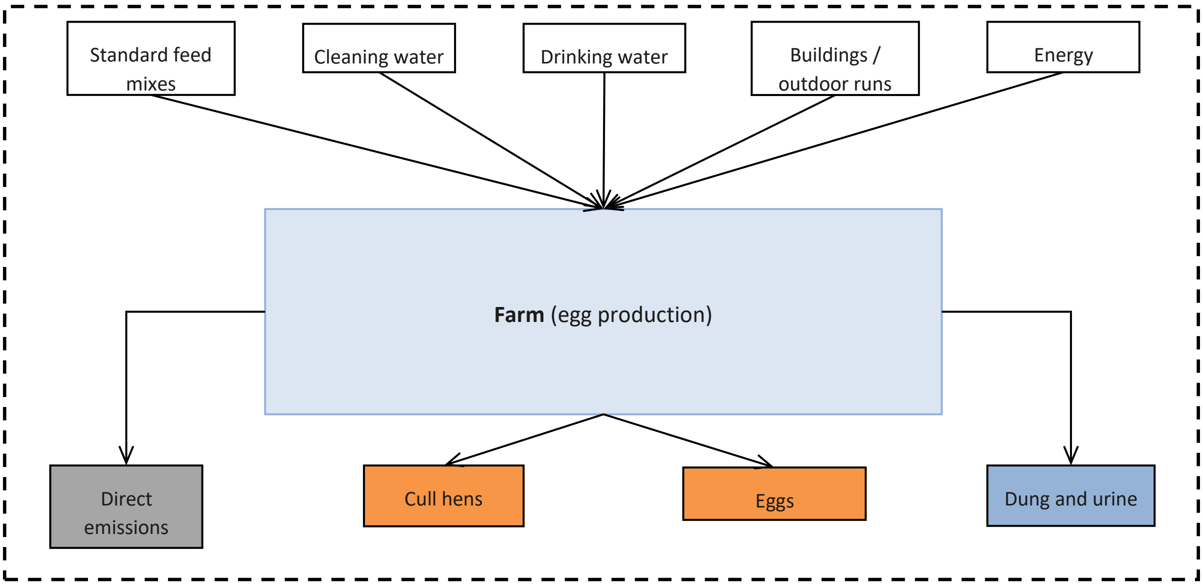

Figure7: System boundaries for layer poultry production.

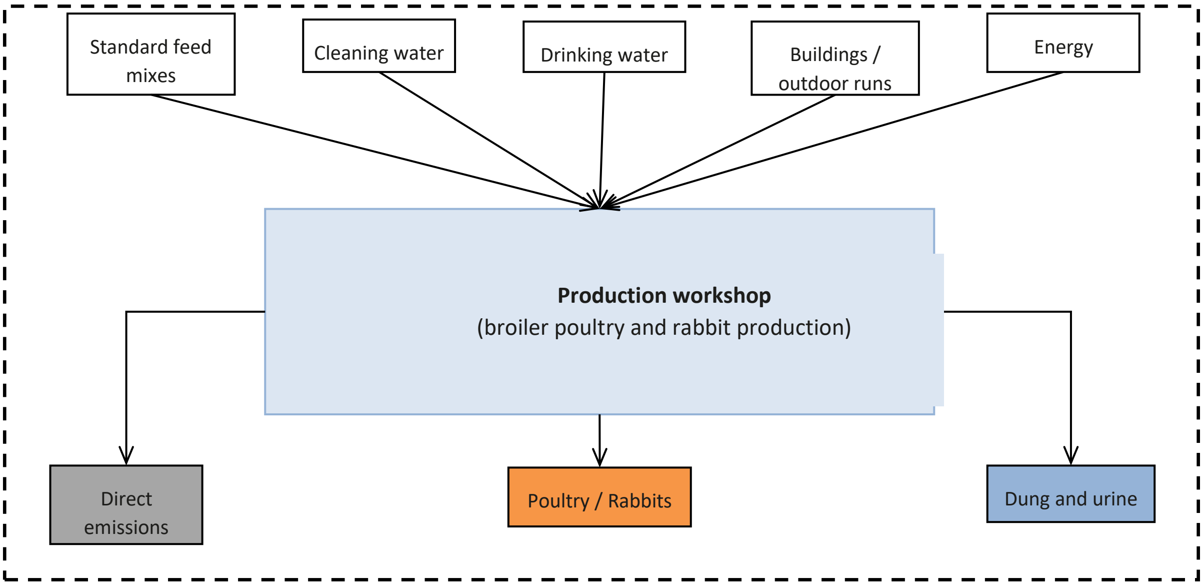

Figure8: System boundaries for broiler poultry (chicken, turkey, palmipeds) and rabbit production.

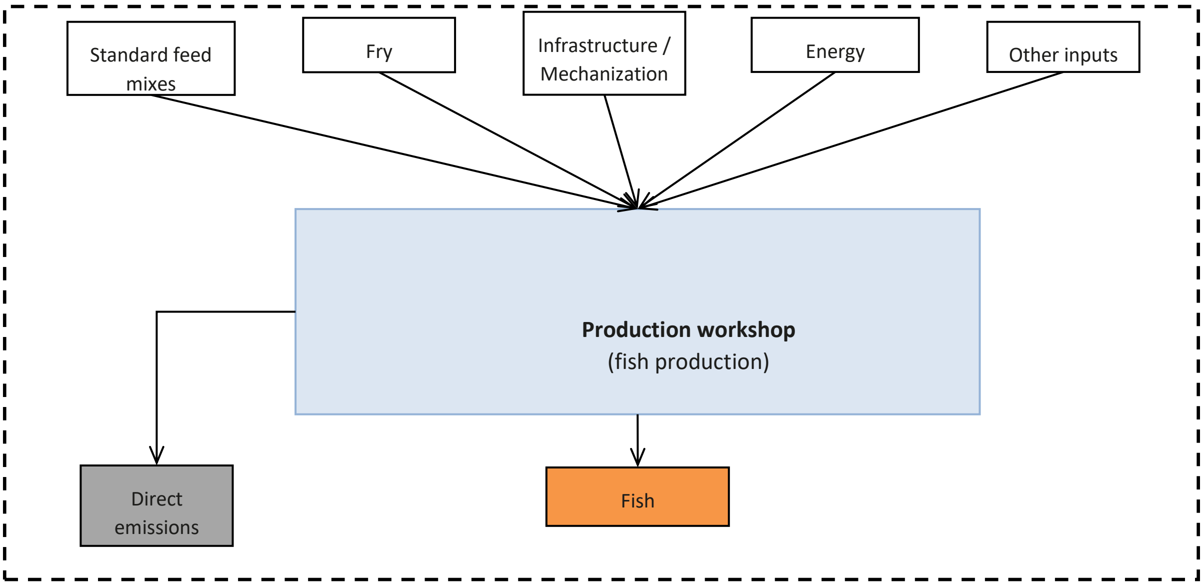

Figure9: System boundaries for fish farming.

1.2.2.1.2. Excluded processes

The items in the table below are not considered for at least one of the following reasons:

- They exist independently of production (column 1, "IP").
- LCIs for these inputs are not available (column 2, default LCI "DI").
- Characterization methods not available (column 3, "DM" method not available)
- Process impacts were deemed negligible (column 4, "IN").
- Activity data are not available for the inputs considered (column 5 "ND").

Table2: Production processes and resources not covered by the AGRIBALYSE® program.

Process, means of production not taken into account	IP	DI	DM	IN	ND
(a) animal, vegetable and tropical production					
Buildings or installations reserved for housing or non-strictly agricultural activities	X				
Cleaning products				X	
The workforce	X				
(b) animal production					
Veterinary products and care		X	X		
Artificial insemination of animals		X			
Small items: consumables					X
Electrical cables in buildings					X
(c) crop production					
Production (and delivery) of biological control agents (auxiliaries), pollinating agents used in market gardening and arboriculture.		X			
Adjuvants in crop protection products		X			
Irrigation equipment for field crops					X
Small items: consumables					X
Trace element supplements					X

1.2.2.2. Temporal hold

1.2.2.2.1. Plant production

Plant inventories are based on single crops rather than rotations. This is due to the objective pursued by AGRIBALYSE®: the creation of a database of agricultural products.

The general temporal perimeter of plant inventories is "harvest to harvest" and not "sowing to sowing". This choice was made because it is a common approach in LCA (for example, the approach applied in Ecoinvent® inventories). However, certain flows have been allocated between crops on the basis of the cropping successions observed in the 2006 cropping practices survey by SSP, AGRESTE, 2006 (see B.3.3).

The temporal limits considered, depending on the type of inventory, are as follows:

- For annual crops:

The time limit is from harvest to harvest. According to the collection guide, the inventory of a crop begins with the harvesting of the previous crop, except in the case of intermediate crops that are economically valued. Given that intermediate crops are very rarely valorized, the harvest date of the previous crop constitutes the temporal beginning of the plant LCIs.

- For meadows:

a) for permanent grassland: the time limit is one year, from January 1 to December 31
b) for temporary grassland and alfalfa: the time limit is equal to the duration of the crop's establishment, from planting to destruction (four years).

- For perennial plants:

The temporal limit is equal to the duration of the crop, i.e. from the production of young trees to the destruction of the orchard/crop.

For special cases (1) (strawberries, melon, rose, tomato and rice)

The temporal limit for crops with several harvests per year has been extended to one year (whether the harvests are - as in the case of tomatoes and roses - harvests of the same crop spread over several months, or harvests of several successively sown crops - as in the case of rice). Thus, technical differences between different production cycles within the year (e.g. 3(rd)) harvest of low-yielding rice) have been taken into account.

- For special cases (2):

For crops where there is no harvest as such (shrubs), the time limit is equal to the duration of the crop, i.e. from the start of production to the end of the plot.

1.2.2.2.2. Animal production

For animal production, the production system has been subdivided into "animal classes" (**Figure 10**). This subdivision makes it possible to record the inputs and outputs of each component of animal production workshops, and to account for the dynamics of animal groups (herds, flocks, etc.).

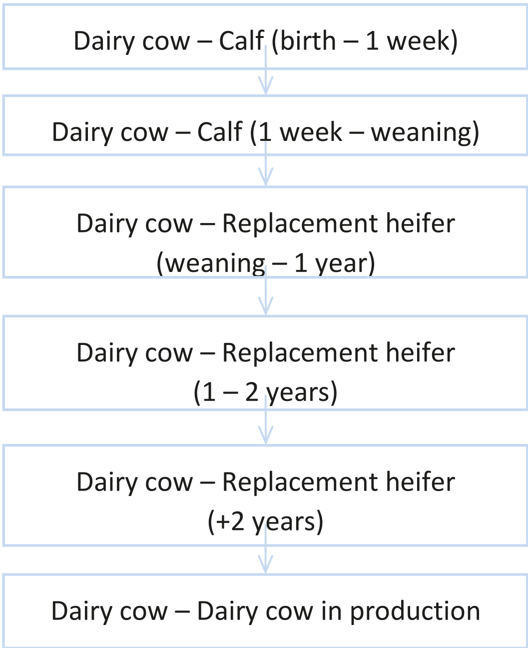

Figure10: Sequence of animal classes a dairy cattle operation.

As a general rule, the time limit runs from January [1]to December 31.

If the length of the production cycle is less than a year (rabbit, pork, veal, broiler poultry), then data were collected on a yearly scale, taking into account several batches or strips[4] . As in the case of crop production, this scale makes it possible to capture the intra-annual variability of production

1.2.2.3. Boundary between crop and livestock production (for flow allocation)

Following a study on the inclusion of organic waste products (OWPs) in LCA[5] carried out by the GIS REVALIM, the boundary between the residue production system and the system benefiting from these residues (potentially transformed) was reviewed for the residue processing sector.

In the interests of consistency with the methodological guidelines, scientific precision and relevance, and the technical feasibility of integration into AGRIBALYSE® , GIS REVALIM has chosen the intermediate cut-off approach along the chain. The intermediate cut-off point determines the boundary between waste treatment and OWP recovery.

In order to locate where this boundary lies on a waste material processing line, we need to identify the "tipping" process. The following question will help identify it:

---

[4] As such, the batch or strip is not an observation level for environmental impact in AGRIBALYSE®.
[5] A. Moreno, M. Chartier Kastler, M. Kiener, C. Dizien, M. Cornélus, S. Rullier, L. Nitschelm, 2024. Prise en compte des produits résiduaires organiques (OWP) en ACV: Application à AGRIBALYSE. 149 pages.

"On average, in France, at what stage* is the material spread?

*N.B.: the process in question must allow a change of state or composition. For example, the tipping process cannot be a transport stage.

1.2.2.3.1. Inventories of modified organic waste products

METHODOLOGY UPDATE FOR VERSION 3.2

Since version 3.1, Organic Residual Product (ORP) inventories have been derived from work carried out as part of the "LCI Mafor" project. The work carried out by GIS REVALIM for update 3.2 has led to a revision of the impact allocation method and therefore to an update of the ORP inventories. All Mafor LCIs (110 LCIs) were analyzed to check their methodological alignment with the new proposal. Figure11 explains the work carried out on the inventories available in AGRIBALYSE® version 3.1.1:

- If the inventory is aligned with the new proposal, it is not modified in content, but now carries the suffix "allocation Cut-off on process" in its name.

If the inventory is not aligned with the new methodology, its content is modified and it is given the suffix "allocation Cut-off on process" in its name. A waste treatment inventory is also created (no impact disappearance). The original inventory is kept in order to leave open the possibility of using other approaches that suit specific research or project objectives. This original inventory is stored in the software architecture under the "burden on downstream" folder and carries this suffix in its name.

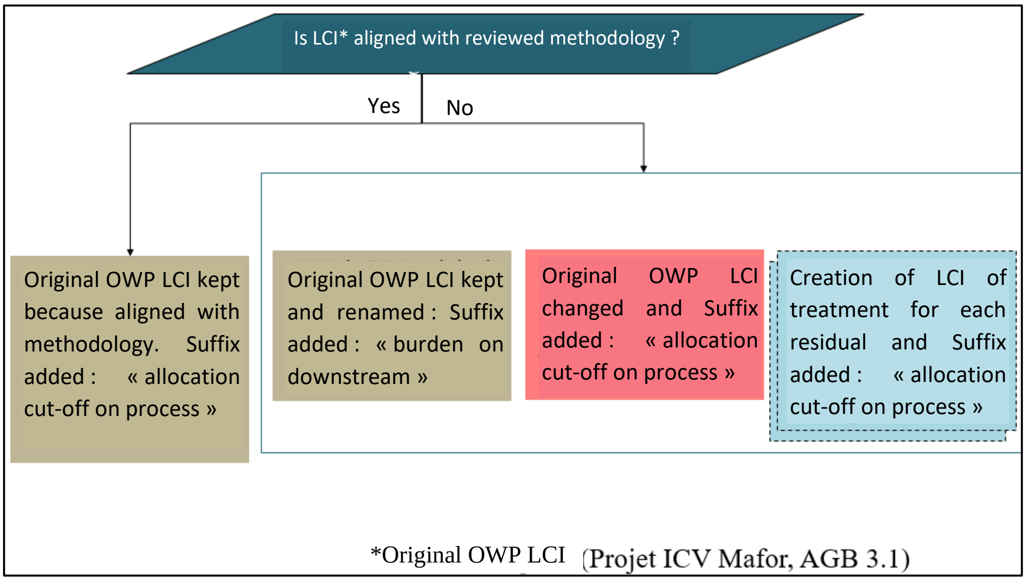

Figure11 Work based on the original ORP LCIs from Agribalyse 3.1.1

Table3 Number and status of waste treatment (MR) and OWP production inventories (LCI) for Agribalyse 3.2.

	Number of OWP inventories in Agribalyse 3.1.1	New inventories created, allocation cut-off on process" suffix	Modified inventories, "allocation cut-off on process" suffix	Original aligned inventories*, suffix "allocation cut-off on process".	Original unaligned* inventories preserved, suffix "burden on downstream".	Process inventories, "allocation cut-off on process" suffix	Number of OWP inventories in Agribalyse 3.2
Compost	10	3	8	2	8	9	**30**
Digestates	26	0	2	24	2	1	**29**
Livestock effluents	18	8	2	16	0	0	**26**

Fertilizers and organic soil improvers	25	0	0	25	0	0	**25**
Other	4	0	0	4	0	0	**4**
Sewage sludge	29	0	27	2	10	2	**41**
Total	**112**						**155**

There are 4 ORP categories whose inventories have been modified to bring them into line with the new proposed impact attribution methodology (blue figures in the table above). These 3 categories are:

- Compost (8 modified inventories) ;
- Digestates (2 modified inventories) ;
- Livestock effluents (2 modified inventories) ;
- Sludge (27 modified inventories).

For livestock effluent inventories, the perimeter has not been modified (see paragraph below).

Please refer to the full report: A. Moreno, M. Chartier Kastler, M. Kiener, C. Dizien, M. Cornélus, S. Rullier, L. Nitschelm, 2024. Prise en compte des produits résiduaires organiques (OWP) en ACV: Application à AGRIBALYSE. 149 pages.

1.2.2.3.2. Livestock effluent: manure management

As far as manure management is concerned, the separation between animal and plant production systems takes place just after on-farm storage. The various stages of on-site manure management are identified and assigned to animal production. Following on-farm manure storage, the stages are assigned to the user of this effluent, depending on the context.

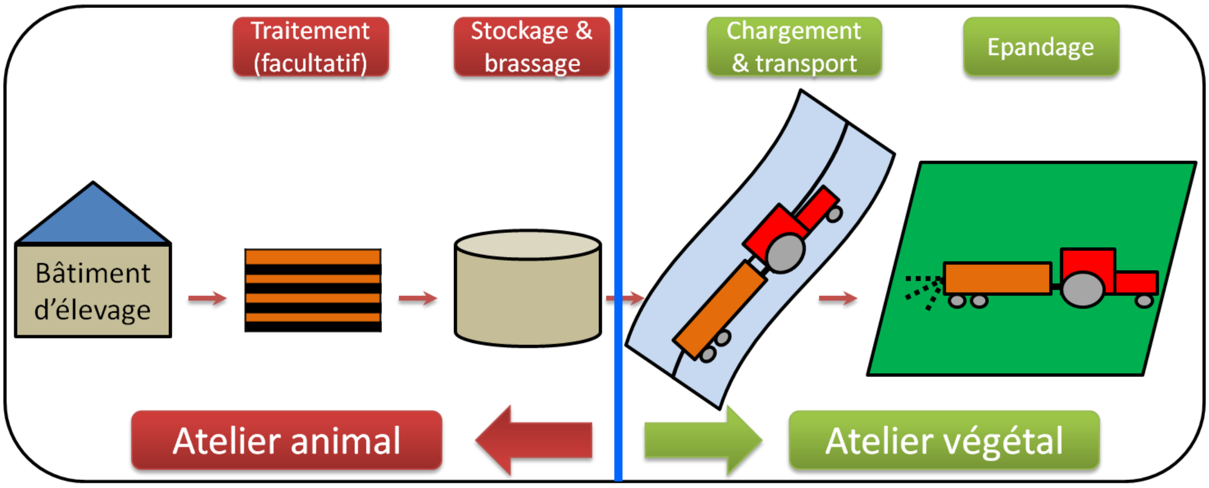

Figure12: Animal and plant workshop boundaries for manure management.

As a result, emissions linked to storage have been attributed to the animal production system, and emissions linked to the other stages encountered by this effluent have been attributed to the plant production system that benefits from this manure.

For the transport of manure (and other organic fertilizers) between the two workshops, an average distance of 10 km was taken into account (Ecoinvent® default distance for transport between sales outlet and farm).

1.2.2.3.3. Self-consumed forage

Forages and other basic foodstuffs produced by the farm and used within the farm (livestock feed), as well as grazed grass, were treated in the same way as forages destined for the sales market. The breakdown between the plant and animal workshops was as follows:

- Plant workshop: forage production and "processing" (silage, wrapping, transformation into hay)
- Animal workshop: storage and distribution to animals

For forage purchased by the farm, a transport process has been added (see B.3.3).

When forages are inputs to the animal workshop, a specific LCI (unit process) has been created for each forage. Consequently, grazing, or more precisely grazed grass, is also represented by a unit process. In operational terms, direct emissions linked to grazing have been distinguished into two categories (see Figure 12):

- Volatilization and leaching due to excreted dejecta (see green arrows in figure 12): These emissions are included in the grazed grass unit process, as they are considered to be emissions due to a fertilization process. For all the pastures studied, only cattle were considered as grazing animals (see B.3.3.8).
- Enteric methane and fecal excretion methane emissions (brown arrows, Figure 12): These emissions are included in the animal production process.

This breakdown is technical in nature. Once the grass has been grazed by the animal, all grazing-related emissions will be attributed to it.

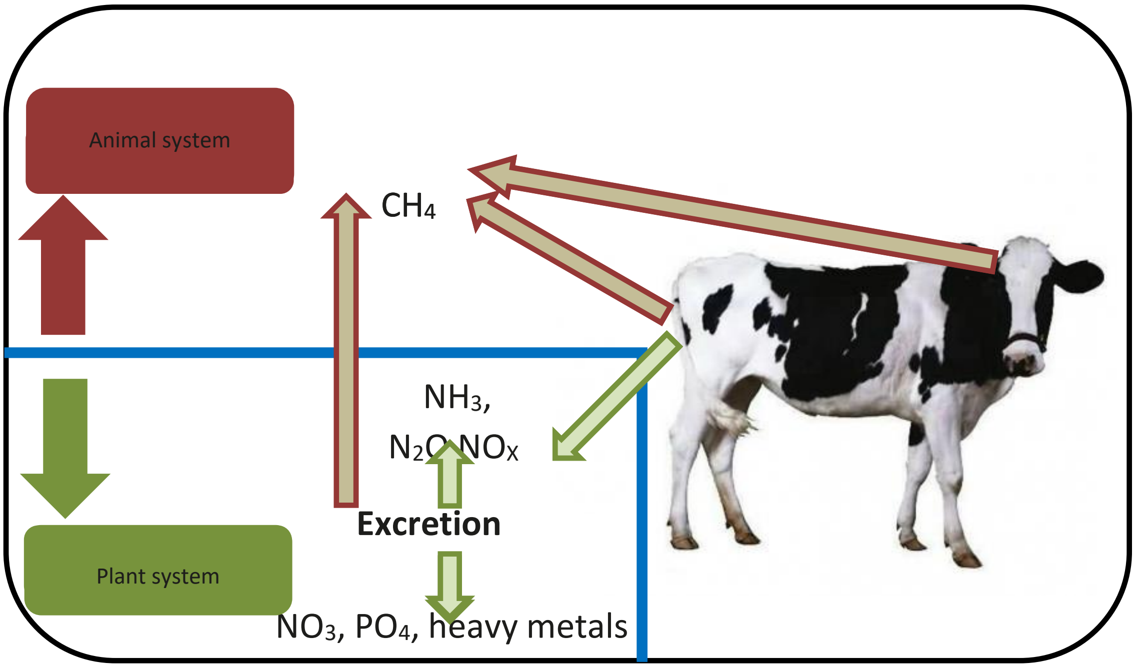

Figure13: Animal and plant system boundaries for grazing-related emissions.

1.2.3. Data requirements

1.2.3.1. Temporal representativeness

The reference period corresponds to the period covered in terms of data representativeness. This period must be chosen to ensure that the data collected:

- Be recent enough at the time of collection for LCIs to best represent current farming practices,
- Include several years to avoid a bias in LCI results due to an exceptional year.

As far as cultivation practices for annual crops are concerned, statistical data sources only cover part of this period. For this part of the data collected, representativeness was ensured by readjusting the data on the basis of "expert opinion". This also applies to the fruit, vegetable and shrub inventories, the vast majority of which have been compiled on the basis of expert opinion (with a few targeted exceptions, such as data relating to phytosanitary inputs).

The inventories of special crops in the tropics and metropolitan France (pink) are based on specific surveys carried out over the reference period.

Information on the period of time when the inventory was collected is kept and specified in the metadata for each inventory.

1.2.3.2. Spatial and technical representativeness

The spatial representativeness of the inventories is indicated in their metadata, as well as in their names. When an inventory is representative on a national scale (inventory with a national scope = "national inventory"), this has always been achieved by taking into account the agricultural practices of different ITKs. This has been achieved either by filling in the data directly in a single inventory, indicating the frequency of each cropping practice (by means of "area concerned"), or by aggregating several sub-inventories.

The "national inventories" have been compiled from:

- Statistical data: Sugar beet[6] , Durum wheat, Soft wheat, Rapeseed, Field bean, Silage corn, Grain corn, Sunflower, Triticale; Standard pork France.
- From a single typical case, an average case based on expert opinion or a single survey: Shrub, Coffee, Clementine, all organic farming plant inventories (soft wheat, faba bean, peach/nectarine, apple, tomato, triticale), Cider apple, Grassland.
- An aggregation of products with different ITKs: conventional carrot, alfalfa, malting barley, feed barley, conventional peach/nectarine, pea, conventional apple, potato (excluding starch), wine grape, rose, tomato for fresh consumption, tomato for fresh consumption conventional under cold cover; milk France, beef France, egg, broiler chicken, turkey.

Appendix AA presents the various "national inventories" calculation modes implemented in AGRIBALYSE® 3.2. For previous versions of AGRIBALYSE® please refer to the previous report Koch and Salou, 2022.

The data produced in phase 2 of the AGRIBALYSE® program (2014-2018) vary in technical and spatial representativeness, and do not necessarily correspond to a national average. This is reflected in the names of the inventories concerned, and the technical and spatial representativeness is also indicated in the inventories' metadata.

1.2.3.3. Direct emissions

For direct emissions into the environment, substance flows (NO_3, active substances, etc.) have been considered, rather than indicators (AOX, COD, BOD, etc.). These flows have been calculated using various models (see Chapters B.3.5).

Direct emissions are calculated by the emission models integrated into MEANS-InOut, based on input quantities and other influencing factors.

1.2.4. Data quality requirements

1.2.4.1. Individual data quality and overall inventory quality

AGRIBALYSE® assessed quality on three levels:

- Quality of individual data

The Ecoinvent®2.0 pedigree matrix (Frischknecht et al, 2007) was used to assess the quality of technical itinerary data (e.g. amount of fertilizer applied, daily amount of compound feed distributed to animals). The pedigree matrix approach makes it possible to determine the confidence interval of the data and thus to define their quality in a homogeneous way across the different inventories in the database. For reasons of efficiency and homogeneity, only the type of source from which a particular piece of data originated was evaluated, and this evaluation was then applied to all data from the same source.

- Quality of direct emissions in the field and workshop (calculated data)

For direct emissions calculated using models (see B.3.5), the Ecoinvent®2.0 pedigree matrix has been applied to the model concerned.

- Overall quality of inventory

For overall inventory quality, the Data Quality Rating (DQR) is based on the PEFCR guidelines[7] . Four data quality indicators (DQI) are taken into account for the DQR measurement:

    - Precision (P)

[6] For beet, five annual inventories were detailed and then aggregated.

[7] European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union; 2010

- Temporal representativeness (TiR)
- Geographical representation (GR)
- Technological representativeness (TeR)

1.2.4.2. Data quality individual data

N.B. Flow data is referred to as individual data. For example, for the inventory "Zucchini, open field, conventional, at farm gate {FR}", an individual data item in this inventory is the fertilizing operation "Fertilizing, with spreader on bed {FR}". Another example of individual data in this inventory is the fungicide applied "Nitrile-compound {GLO}| market for | Cut-off, S - Copied from Ecoinvent".

In line with the AGRIBALYSE® data collection guide (Biard et al., 2011), the different types of data sources have been categorized as follows (Table4):

- Statistical source, differentiated into:
  - Publicly accessible, well-documented statistics,
  - Statistics with restricted access or publicly accessible scientific literature
- Typical case, differentiated into:
  - Well-documented case study
  - A poorly documented test case
- Expert opinion
- Individual case / estimate

The pedigree-matrix (Table5) has been used as standard by Ecoinvent®(Frischknecht et al, 2007) to describe data variance and assess data quality. The values of the five indicators are transformed using a mathematical formula and translated into a 95% confidence interval.

Table4: Types of sources used in the AGRIBALYSE® program and their "quality score" (confidence interval of a lognormal distribution) based on the Ecoinvent®2.0 pedigree matrix (Table5). A lower value indicates higher precision.

Source type	Uncertainty base	Pedigree matrix values	"Quality score (95% confidence interval)
Publicly accessible and well-documented statistics	**1,05**	{1,1,1,1,1}	**1,050**
Statistics with restricted access or publicly accessible scientific literature	**1,05**	{2,3,2,2,2}	**1,108**
Well-documented case study	**1,05**	{1,2,1,1,1}	**1,054**
A poorly documented test case	**1,05**	{2,3,2,3,2}	**1,109**
Expert opinion	**1,05**	{3,3,2,1,2}	**1,140**
Individual case / estimate	**1,05**	{4,4,2,1,2}	**1,245**

Note: The basic uncertainty, which differs according to the type of data, has been taken from Table 7.2 of the Ecoinvent® report (Frischknecht *et al,* 2007). For most inputs, the basic uncertainty is 1.05; for transport and infrastructure (buildings), it is 2 and 3 respectively.

Table5: Pedigree-matrix, after Frischknecht *et al*, 2007.

	Indicator score					
Indicator	1	2	3	4	5 (default)	Remarks
Reliability	Verified data based on measurements	Verified data partly based on assumptions ***or*** non-verified data based on measurements	Non-verified data partly based estimates by qualified experts	Estimate by a qualified expert	Estimate by a non-qualified source	Verified means: published in public environmental reports of companies, official statistics, etc Unverified means: personal information by letter, fax or e-mail
Completeness	Representative data from all sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from >50% of the sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from only some sites (<<50%) relevant for the market considered ***or*** >50% of sites but from shorter periods	Representative data from only one site relevant for the market considered ***or*** some sites but from shorter periods	Representativeness unknown or data from a small number of sites ***and*** from shorter periods	Length of adequate period depends on process/technology
Temporal representativeness	Less than 3 years of difference to the time period of the data set	Less than 6 years of difference to the time period of the data set	Less than 10 years of difference to the time period of the data set	Less than 15 years of difference to the time period of the data set	Age of data unknown or more than 15 years of difference to the time period of the data set	
Geographical representativeness	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown ***or*** distinctly different area (North America instead of Middle East, OECD-Europe instead of Russia)	
Further technological representativeness	Data from enterprises, processes and materials under study	Data from processes and materials under study (i.e. identical technology) but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials	Data on related processes on laboratory scale ***or*** from different technology	
Sample size	>100, continuous measurement, balance of purchased products	>20	> 10, aggregated figure in env. report	>=3	unknown	Sample size behind a figure reported in the information source

1.2.4.3. Quality of direct emissions models in the field and in the workshop (calculated data)

The quality of the models used was also assessed using the pedigree matrix. The "completeness" criterion (**Table5**) was adapted by assessing the number of important parameters considered in the model in question.

Table6: Direct emissions calculation models (details see B.3.5) used in the AGRIBALYSE® program and their "quality score" (confidence interval of a lognormal distribution) based on the Ecoinvent®2.0 pedigree matrix (**Table5**

Source type	Model	Uncertainty base	Matrix pedigree values	"Quality score (95% confidence interval)
Carbon dioxide fixation by products (CO_2)	Ecoinvent®v2	**1,2**	{2,2,1,2,1}	**1,209**
Occupancy (m^2.year)	Ecoinvent®v2	**1,2**	{2,2,2,1,1}	**1,212**
Ammonia emissions (NH_3)	EMEP/EEA 2019 Level 2	**1,2**	{2,3,2,2,1}	**1,218**
Nitrogen excreted by animals	CORPEN	**1,2**	{2,2,3,3,1}	**1,238**
Methane emissions from manure storage (CH_4)	IPCC 2019 Level 2	**1,2**	{2,2,3,3,1}	**1,238**
Enteric methane emissions from ruminants (CH_4)	INRA Feeding System for Ruminants 2018 Level 3	**1,2**	{1,1,1,1,1}	**1,2**
Enteric methane emissions from pigs (CH_4)	IPCC 2019 Level 1	**1,2**	{2,2,3,3,1}	**1,238**
Carbon dioxide (CO_2) emissions from liming and urea application	IPCC 2019 Level 1	**1,2**	{2,3,3,4,1}	**1,249**
Phytosanitary active substance emissions	OLCA-Pest: Nemecek et al, 2020	**1,2**	{4,5,1,3,1}	**1,372**
Nitrogen oxide emissions (NO_x)	EMEP/EEA 2016 Level 1	**1,4**	{2,4,2,2,1}	**1,425**
Nitrous oxide (N_2O) emissions	IPCC 2019 Level 1	**1,4**	{2,4,3,4,1}	**1,446**
Nitrate emission (NO_3) -annual crops	COMIFER 2001 adapted (Tailleur *et al*, 2012)	**1,5**	{2,3,1,1,1}	**1,509**
Allocation of P, K and N_{org}	This report	**1,5**	{2,3,1,1,1}	**1,509**
Nitrate emission (NO_3) - perennial crops and field vegetables	SQCB (Faist *et al*, 2009)	**1,5**	{2,3,1,5,1}	**1,525**
Nitrate emission (NO_3) - tropical crops	IPCC 2006b, Level 1	**1,5**	{3,3,1,3,2}	**1,855**
Emission of Trace Metal Elements (TMEs)	SALCA-SM adapted	**1,5**	{2,2,3,4,1}	**1,526**
Phosphorus and phosphate emissions (P, PO_4)	SALCA-P	**1,5**	{2,3,3,4,1}	**1,530**
Nitrate emission (NO_3) - above ground	This report	**1,5**	{4,3,1,1,1}	**1,564**

Note: The basic uncertainty, which varies depending on the type of data, has been taken from Table 7.2 of the Ecoinvent® report (Frischknecht *et al,* 2007).

1.2.4.4. Overall quality of inventories according to le PEF

For overall inventory quality, the Data Quality Rating (DQR) is based on the PEFCR guidelines[8] . Four data quality indicators (DQI) are taken into account for the DQR measurement:

- Precision (P)
- Temporal representativeness (TiR)
- Geographical representation (GR)
- Technological representativeness (TeR)

The average of the four overall DQIs gives the final overall DQR. These four criteria were evaluated on an inventory's data set by judging the extent to which the inventory fulfilled the requirements (on a scale of 1 to 5, respectively 0 for not applicable). An inventory is considered of "good quality" for a score ≤ 1.6, of "basic quality" for a score between 1.6 and 3, and of "estimation" for a score >3.

Given that the scales proposed by the PEF were very generic in nature, and in order to guarantee a homogeneous evaluation, the scores per criterion to be evaluated were specified as follows:

Criteria	Rating
Technological representativeness	Technological representativeness is good when the different agricultural practices considered in the inventory are representative of the total number of ITKs implemented for the production considered (considering their distribution/importance). 1 = Very good: almost all possible ITKs are included in the inventory 2 = Good: the majority of ITKs have been considered 3 = SFUficient: it is not certain that the majority of ITKs have been considered 4 = Not sFUficient: Only a few ITKs have been considered 5 = InsFUficient: the inventory is based on only one ITK 0 = Not applicable
Geographical representation	Geographical representativeness reflects the rate of representation of production areas for the crop in question in an inventory, based on the area cultivated (in ha), or the quantity produced, depending on the data available.
Temporal representativeness	Temporal representativeness reflects the extent to which the temporal reference period has been taken into account. 1 = Very good: data on all five years of the reference period 2 = Good: data on at least three years of the reference period with little evolution/variation in the KTIs 3 = SFUficient: data on at least two years of the reference period with little evolution/variation in the KTIs 4 = Not sFUficient: data on two or three years of the reference period but with a strong change in the KTIs not included 5 = InsFUficient: data on only one year of the reference period 0 = Not applicable
Precision	Precision reflects the variability of data values, for each data item expressed (low variance = high precision). If you are using the AGRIBALYSE® methodology, the recommended precision score is 3.

1.2.5.Type of critical review - Quality control

1.2.5.1. For inventories created between 2005 and 2009

[8] European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union; 2010

For inventories created as part of the AGRIBALYSE program® (inventories dating from 2005-2009), a critical review as defined in ISO 14040/14044 (ISO, 2006a and ISO, 2006b) and in line with the ILCD-A situation (see A.2.2) was carried out. This review focused on quality control:

- Technical itinerary data
- Models for calculating direct emissions
- LCI and ALCI results

This quality control was carried out in three stages:

1. Internal verification: In the AGRIBALYSE® program, the tasks of collecting data and calculating LCI/ALCI were carried out by different people: data authors (see metadata: "author") and LCI creators (see "data generator"). The data collected by the authors were verified by the creators (Colomb et al, 2013).
2. Quality control of data describing the technical itineraries of French agricultural production processes, carried out by experts from institutions outside the project wherever possible.
3. Quality control of LCI and ALCI results, as well as models for calculating direct emissions, carried out by the Technical Institutes.

Each of the Phases 2 and 3 was concluded with a working seminar. The same logic of quality control has been maintained for the new data, even if small variations may appear (see specific reports).

For more information on this critical review, please refer to the previous Koch and Salou 2022 report, paragraph A.2.5.1 .

1.2.5.2. For inventories created by external contributors after 2005-2009

Inventories created by contributors external to the AGRIBALYSE® program or to GIS REVALIM have been subjected to an external critical review in ISO format, or to a critical review by the Technical Institute member of GIS whose expertise was sought.

1.2.5.3. For inventories created by contributors associated with the AGRIBALYSE® program or members of the GIS after 2005-2009

Inventories created by internal contributors to the AGRIBALYSE® program or to the GIS REVALIM have been subjected to an external critical review on the scope and use of technical data for inventory construction AND to an internal critical review within the GIS on methodological compliance with the guidelines detailed in this guide.

1.2.6. Type and format of report specified for the study

The ISO 14044 standard (ISO, 2006b) and the ILCD Handbook (JRC and IES, 2010a) provide recommendations on the types of deliverables expected. In line with these recommendations, AGRIBALYSE® communicates its results in the following forms:

- A methodological report dealing with the study's hypotheses: this is the report.

For each product, results are provided:

- In terms of impact indicator values
- In terms of inventory flow values

These documents are available on the "AGRIBALYSE® - GIS REVALIM" dataverse in the AGRIBALYSE® collection on the open French public data platform data.gouv.fr.

AGRIBALYSE® also provides the following documents to help disseminate its results:

A database in unit process format, available in LCA software, containing the inventories in the database. This format is accessible only to users with an Ecoinvent license, since Agribalyse relies on the background data of the Ecoinvent database. For further information on conditions of use, please refer to the Ecoinvent license conditions.

2. Inventory

2.1. Tools used in AGRIBALYSE®

AGRIBALYSE® attaches particular importance to the comparability of the processes selected. This requires a tool that can be used to "standardize" the production of LCIs. Starting with AGRIBALYSE® version 3.0, INRAE and CIRAD's MEANS-InOut software is used to update data and generate new data. The use of InOut software ensures greater comparability of LCIs.

MEANS-InOut software (INRAE-Cirad) was used to enter production itineraries and perform calculations (Auberger et al, 2018). It replaces the tools created for AGRIBALYSE® versions 1 to 1.3. Easier to use, it is accessible to users wishing to carry out new LCAs based on AGRIBALYSE® methodology, subject to service contract conditions.

- Simapro® + Ecoinvent®: The majority of upstream/indirect flows were calculated using Simapro® software and the Ecoinvent® database, cut-off version.

2.2. Data collection

2.2.1. Data collection

2.2.1.1. MEANS-InOut: the tool for entering technical itineraries and calculating direct emissions

The data entry interface in InOut is based on the Computerized Data entry Tool (CDT) developed for AGRIBALYSE®. It provides:

- Forms to describe the technical itineraries of the productions studied in AGRIBALYSE®:
- Arable crops, meadows, field vegetables
- Special crops (especially greenhouses)
- Perennial crops
- Animal production
- Drop-down menus offering lists of inputs adapted to the productions studied
- Documentation of the technical itinerary described according to ILCD requirements (JRC and IES, 2010a)
- Integration of the evaluation of the quality of specific data through its source.
- InOut comes with documentation to support data collection and entry.

2.2.2. Categories of data collected

2.2.2.1. Inputs

All data collection, i.e. the entry of all the information required to take into account the elements forming part of the system (see chapter A.2.2), was carried out by the Technical Institutes, using the data entry tool (OIS before 2016, MEANS-InOut since).

2.2.2.1.1. Plant production

For each input, the following information was collected:

- The name of the specific input (e.g. ammonitrate, rabbit manure or metolachlor).
- Equipment names were chosen from a predefined list, which could be expanded if necessary, provided the new equipment was defined.
- Quantity applied/consumed (specifying unit)
- Data source

- The percentage of surface area concerned, in order to take into account different practices in certain technical itineraries (e.g.: 30% direct seeding; 70% seeding with conventional seeders).
- Application date and data range (minimum and maximum): optional
- An optional comment

TheTable7 specifies the additional information required by input category:

Table7: Additional data collected according to input type.

Input category	Additional elements collected	Products concerned
Seed	Proportion of farm seeds	Annual crops
Fertilizers (organic/mineral)	Number of passages	All
Crop protection products	Number of passages	All
processes **- Soil preparation** **- Sowing** **- Fertilization** **- Plant protection** **- Crop care** **- Harvesting**	Number of passages	All
- Irrigation	Quantity of water supplied, source of energy used and quantity of energy consumed	All
Buildings	Surface	Specialty crops in mainland France (greenhouses)
Other inputs	Purpose of use	All

Inputs are entered on the basis of predefined lists. When a new material (fertilizer, active substance, process) has been introduced, the following information has been entered in order to be able to construct a specific LCI or to adapt a pre-existing LCI:

- New fertilizer: name, unit, composition (total N, N available to plants, P2O5), source.
- New agricultural process: name of work process, description, unit, machinery required (traction and a maximum of two machines), site throughput, energy consumption and type, source.
- New machine: machine name, description, service life, machine weight, footprint, source.

2.2.2.1.2. Animal production

Two types of data were collected for the animal inventories:

- Technical data describing the animal class (e.g. number of incoming animals, age and weight of incoming and outgoing animals, mortality, etc.).
- Feed-related data. Data entry was carried out in two stages. In the first stage, compound feeds are defined, and in the second stage, the annual ration is defined. In the first stage, the raw materials and their rates of incorporation into the compound feed are entered. In the second stage, compound feeds and/or elementary feeds (raw materials directly consumed by the animals, including forage and grazed grass) are listed to precisely define the ration distributed to the animals.

2.2.2.2. Direct emissions

Flows of potentially polluting substances directly associated with animal and plant production processes, i.e. direct emissions, are not entered but calculated by MEANS-InOut, see chapter B.3.5. The data and parameters required to calculate direct emissions are described in the data sheets.

2.3. Calculation of LCI

2.3.1. Description of calculation tools

Means InOut software is used to calculate emission flows based on technical itineraries. It enables the models selected in AGRIBALYSE® to be implemented and transparently provides forms for parameterizing these models while proposing default parameters.

2.3.2. Linking data to the Functional Unit

In several cases, the data were collected for the collection unit (CU), which differs from the functional unit (generally, the collection unit for plant inventories is the hectare, that for animal inventories is the herd). The LCIs were then assigned to the functional unit using a conversion factor, based on the reference flow also entered at the time of collection.

2.3.3. Calculating LCIs for agricultural production inputs

AGRIBALYSE® distinguishes three types of input for agricultural inventories:

1. Agricultural inputs (from mainland France or elsewhere) - e.g. feed barley, seeds, etc. These inputs come from the agricultural sector, and their inventories have been developed by the AGRIBALYSE® program.
2. Non-agricultural inputs specific to agriculture - e.g. tractors, pesticides, fertilizers, etc.
3. Non-agricultural inputs not specific to agriculture - e.g. electricity, diesel, steel for fencing, tires for tractors. These inputs were produced outside the agricultural sector and are used by all economic sectors.

With regard to LCIs/LCAs for inputs of types (2) and (3), the basic principle of the AGRIBALYSE® program was to use Ecoinvent® data, the most comprehensive available to date. However, as Ecoinvent® LCIs are not always adapted to the French context, adaptations were made for inputs of type (2), where possible, on the basis of existing inventories (see following chapters)

Where necessary, LCIs for inputs of type (2) have been constructed based on existing inventory data and adapted to French conditions. For example:

- ✓ Machines: machine sizes and construction rates have been adapted to the French context and to the context of the tropical industries studied.
- ✓ Livestock buildings: the source data comes mainly from the CASDAR project "Eco-construction and livestock buildings" (IE et al, 2009). The units used are: the annual surface area used in m2.year, or a space used for one year.
- ✓ Fish farm buildings: the inventories used for fish farm infrastructures come from the databases of UMR SAS, INRAE Rennes.
- ✓ Plant production buildings: for greenhouses (glass, double-walled inflated and plastic tunnels), LCIs based on data from French manufacturers were used (Boulard et al, 2011).

The following pages describe the procedures used to build LCIs when pre-existing LCIs did not exist in existing databases.

2.3.3.1. Seed and seedlings

The following approaches were used to build the seed and plant inventories:

1. Extrapolation by applying a factor to the valorized crop inventory. The "seed" inventory flows (resource requirements and emissions) were calculated by multiplying the "crop" inventory with an extrapolation factor. For ten crops, data are available in GESTIM (Gac et al, 2010), but these were established to study the impacts of primary energy consumption and global warming. Some inputs and flows contributing to the other impacts are absent or insufficiently detailed. Quantities for the missing inputs and flows were obtained by multiplying the quantities obtained for the inventory of the valued crop by an extrapolation factor. This extrapolation factor corresponds to the ratio between the primary energy consumption obtained in GESTIM for seed production and the product inventoried according to data collected as part of the AGRIBALYSE® program (details inAppendix BBSheet n°15: Extrapolation of LCI for seeds and seedlings).
2. Creation of a separate inventory.
3. In the absence of the required information: substitution by the inventory of the crop being valued, or use of a pre-existing LCI.

The extrapolation was applied to ten annual crops: Sugar beet, Durum wheat, Soft wheat, Rapeseed, Corn (grain and silage), Barley (malting and feed), Peas, Potatoes, Sunflower, Triticale. For "similar" crops, we have used the most common purchased seed: thus, all wheat uses seed extrapolated from "average wheat", all maize uses "grain maize" seed, and all barley uses "spring barley" seed (cf.Table130). Based on expert opinion, approach 2 has also been applied to carrots and tomatoes.

For other crops, approach 3 was used: for faba beans and organic annual crops (soft wheat, triticale), seeds were considered using the LCI of the final product as a substitute. For meadows and alfalfa, pre-existing Ecoinvent® inventories were used. In the case of orchards, vines, coffee and clementines, an area equivalent was calculated by assuming the number of hectares of marcottes and grafts required to plant one hectare of orchard/enclosure; the "orchard/vineyard in full production" inventory was taken as a surrogate.

2.3.3.2. Medium fertilizer construction

Three "average mineral fertilizer, as N/P/K, at regional storehouse, FR" inventories were constructed, based on average mineral fertilizer consumption in France from 2005 to 2009, for which an LCI is available (Appendix FF). For this, the UNIFA database was used, exploiting statistical information on fertilizer deliveries for the 2004/2005 to 2008/2009 campaigns (UNIFA, 2009). Unspecified binary and ternary fertilizer categories (PK, NP, NK, NPK) were assigned to Ecoinvent® LCIs with the help of more detailed GESTIM analyses (Gac *et al*, 2010). Organo-mineral" fertilizers were allocated to other fertilizers on the basis of N/P/K content. Transport distances from the place of production to the place of sale are also based on GESTIM analyses (Gac *et al*, 2010). Details are available **in**Appendix FF

2.3.3.3. Construction of LCI machines

New production-specific inventories have been calculated by parameterizing the six machine inventories available in the Ecoinvent® database. Machine LCIs include flows linked to:

- Production
- To the repair
- Tire and engine maintenance (where applicable)
- End-of-life ("waste management")

TheTable8 summarizes the parameterization of the various LCI elements. Maintenance-related flows are only required for machines with engines (oil and filters) and wheels (tires).

Table8: Machine LCI parameters based on available Ecoinvent® LCIs.

LCI element	Parameter setting with	Tractor	Self-propelled machine	Trailer	Pressure tanker	Trailed machine	Mounted machine
Production	Weight	yes	yes	yes	yes	yes	yes
management		yes	yes	yes	yes	yes	yes
Repair	weight and service life (= repair factor)	yes	yes	yes	yes	yes	yes
Waste management		yes	yes	yes	yes	yes	yes
Maintenance (tires)	Weight and machine/tire life	yes	yes	yes	yes	yes	no
Waste management		yes	yes	yes	yes	yes	no
Maintenance (filter, oil)	Weight and machine life	yes	yes	no	no	no	no
Waste management		yes	yes	no	no	no	no

The machines were grouped into the following 14 groups[9] according to: i) machine type (tractor, self-propelled machine, trailer, pressure tanker, trailed machine, mounted machine) and ii) indicated service life. The base Ecoinvent® LCI is shown in brackets.

1. Tractor, 7'200 h (based on bibliographic source)[10]

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[9] Four Ecoinvent®standard LCIs are used for trucks (lorry 16t/RER/I U, lorry 40t/RER/I U), vans (van <3.5t/RER/I U) and helicopters (Helicopter/GLO/I U).

[10] Marilys Pradel, Life cycle inventory data of agricultural tractors, Data in Brief, Volume 48, 2023, 109174, ISSN 2352-3409, https://doi.org/10.1016/j.dib.2023.109174.
https://www.sciencedirect.com/science/article/pii/S2352340923002937

2. Tractor, 10,000 h (based on bibliographic source)
3. Tractor, 12,000 h (based on bibliographic source)
4. Self-propelled machine, < 5000 h (based on "harvester")
5. Self-propelled machine, 5'000 - 10'000 h (based on "harvester")
6. Self-propelled machine, > 10,000 h (based on "harvester")
7. Trailer <20 t (based on "trailer")
8. Trailer, >20 t (based on "trailer")
9. 5000 l pressure tanker, (based on slurry tanker)
10. Trailed machine, < 2,500 h (based on "agricultural machinery, general")
11. Trailed machine, 2'500 -5'000 h (based on "agricultural machinery, general")
12. Trailed machine, >5000 h (based on "agricultural machinery, general")
13. Mounted machine (based on "agricultural machinery, general")
14. Machine with electric motor

The functional unit of the LCI machines is always "1 kg of machine for the entire service life". Details are available Appendix GG

2.3.3.4. Construction of LCIs for agricultural processes

An agricultural process encompasses the flows linked to the use of infrastructure to carry out soil work, maintenance and harvesting, namely:

- The production, maintenance and end-of-life of the machines used for the process (e.g. a tractor and a five-share plough for the "ploughing" process).
- All inputs and outputs required infrastructure operation, i.e. energy (diesel, electricity) and combustion-related emissions. However, variable products diffused or applied by processes, such as fertilizers or active substances, are not included. These inputs have been entered separately.
- Machine storage areas, whether sheltered in sheds or in the open air.

New inventories have been calculated on the basis of the information initially entered in the OIS (site throughput, diesel consumption, etc.). In collaboration with the Technical Institutes, the agricultural processes initially entered in the OIS were harmonized and grouped into final processes (Appendix HH

In line with Ecoinvent® , an LCI "agricultural process" encompasses the following elements:

- The need for one or more machines
- Energy requirements (fuel/electricity, etc.)
- Combustion emissions (where applicable)
- Tire abrasion (where applicable)
- The need for a garage to store tractors and self-propelled machines, or the need for a surface area for towed equipment (assuming open-air storage).

The functional unit for agricultural processes is "one working hour", which differs from the Ecoinvent approach® , where in most cases the functional unit is "one hectare". The "one working hour" functional unit is more flexible, allowing different work rates (h/ha) to be taken into account for the same process (e.g. ploughing in different soil types). The machine requirement for one hour of process is calculated by dividing its weight by its lifetime (because the LCI machine FU is kg machine for the whole lifetime).

$$Machine\ requirement = \frac{Machine'sweight}{Machine's\ lifetime}$$

2.3.3.5. Active ingredients

The active substances used were assigned to pre-existing LCIs. Based on the phytosanitary index (ACTA, 2005 and ACTA, 2009), the active substance was assigned to a pre-existing LCI (e.g. "Cyclic N-compound {GLO}| market for | Cut-off", "Pyridine-compound {GLO}| market for | Cut-off") using its chemical family. Where this was not possible, a more generic LCI was assigned ("Pesticide, unspecified {GLO}| market for | Cut-off", etc.).

Examples:

Fluazinam➔ chemical family: pyridinamine➔ Pyridine-compound {GLO}| market for | Cut-off

Flurtamone➔ chemical family: furanone➔ Pesticide, unspecified {GLO}| market for | Cut-off

2.3.3.6. Greenhouse LCI construction

For the greenhouses (glass, double-walled inflatable and plastic tunnel), pre-existing LCIs (Boulard et al, 2011) were used and adapted. Adaptations were required for reasons of consistency and homogeneity. In the original LCIs, several inputs were linked to non-Ecoinvent inventories® . For example, for steel, the LCI "X12Cr13 (DIN 1.4005, AISI 416)" from the IdeMAT database (IdeMAT, 2001) was used, whereas in AGRIBALYSE® the steel considered is always "Steel, low-alloyed, hot rolled {RER}| production | Cut-off". Adapted greenhouse LCIs are available in the AGRIBALYSE® database.

2.3.3.7. Construction of LCIs for livestock buildings

LCIs for the livestock buildings used:

- From internal UMR SAS (INRAE Rennes) databases, infrastructures relating to aquaculture production
- Based on data from the CASDAR project "Eco-construction des bâtiments d'élevage" (IDELE et al, 2009).

2.3.3.8. LCI construction for animal feed

Most of the LCIs for elemental feed, pasture and forage were produced within the AGRIBALYSE® framework, with transport added where necessary.

The LCI MP used for the formulation (manufacture) of commercial concentrated feeds come from:

- of LCIs produced by AGRIBALYSE® plant chains: soft wheat, organic soft wheat, faba bean, organic faba bean, rapeseed, sunflower seed, mown grass (silage or silage), grazed grass, alfalfa for dehydration, silage maize, grain maize, feed barley, protein peas, sugar beet, triticale, organic triticale.
- of LCI produced within the framework of the ECO-ALIM project: processed foods (oil cakes, toasted, dried, pressed foods, etc.)
- LCIs from the internal databases of UMR SAS (INRAE Rennes). These are products other than plant raw materials which may have been processed via CDT, or products which have been the subject of specific studies (e.g. fish meal).
- LCIs from commercial databases (Ecoinvent® , ...). For the purposes of this project, these processes have sometimes been adapted.

Compound feed inventories have been made available to AGRIBALYSE®. The procedure for carrying out these processes is detailed inAppendix II

Clarification concerning the calculation of grazed grass inventories: Within the framework of the AGRIBALYSE® program, grazing, respectively grazed grass, has been treated in the same way as other forages, which means that a specific LCI has been constructed (see A.2.2.4b). The data collected as part of the AGRIBALYSE® program reflect, sensu stricto, only the situation of cattle grazing. The "grazed grass" inventories have also been used without modification for sheep and goats, on the assumption that:

a) Cattle make up the majority of ruminant livestock in France.

b) loading (expressed in livestock units) is comparable, which means that overall yield and excretion levels are comparable.

c) for the calculation of direct emissions linked to excreted dejecta, the content of bovine manure was used.

Harvesting losses were taken into account in the grazed, wilted, ensiled and wrapped grass inventories. To obtain the yield, collection losses, storage losses and losses due to forage consumption by animals were subtracted (Appendix II , sub-chapter 3).

2.3.4. Transport of inputs

The transport of inputs from the point of purchase to the farm has been taken into account by means of transport models. A transport model gathers information on the means of transport used and the distances covered, and applies to groups of inputs. The following types of input were differentiated:

- Fertilizers (mineral and organic)
- Crop protection products
- Other inputs
- Feed raw materials (note: when forages and raw materials are produced on the farm, no transport is considered).

In these models, the journey from the "point of purchase" (storage/distribution site) to the "farm" can encompass the two elements presented inTable9

With regard to the weight transported, the gross weight of the product was taken into account. In line with Ecoinvent® (Nemecek and Kägi, 2007), an average active substance content of 50% for crop protection products was used to estimate the weight of the crop protection product based on the quantity of active substance applied.

Table9: Input transport assumptions.

Type of input	Transport from foreign point of purchase to French point of purchase	Transport from the point of purchase in France to the farm
Inputs produced on the farm	no	no
Inputs produced in France (LCI type FR)	No	Yes: 15 km with tractor and trailer/tanker
Fertilizers, Raw materials for imported feeds	Yes, GESTIM (**Table10**)	
Other imported inputs (LCI type RER or GLO)	Yes, Ecoinvent® assumption, market processes	

For AGRIBALYSE® inventories in mainland France, the distance between the point of purchase (store) and the farm is 15 km by tractor with trailer or tanker. For organic fertilizers, which can either come from a workshop on the farm (mixed crop-livestock), or from a neighboring farm, a transport distance of 10 km with trailer or tanker was considered. Lastly, transport on the farm (farm-to-farm) is included directly in the LCI agricultural processes, taking into account an average of ten km (Appendix HH

In the absence of data, the same assumptions were applied for tropical crops.

For imported inputs, Ecoinvent® default values were used, via the "market processes", with the exception of mineral fertilizers and animal feed, for which specific data from GESTIM (Gac *et al*, 2010) were mobilized (**Table10**)

For animal feed, we considered:

- Transport from raw material production/storage site to feed manufacturing plant
- Transporting feed from the feed mill to the farm

For feed manufactured on the farm, only the transport of raw materials from their place of production/storage to the farm has been taken into account.

An average transport distance in mainland France, depending on the type of transport, was calculated according to Nguyen *et al* 2012. For raw materials from abroad, the transport distance proposed by GESTIM (Gac *et al*, 2010) was used.

Table10: Transport models (TM) used for AGRIBALYSE® animal feed.

Ecoinvent® process	Place of manufacture raw material⇨ Manufacturing plant	Manufacturing plant⇨ Farm
Transport, lorry >32t, EURO3/RER U	110 km[a] + GESTIM assumptions[b]	130 km[b]

Transport, freight, rail/RER U	390 km[a] + Assumptions GESTIM[b]	-
Transport, transoceanic freight ship/OCE U	GESTIM[b] assumptions	-

[a] Transport distance in metropolitan France calculated from Nguyen *et al* (2012).

[b] Transport distance according to Gac *et al* (2010).

2.3.5.Models for calculating resource consumption and direct emissions of pollutants

2.3.5.1. General principles and overview of selected models

For the purposes of AGRIBALYSE®, direct emissions have been defined as the flows of potentially polluting substances into the environment, directly associated with animal and plant production, on the production site. However, this concept has been supplemented by the consumption of resources required for production processes (water consumption, land use, etc.).

As recommended by ILCD (JRC and IES, 2010a) and ISO standards (2006a and 2006b), and wherever possible, only elemental substance flows were calculated. Indicators such as COD (chemical oxygen demand) or AOX (absorbable organic halogens) have not been considered.

Indirect emissions - flows of potentially polluting substances into the environment associated with the production of inputs used on the production site - have not been modeled in AGRIBALYSE®. These indirect emissions are included in the generic data of pre-existing databases (Ecoinvent®, etc.).

AGRIBALYSE® drew on the recommendations of international standards to rationalize the choice of models used in the program. According to the recommendations of the IPCC and EMEP/EEA, the models selected must enable an estimate that is as accurate and correct as possible. Models that introduce a systematic bias cannot be selected. Several criteria were taken into account when selecting models for calculating direct emissions and resource consumption:

- Scientific validity: AGRIBALYSE® aspires to international recognition. The methods used must therefore be scientifically recognized and be the subject of an international consensus.
- Area of validity: Since AGRIBALYSE® mainly produces LCIs for French agricultural production, the models selected must, at the very least, be applicable to the French context.
- Technical feasibility: AGRIBALYSE® focuses on the implementation of models that are easy to apply, particularly in terms of the amount of data required to implement the calculation models. The granulometry of the selected models must be compatible with the input data collected.

The models used to calculate direct emissions and resource consumption for tropical crops were selected according to the same principles, with the range of validity adapted to each product under consideration.

This section of the report presents the main requirements for each substance emitted, the models identified in the literature that could potentially be applied in AGRIBALYSE® , then the models and emission items finally selected. The parameterization of all models is described inAppendix BB

2.3.5.1.1. List of substances / direct emissions taken into consideration

Agricultural production activities generate direct emissions and resource consumption. The**Table11** presents the emissions and consumption selected, the items considered and the models chosen. This choice in no way stipulates the scientific predominance of the chosen model over the others. The models selected are only the best under the conditions and objectives of the AGRIBALYSE® program.

Table11: Substances emitted/resource consumption, emission items and models used in AGRIBALYSE®.

Substance emitted / Resource consumed	Emission item / Resource consumption item	Model selected
Ammonia (NH_3)	Animal manure (building/storage)	
	- calculation of excreted nitrogen quantities	CORPEN 2006, 2003, 2001, 1999a and 1999b
	- emission factors	EMEP/EEA 2019 Level 2
	Organic fertilizers and grazing manure	EMEP/EEA 2019 Level 2
	Mineral fertilizers	EMEP/EEA 2019 Level 2
Carbon Dioxide (CO_2)	Absorption by plants	Ecoinvent®v2 (Nemecek and Kägi, 2007)
	Lime and urea inputs	IPCC 2019 Level 1

Trace Elements (TME: Cd, Cu, Cr, Hg, Ni, Pb, Zn)	Leaching: Mainland crops	SALCA-SM adapted to France (Freiermuth, 2006, SOGREAH, 2007 and Levasseur et al., 2021)
	Runoff: Mainland crops	
	Soil accumulation: Mainland crops	
Energy stored by plants	All crop production	Product's gross calorific value (GCV)
Combustion gas	CO_2	Dataset Pradel, Marilys, 2023, "Life Cycle Inventory of agricultural tractors", https://doi.org/10.57745/JYXPHZ, Recherche Data Gouv, V12 accounting for emissions linked to fuel combustion in tractors, taking into account integrated pollution control systems and the adbue required by the engine.
	Other air pollutants (Metals, VOCs, SO_X, NO_X...)	
Methane (CH4)	Animal manure (building/storage/grazing/range)	IPCC 2019 Level 2
	Enteric emissions: cattle, sheep and goats	INRA Feeding System for Ruminants 2018 Level 3
	Enteric emissions: other animals	IPCC 2019 Level 1
Nitrate (NO3)	Leaching: Annual crops	COMIFER 2001 adapted (Tailleur *et al*, 2012)
	Leaching: Special crops, orchards, vines	SQCB (Faist *et al,* 2009)
	Leaching: Specialty soilless crops	This report: Based on discharged/lost water
	Leaching: Grasslands	This report
	Leaching: Tropical crops (excluding rice)	IPCC 2006b Level 1
	Thai rice	This report: Based on a water balance
	Animal production: Pathways	Basset-Mens *et al*, 2007
Land use	All productions	Ecoinvent® v2 (Frischknecht *et al*, 2007)
Nitrogen oxides (NO_x)	Plant production	EMEP/EEA 2016 Level 1
	Animal production	EMEP/EEA 2019 Level 1
	Thai rice	IPCC 2006b Level 2
Phosphorus (P)	Leaching: Mainland crops	SALCA-P (Nemecek and Kägi, 2007 and Prasuhn *et al*, 2006)
	Runoff: Mainland crops	
	Emissions from grazing and grasslands	
	Tropical crops	
	Specialty soilless crops	This report: Based on discharged/lost water
Phytosanitary active substances	Product application: Mainland crops, clementines, coffee	OLCA-Pest: Nemecek et al, 2020
	Product application: Thai rice	This report
Nitrous oxide (N_2O)	Plant production	IPCC 2019b Level 1
	Specialty crops in mainland France	IPCC 2019b Level 1
	Tropical crops (excluding rice)	IPCC 2019b Level 1
	Thai rice	IPCC 2006b Level 2
	Animal production (building and storage)	IPCC 2006b Level 2
Eroded earth	Vegetable production in metropolitan France	RUSLE (Foster, 2005)
	Soilless production	Erosion set to 0
	Tropical production	Erosion set to 0
Direct land processing	All productions	Not taken into account
Phosphorus, nitrogen, suspended solids (SS)	Fish farm	Papatryphon *et al*, 2005

2.3.5.1.2. List of flows not considered

AGRIBALYSE® did not consider several flows:

- **CO2 emissions from animal respiration**: in line with IPCC recommendations (2006b). It is assumed that the CO2 absorbed by plants during photosynthesis, and therefore contained in livestock feed, is returned to the atmosphere in this form. As this is not a long-term storage process, there is no need to consider this emission item.
- **Carbon storage in the wood of perennial crops (vines and arboriculture),** the fate of wood being difficult to assess (storage or short cycle), the quantities of CO2 involved being small and in line with the calculations made by CITEPA as part of national inventories (CITEPA, 2011).

Water abstraction flows: Methods for taking more detailed account of water in LCA (green water, blue water, grey water) are currently being developed. The most operational method to date is that developed by Pfister et al (2009). However, it was deemed inapplicable to AGRIBALYSE®. As a result, direct water consumption was only taken into account for irrigation, fertigation, watering and cleaning. Please refer to the AGRIBALYSE®-Water project documentation (Martin et al. 2019).

Gaseous emissions linked to fish farming activities have not been taken into account, as data are too sparse for trout and non-existent for sea bass/dorado production. However, work is underway to collect this type of data.

- Emissions of TMEs other than Cd, Cu, Cr, Hg, Ni, Pb and Zn have been neglected, due to the lack of reliable data.
- **Particle emissions from farm activities (animal and crop production).** In fact, the data currently available at French and European level have been deemed too few to ensure satisfactory consideration of these emissions (Faburé et al, 2011).
- **Parameterization of the "ETM" and "eroded soil" models** was not possible for tropical crops due to a lack of information/data.
- NOx other than NO2 for direct flows, due to the lack of a suitable model.

2.3.5.2. Calculation of ammonia (NH3) emissions

A detailed description of the parameterization of NH3 emission calculation models can be found inAppendix BB -Sheet n°1: Ammonia (NH_3)

2.3.5.2.1. Challenges and requirements

In agricultural production systems, ammonia is emitted by volatilization of the nitrogen contained:

- In mineral or organic fertilizers,
- In animal waste excreted during grazing or in buildings,
- In animal manure during storage.

Emissions depend on the type of product applied or excreted, as well as soil, climate and microbiological conditions.

2.3.5.2.2. Available models

Several models have been identified in the literature:

- CORPEN (2003) and CORPEN (2006)
- MELODIE (Chardon et al, 2011)
- Gac et al, 2006
- STICS (Brisson et al, 1998)
- Volt'Air (Le Cadre, 2004)
- Payraudeau et al, 2007
- Ecoinvent®V2 (Nemecek and Kägi, 2007)
- EMEP/EEA, 2009
- EMEP/CORINAIR, 2006
- IPCC, 2006b
- Yan et al, 2003b

2.3.5.2.3. Models and emission items

The evaluation of the previous models, taking into account the selection criteria (see B.3.5), led to the selection of the following models (Table12). The reasoning behind the selected models is based primarily on: (a) their appropriate granulometry and (b) their international recognition.

Table12: NH3 emission models

NH_3 emission item	Model selected
Dejecta in the building and on the course	**CORPEN 2006, 2003, 2001, 1999a and 1999b:** for calculation of nitrogen excreted by animals
	EMEP/EEA 2009 Level 2: for emission factors
Manure storage	**EMEP/EEA 2019 Level 2:** for emission factors
Organic fertilization and grazing manure	**EMEP/EEA 2019 Level 2**
Mineral fertilization	**EMEP/EEA 2019 Level 2**
Thai rice	**Yan *et al*, 2003b**

EMEP/EEA (2009) and EMEP/CORINAIR (2006) propose an approach based on mass flows, enabling emissions to be distinguished for each of the items considered. These two models were used until AGRIBALYSE® version 1.3. For version 3.2, the EMEP/EEA (2019) model, which is an updated version of these models, was used.

The methodology proposed for rice is based on the IPCC (2006b) method, in which the emissions factors specific to rice growing proposed by Yan *et al* (2003b) have been used.

2.3.5.2.4. Calculating nitrogen excretion by animals

A detailed description of the parameters used to calculate nitrogen excretion by livestock can be found atAppendix BB -Sheet n°2: Nitrogen excreted by livestock

The model used to calculate direct NH3 emissions is based on the nitrogen excreted by animals. It is therefore necessary to estimate this parameter as accurately as possible. The most recent CORPEN equations for each type of animal have been used. These equations make it possible to determine the quantities of nitrogen excreted using a mass balance. The quantities of nitrogen ingested are determined from the composition of the feed rations distributed. Nitrogen fixed by animals is determined according to species and physiological stage. The models are presented inTable13:

Table13: Models of nitrogen excretion by animals.

Animal categories	Model selected
Dairy cow	**CORPEN 1999a**
Suckling, growing or fattening cattle (suckling and dairy)	**CORPEN 2001**
Pork	**CORPEN 2003 and RMT Livestock and Environment, 2016**
Poultry	**CORPEN 2006 and ITAVI, 2013**
Rabbit	**CORPEN 1999b**

2.3.5.3. Calculation of carbon dioxide (CO_2) flows and emissions

A detailed description of the parameterization of the models used to calculate CO2 emissions can be found inAppendix BB -Sheet n°3: Carbon dioxide (CO_2)

2.3.5.3.1. Challenges and requirements

Several processes lead to CO2 emissions from agricultural production systems:

- Liming and urea application
- Type of land use/occupation and management (Appendix CC
- Fossil fuel combustion processes (agricultural machinery, livestock buildings, greenhouses), see also B.3.3.4

The ILCD makes a number of recommendations concerning CO2 emissions:

- Distinction between fossil CO2 and biogenic CO2 emissions: i) for greater clarity and methodological flexibility; ii) because biogenic CO2 is not included in the GWP category for assessment purposes.
- Carbon assimilated by plants inventoried as "Resources from air".
- Storage/unstorage of CO2 in soil and biomass linked to a change in land use (LUC) or a change in cultivation practices, inventoried as "Carbon dioxide (land transformation)".
- Use of the latest IPCC method, or a more relevant method if available, to quantify soil carbon storage/removal.

Taking into account the dynamics of carbon in soils, mainly linked to LUC and changes in practices, is also a major challenge. However, as no satisfactory method has been found to take these emission items into account, these flows are not included in the AGRIBALYSE® database inventories. This issue was the subject of an AGRIBALYSE® project during the 2014-2018 period: the SOCLE project (Bessou et al., 2018).

2.3.5.3.2. Available models

Several models have been identified in the literature:

- BPX 30-323 (AFNOR, 2011)
- IPCC, 2006b
- Ecoinvent®v2 (Nemecek and Kägi, 2007)
- PAS 2050 (Carbon Trust et al, 2008)
- GGELS (JRC, 2010)
- Arrouays et al, 2002
- IDF, 2010

2.3.5.3.3. Models and emission items

The evaluation of the previous models, taking into account the requirements of the AGRIBALYSE® program (see B.3.5), led to the selection of the following models (Table14).

Table14: Models selected by CO2 emission item.

CO2 emission item	Model selected
Absorption by plants	Ecoinvent®v2 (Nemecek and Kägi, 2007)
Lime and urea inputs	IPCC 2019 Level 1

The methods proposed by Vertregt and Penning de Vries (1987) and Nemecek and Kägi (2007) make it possible to determine the amount of carbon fixed in plant biomass, based on carbohydrate, lipid, protein, fiber and mineral content.

CO2 emissions linked to lime and urea inputs are determined using an emission factor, specific to each of the substances considered, applied to the quantity input. Liming was considered only for carrot, cider apple and alfalfa. The IPCC 2006 model was used up to AGRIBALYSE® version 3.1.1. For version 3.2, the IPCC 2019 model, an updated version of the model, was used.

2.3.5.4. Calculation of trace metal emissions (TME)

A detailed description of the parameterization of the models used to calculate ETM emissions can be found inAppendix BB - Sheet no. 4: Metal Trace Elements (MTE)

2.3.5.4.1. Challenges and requirements

The ILCD guide recommends taking into account the uptake of heavy metals by plants, by inventorying the different flows corresponding to each metal. It is also advisable to take stock of the net accumulation of substances in the soil, particularly heavy metals (see chapter 7.4.4.1 "Modelling agro- and forestry systems", JRC and IES 2010a).

2.3.5.4.2. Available models

Two elements have been identified:

- Data source: Estimated average flows of heavy metals (As, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Se, Zn) into soils, based on the SOGREAH study (2007).
- A flux calculation model: SALCA-SM/Ecoinvent®: calculation of heavy metal flows (Cd, Cu, Zn, Pb, Ni, Cr, Hg) based on a mass balance (Freiermuth, 2006).

For the AGRIBALYSE® 3.2 update, a new data source was used, that of the TRACTION report (Levasseur et al., 2021) on the ETM content of raw and processed animal manure.

2.3.5.4.3. Adaptations made

SALCA-SM is an heavy metal flows quantification tool, which is sensitive to agricultural activities. It has been adapted to the French context using SOGREAH data. The AGRIBALYSE® program has thus developed "SALCA-ETM-Fr".

2.3.5.4.4. Models and emission items

The main source of heavy metal emissions is the agricultural plot. In line with JRC and IES 2010a, the following emission sources have been identified (Table15

- Emissions to surface water (due to erosion)
- Leaching emissions
- As balance of flows: emission to soil

Table15: Models selected for each ETM emission station.

ETM emission station	Model selected
Leaching: Mainland crops	SALCA-SM adapted to France (Freiermuth, 2006, SOGREAH, 2007, Levasseur et al., 2021)
Runoff and erosion losses: Mainland crops	
Accumulation or loss in the soil: Mainland crops	
Tropical crops	Not considered (see B.2.4.1)

2.3.5.5. Calculating heavy metals emissions from erosion: calculating the amount of soil eroded

The calculation of heavy metal emissions due to erosion is partly based on the calculation model for the quantity of soil eroded.

A detailed description of the parameters of the models used to calculate the quantities of soil eroded can be found inAppendix BB -Sheet n°5: Land erosion

2.3.5.5.1. Challenges and requirements

The quantity of eroded soil does not constitute a flow inventoried in the AGRIBALYSE® LCIs. Erosion is a source of emissions of various substances contained in eroded soil. It is therefore an important parameter for calculating TME flows and phosphorus losses due to erosion.

JRC and IES (2010a) recommend inventorying the various substances eroded through flows to the "surface water" and "air" compartments (JRC and IES, 2010a).

2.3.5.5.2. Available models

The following models were evaluated:

- Ecoinvent®v2 (Oberholzer et al, 2006)
- Study of soil water erosion in France (Le Bissonnais et al, 2002)

- LANCA (Beck et al, 2008)
- RUSLE (Foster, 2005)

2.3.5.5.3. Model selected

The RUSLE model was chosen because it matched the AGRIBALYSE® selection criteria, and because its granulometry was particularly well-suited to the work in hand.

2.3.5.6. Calculation of flue gas emissions

A detailed description of the parameterization of models for calculating combustion gas emissions during cultivation operations can be found inAppendix BB -Sheet n°6: Combustion gases

2.3.5.6.1. Challenges and requirements

A significant proportion of pollutant emissions into the air are due to the combustion of fuel oil by tractors or power tools (using diesel or gas oil), or to the combustion of fossil fuels for heating purposes (e.g. greenhouses).

2.3.5.6.2. Models and emission items

For fuel combustion, the inventory proposed by Marylis Pradel (cfAppendix BB -Sheet n°6: Combustion gases) has enabled us to update the combustion emissions previously modeled on the basis of the model proposed by Ecoinvent®v2 (Nemecek and Kägi, 2007). For each type of substance, an emission factor is applied to the fuel quantity. Emissions linked to energy consumption in livestock buildings and greenhouse heating were taken into account through pre-existing LCIs.

2.3.5.7. Calculation of methane emissions (CH_4)

A detailed description of the parameters used to calculate $CH_{(4)}$ emissions can be found inAppendix BB -Sheet n°7: Methane (CH_4)

2.3.5.7.1. Challenges and requirements

Enteric emissions from ruminants represent a major source of greenhouse gas emissions, accounting for 6% of quantified emissions in France in 2009 (CITEPA, 2011). According to the IPCC, they are therefore a key source. It is recommended that they be accounted for using methods above Tier 1.

Methane emissions are also significant in the rice fields of Southeast Asia. A Level 2 approach is recommended.

2.3.5.7.2. Available models

Two models have been identified in the literature:

- IPCC, 2006b
- GESTIM (Gac et al, 2010)

2.3.5.7.3. Models and emission items

The evaluation of the previous models, taking into account the requirements of the AGRIBALYSE® program (see B.3.5), led to the selection of the following models (**Table16**

Table16: Models selected by CH_4 emission item.

CH_4 emission item	Model selected
Enteric emissions **Cattle** **Sheep** **Goats** **Pigs**	 **INRA Feeding System for Ruminants 2018, Level** **INRA Feeding System for Ruminants 2018, Level 3 INRA Feeding System for Ruminants 2018, Level 3** **IPCC 2019 Level 1**
Dejecta in the building and during storage	**IPCC 2019 Level 2**

Manure on pastures and rangelands	IPCC 2019 Level 2
Thai rice	IPCC 2006b Level 2

As part of the AGRIBALYSE® 3.0 update, a new model has been used to calculate enteric methane emissions from ruminants. CH4 emissions are estimated on the basis of the quantity of digestible organic matter ingested by the animals.

Emissions from manure depend on the type of manure produced, and on the manure management system in the building, at storage and at grazing. Up to AGRIBALYSE® version 3.1.1, the IPCC 2006 model was used to estimate the quantities of methane emitted by dejecta during storage or grazing. For version 3.2, the IPCC 2019 model, an updated version of the model, was used.

In the IPCC method, emissions from rice cultivation are calculated on the basis of a basic emission factor that is adjusted according to: i) water regime, ii) type and quantity of organic matter added, iii) soil type and cultivar.

2.3.5.8. Calculation of nitrate emissions (NO_3)

A detailed description of the parameterization of $NO_{(3)}$ emission calculation models can be found inAppendix BB -Sheet n°9: Nitrate (NO_3^-)

2.3.5.8.1. Challenges and requirements

Given the contribution of nitrate emissions to eutrophication problems, this flow has been quantified as part of AGRIBALYSE®. Nitrate emissions also contribute to greenhouse gas emissions (indirect nitrous oxide emissions).

The leaching phenomenon that affects the nitrogen received by a crop mainly takes place during the drainage period following the crop's harvest. To estimate nitrogen leaching, this period was taken into account, even though it falls outside the temporal limits set for plant inventories (from harvest of the previous crop to harvest of the crop concerned, see chapter A.2.2.2).

2.3.5.8.2. Available models

The preparatory work for model selection highlighted two types of model for estimating NO_3 emissions:

Dynamic models or dynamic balances:

- DEAC (Cariolle, 2002, Cohan *et al*, 2011) and SALCA-N (Richner *et al*, 2006). These models require input data relating to the soil and climate context, as well as data on agricultural practices.
- Nitrogen mass balance + water balance
- SQCB - Sustainable quick check for biofuels (Faist *et al*, 2009)

Models with fixed emission factors:

- COMIFER diagnostic grid (2001)
- Grid established by INRA (Basset-Mens *et al*, 2007)
- IPCC (2006b), Level 1

2.3.5.8.3. Models selected and emission item

None of the models evaluated met the specific needs of all the crops considered (annual, perennial, tropical). For this reason, different models were used to calculate nitrate leaching, depending on the type of crop.

- **Annual crops in mainland France**

Dynamic models can be used to accurately simulate emissions at plot level as a function of practices and the environment. However, their use requireson the one hand, a large amount of input data, not always available within the data collected as part of the program, and, on the other hand, significant parameterization work that was not compatible with the AGRIBALYSE® schedule. The INRA grid was designed for a specific soil and climate context and for specific production systems.

It was therefore decided to develop a new approach based on the COMIFER grid, applicable throughout France. The COMIFER grid is a simplified approach, developed by a group of recognized experts, for diagnosis at plot level, and can be used on a wider scale (regions, etc.). This method takes into account the main factors determining leaching, and has the added advantage of being rapidly operational.

- **Orchards and vineyards, special crops in mainland France (including carrots and soilless crops)**

For orchards, vineyards and metropolitan special crops, the SQCB model (Faist *et al*, 2009) was used. For grassed vineyards, leaching was considered for 50% of the total surface area, in order to take into account the effect of grassing. The effect of grassing was not taken into account in orchards.

For soilless crops (shrub, rose and tomato) with open or closed fertigation: leaching was calculated either on the basis of discharged water, which is then assumed to be leached into surface water, or on the basis of a nutrient solution loss rate defined by experts.

- **Meadows**

Neither the COMIFER adapted grid (model for annual crops) nor the SQCB model could meet the specific requirements of the different types of grassland (temporary, permanent, grazed). Given that DEAC is specifically parameterized for France, and that this model takes into account the parameters that make it possible to discriminate between different types of grassland, nitrate leaching under grassland was calculated separately for the 17 AGRIBALYSE® grassland inventories, using the DEAC model.

- **Pathways for animal**

Nitrate losses under rangeland were estimated based on the work of Basset-Mens *et al* (2007). An emission factor of 17.5% of the nitrogen supplied was used. This was applied to all grazing areas, of the type of animal present.

- **Tropical crops**

For tropical crops, the IPCC (2006b) Level 1 model was chosen, due to the lack of information needed to implement other methods, and to ensure methodological consistency between the various tropical crops. For the special case of rice, a specific model has been selected. It is based on a nitrogen mass balance and a water balance.

The models selected are presented in**Table17**:

Table17: Models selected by NO_3 emission station.

NO_3 emission item	Model selected
Annual crops in mainland France	**COMIFER 2001 adapted (Tailleur *et al*, 2012)**
Specialty crops in mainland France	**SQCB (Faist *et al,* 2009)**
Specialty soilless crops	**This report:** Based on water discharges/losses
Meadows	**This report:** DEAC
Tropical crops (clementines, coffee)	**IPCC 2006b Level 1**
Thai rice	**This report**: Based on a water balance
Animal production: Pathways	**Basset-Mens *et al,* 2007**

2.3.5.8.4. Adaptations made

The COMIFER grid (2001) takes into account a "crop" risk (a function of the length of time without the presence of a plant cover capable of absorbing nitrogen, the quantity of nitrogen returned by crop residues, the capacity of the following crop to absorb nitrogen in the autumn, and the application of organic fertilizers in the autumn) and an "environmental" risk (a function of the drainage layer (CORPEN, 1991) and mineralization conditions). However, it does not originally take into account fertilization practices on the crop prior to the leaching period in relation to its needs. This parameter has now been adapted and integrated. Each level of leaching risk is associated with a quantity of nitrate leached, based on experimental data or, where experimental data were insFUficient, on estimates derived from the DEAC model (Cariolle, 2002; Jolivel, 2003).

2.3.5.9. Land use and land use change

A detailed description of the parameterization of the models used to calculate land use and land transformation can be found atAppendix BB -Sheet n°10: Occupation (m^2.an) and land use change (m^2)

2.3.5.9.1. Challenges and requirements

In LCA, land use, from the point of view of the economic competition of activities requiring land surfaces, covers the aspects of land occupation and land use transformation. Land use does not in any way prejudge the storage or removal of carbon from the soil. What is considered here is the possible "loss" of the land resource. A distinction is made between:

- Land occupation: the inability of an area to return to its natural state as a result of the activities carried out on it (Frischknecht et al, 2007).
- Land transformation: the transition from one type of occupation to another (Frischknecht et al, 2007).

2.3.5.9.2. Models selected and emission item

The models used to calculate this parameter are presented inTable18

Table18: Models of land use and land use change.

Type of resource consumption	Model selected
Land use	Ecoinvent® v2 (Frischknecht et al, 2007)
Transformation of land use	Not considered for French productions.

For AGRIBALYSE® v3.0, the feasibility of implementing the PAS 2050-1:2012 methodology for French production was studied, but the data for tracing land-use change was not sFUficiently precise to be usable at this stage.

2.3.5.10. Calculation of nitrogen oxide (NO_x) emissions

A detailed description of the parameters used to calculate nitrogen oxide (NO_x) emissions can be found atAppendix BB -Sheet n°8: Nitrogen monoxide (NO)

2.3.5.10.1. Challenges and requirements

Nitric oxides are produced during denitrification processes. In an agricultural context, these emissions can increase significantly as a result of nitrogen inputs in the form of mineral and organic fertilizers, or animal manure.

2.3.5.10.2. Available models

Several models have been identified in the literature:

- Ecoinvent®v2 (Nemecek and Kägi, 2007)
- GESTIM (Gac et al, 2010)
- EMEP/EEA, 2009
- IPCC, 2006b
- MELODIE (Chardon et al, 2011)
- Yan et al, 2003b

2.3.5.10.3. Models and emission items

The models selected are presented inTable19

Table19: Models selected by NOx emission station.

NOx emission station	Model selected
Dejecta in the building	EMEP/EEA 2019, Level 1
Dejecta during storage	EMEP/EEA 2019, Level 1
Mineral and organic fertilization	EMEP/EEA 2016, Level 1
Thai rice	Yan et al, 2003b

Emissions from animal manure in buildings and storage facilities depend on: i) the type of animal and the type of effluent; ii) the number of animals; iii) the length of time they are present

For mineral and organic fertilization, a single emission factor has been used, the type of product.

2.3.5.11. Calculation of phosphorus emissions (P/PO_4)

A detailed description of the parameterization of the models used to calculate phosphorus emissions can be found inAppendix BB -Sheet n°11: Phosphorus (P)

2.3.5.11.1. Challenges and requirements

Given the importance of phosphorus in eutrophication problems, this flow was inventoried in the AGRIBALYSE® inventories. Phosphorus emissions mainly consist of flows (due to fertilization) towards the "surface water" and "groundwater" compartments.

2.3.5.11.2. Available models

Three models have been identified in the literature:

- **SALCA-P/Ecoinvent®**: Method applied to calculate phosphorus emissions in Ecoinvent® LCIs and documented in Nemecek and Kägi (2007) and Prasuhn et al (2006).
- **Application of fixed factors** (e.g. 0.69% applied P), derived from experimental results in several French catchments (Castillon and Lesouder, 2010).
- **ECODEFI:** A methodological approach based on the work of the ECODEFI project, which focuses on runoff (Pradel et al, 2011).

2.3.5.11.3. Models and emission items

Few studies have been carried out in France on a scale as large as that implemented by AGRIBALYSE® (Thomas NESME, ENITA Bordeaux, personal communication 2011). The ECODEFI and "application of fixed factors" approaches are based on French data. However, they were not retained as they were deemed too specific. The SALCA-P model was chosen because it is more generic in scope, taking into account the main emission items, and is applicable to both field crops and grassland. It should be noted, however, that this model has been validated for Switzerland but not for France. The following emission items are presented inTable20

Table20: Models selected for each P emission station.

P emission station	Model selected
Leaching emissions	SALCA-P (Nemecek and Kägi, 2007 and Prasuhn et al, 2006)
Runoff emissions	
Emission by erosion	
Tropical crops (clementines, coffee)	
Thai rice	This report: based on a water balance
Specialty soilless crops	This report: based on discharged/lost water
Emissions during manure storage	Not considered

2.3.5.11.4. Adaptation

Phosphorus levels in organic manures and sludges have been adapted to French conditions. Adaptation was not possible for the following three parameters due to the lack of available data (Appendix BB -Sheet n°11: Phosphorus (P):

- Average quantities of phosphorus lost through leaching
- Average quantities of phosphorus lost through runoff

- Average soil phosphorus content

For these parameters, default values from the SALCA-P models were used.

2.3.5.12. Calculating phosphorus emissions through erosion: calculating the amount of soil eroded

The calculation of phosphorus emissions due to erosion is based on the calculation model for the quantity of soil eroded (see B.3.5.4.e).

2.3.5.13. Calculation of phytosanitary active substance emissions

A detailed description of the parameters used to set up models for calculating emissions of active plant protection substances can be found inAppendix BB -Sheet no. 13: Phytosanitary active substances

2.3.5.13.1. Challenges and requirements

The application of plant protection products entails, in addition to the initial objective of protecting plants against harmful organisms, emissions of active substances into the water, air and soil compartments, with the risk of toxicity for organisms not targeted by these products.

2.3.5.13.2. Available models

In all, the following five models were studied:

- Audsley et al (2003), which proposes a breakdown of active substance emissions into soil (88.4%), crop (8%), air (2%) and water (1.6%) compartments.
- Anton et al (2004), who developed a dynamic model focused on the application of phytosanitary products in greenhouses, taking into account numerous factors: drift, canopy, vapour pressure and so on.
- Ecoinvent®v2.0 (Nemecek and Kägi, 2007), according to which 100% of applied active substances are emitted into the soil compartment
- EMEP (EMEP/EEA, 2009), part 4G - level I - which proposes five emission factors into the air compartment, depending on the saturation vapour pressure of the active substance (between 1% and 95%)
- PestLCI 1.1 (Birkved and Hauschild, 2003), which calculates emissions and their fate as a function of time since application, based on a dynamic model that requires extensive input data

2.3.5.13.3. Adaptation

In 2020, the results of a vast research project called OLCA-Pest11 were published: PestLCI model 1.1. A consensus between the main European teams working on pesticides in LCA for a new modeling approach at LCI and environmental impact assessment level was published. Different levels of modelling accuracy and detail have been provided, depending on data availability and the aim and scope of the study.

An approach based on "archetypes" is proposed for "background processes" and for database inventories in particular. These archetypes and emission fractions are built on the basis of the consensus Pest-LCI model, available online at12 . AGRIBALYSE® considers this approach to be a significant improvement, and has implemented the recommendations of the OLCA-Pest project with technical support from Ecoinvent. We would like to thank the Ecoinvent team for their technical support, as well as the OLCA-PEST research team for their work (T. Nemecek, P. Fantke, C. Gentil, C. Basset-Mens and C. Renaud in particular).

A summary of the implementation method is described inSheet no. 13: Phytosanitary active substances

The only exception was rice, which is grown in fields that are flooded for part or all of the growing season. For this crop, it was assumed that phytosanitary active ingredients are emitted equally from the water and soil compartments.

2.3.5.13.4. Models and emission items

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[11] https://www.sustainability.man.dtu.dk/english/research/qsa/research/research-projects/olca-pest

[12] https://pestlciweb.man.dtu.dk/documentation/PestLCI_Consensus_documentation.pdf

The models selected are presented inTable21

Table21: Models selected for each pesticide active substance emission item.

Transmitter station	Model selected
All crops	OLCA-Pest recommendations[13] (Nemecek et al, 2020)
Rice Thailand	Expertise S. Perret (CIRAD)
Soilless crops	This report
Plastic-covered floor	This report

2.3.5.14. Calculation of nitrous oxide (N_2O) emissions

A detailed description of the parameterization of the models used to calculate N_2O emissions can be found inAppendix BB - Sheet n°12: Dinitrogen monoxide (N_2O)

2.3.5.14.1. Challenges and requirements

In agriculture, N_2O emissions are mainly due to mineral and organic nitrogen fertilization, as well as animal waste management. The N_2O emitted results from nitrification-denitrification processes, and contributes to global warming.

2.3.5.14.2. Available models

Several models have been identified in the literature:

- CORPEN (2003) and CORPEN (2006)
- MELODIE (Chardon et al, 2011)
- Nemecek and Kägi, 2007
- EMEP/EEA, 2009
- IPCC, 2006b (updated 2019)
- Daum and Schenck, 1996

2.3.5.14.3. Models and emission items

The model initially selected for AGRIBALYSE® for nitrous oxide emissions was the one proposed by the IPCC (2006b), given its scientific and international recognition. As of AGRIBALYSE® version 3.1, the IPCC 2019 model has replaced it. When Tier 2 emission factors were available, they were used. However, in several cases, we had to make do with Tier 1.

The emission models and items used to calculate N2O emissions are presented inTable22

Table22: Models selected for each N2O emission source.

N2O emission station	Model selected
Crop production (Agricultural soils)	IPCC 2019, Level 1 (for emission factors)1)
Specialty crops in mainland France	IPCC 2019, Level 1 (for emission factors)1)
Tropical crops (clementines, coffee)	IPCC 2019, Level 1

[13] https://www.sustainability.man.dtu.dk/english/research/qsa/research/research-projects/olca-pest

Thai rice	IPCC 2006b, Level 2 based on Yan et al, 2003b
Grazing	IPCC 2019, Level 1
Dejecta in building/storage	CORPEN 2006, 2003, 2001, 1999a and 1999b: for calculation of nitrogen excreted by animals
	IPCC 2019, Tier 2 for emission factors (and leached fraction):
Droppings on the course	IPCC 2019, Tier 2 for emission factors (and leached fraction

1) Indirect N2O emissions have not been calculated using the IPCC default leached and volatilized fractions, but by calculating leached and volatilized quantities via the nitrate and ammonia models.

Daum and Schenck (1996) analyzed N2O volatilization for soilless crops. As the emission factor they propose is close to that of the IPCC (2006b), and uncertainties are associated with it, the method of estimating N2O flows used for agricultural soils was finally chosen.

2.3.5.15. Water use

As part of the LCA approach, water is considered as a potential receptor of pollutant emissions. Water quality is therefore taken into account, notably through the impact categories of eutrophication, acidification and ecotoxicity.

However, until now, water as a resource has not been taken into account. Recent methodological developments have made it possible to take into account the impact of water consumption

A project on the subject has been conducted to define the methodology to be implemented and to test it on a few AGRIBALYSE® products, using Means-InOut (Martin et al. 2019). The aim is to be able to cover the entire AGRBALYSE database correctly in this respect in the coming years

2.3.5.16. Calculation of phosphorus, nitrogen and suspended solids emissions for fish farming

A detailed description of the parameters of the models used to calculate N/P/MES emissions linked to fish farming activities can be found inAppendix BB -Sheet no. 14: Fish farming emissions

2.3.5.16.1. Challenges and requirements

Due to the specific nature of their farming methods, fish farms have a potentially significant impact on the environment, particularly in terms of eutrophication. It is therefore important to estimate as accurately as possible emissions of suspended solids (SS), nitrogen and phosphorus, in both dissolved and particulate forms, using specific models.

2.3.5.16.2. Models and emission items

In France, emission models for phosphorus, nitrogen and TSS have been developed specifically for French fish farms (Papatryphon et al, 2005). The models used to calculate this parameter are presented inTable23

Table23: Models selected for fish farming, by substance emitted.

Transmitter station	Model selected
Nitrogen	Papatryphon et al, 2005
Phosphorus	
Suspended solids (SS)	

The principle of the model adopted is that of an input/output balance requiring knowledge of the composition of the feed rations distributed to the animals, the composition of the animals (element content of tissues), and the quantity of undigested nutrients.

2.4. Allocation of flows and emissions

2.4.1. Allocation of shared inputs: infrastructure

The need for agricultural infrastructure has been taken into account by amortizing the impact of the infrastructure in proportion to the site throughput (for agricultural processes in the plant sector) or in proportion to the time required to occupy the required surface area (for buildings). Site throughput encompasses the time required for the work as well as that for preparation. This approach is standard for LCAs of agricultural products (Nemecek and Kägi, 2007; Gac *et al*, 2010).

2.4.2. Allocation to co-products

With the exception of certain on-farm transformations (e.g.: wrapping, silage, etc.), "on-farm" and "post-farm" transformation processes have been considered separately from the agricultural phase. Co-products such as oilseed cakes, which result from post-farm transformation processes, are therefore not included in the scope of AGRIBALYSE® "agricultural phase". Specific work has been carried out on certain co-products, but only in the context of requirements for animal feed and by reusing existing work for the whole of the processing partAppendix JJ

2.4.2.1. Definition of "co-product

Agriculture is multifunctional, and farming systems often produce several co-products. The "main product" is defined in AGRIBALYSE® as the output that corresponds to the main function of the system under consideration; all other jointly produced outputs of interest are defined as co-products.

2.4.2.2. Principles and choices

2.4.2.2.1. Basic rule

As a general rule, AGRIBALYSE® complies with international standards; whatever allocation rule is chosen, it must be as relevant for the main product as for the co-product. In all cases, the allocation procedure is clearly explained.

2.4.2.2.2. Hierarchy

Allocation rules are based on the recommendations of the reading guide of the Methodological Appendix of the BPX 30-323 standard (AFNOR, 2011). In accordance with ISO 14044 (ISO, 2006b), in AGRIBALYSE® the general hierarchy of allocation modes is as follows:

- 1st choice: avoid the:
    - Dividing the elementary process to be assigned into two or more sub-processes, and collecting input and output data related to these sub-processes
    - By extending the product system to include the additional functions of co-products, taking into account the requirements defined in paragraph 4.2.3.3 of ISO 14044 (ISO, 2006b). This does not apply to the atributional LCA framework used for AGRIBALYSE®.
- **2nd choice: "physical allocation":** The system's inputs and outputs should be allocated to its various products or functions in a way that reflects the underlying physical relationships between them. In other words, these physical relationships should illustrate how inputs and outputs evolve with quantitative changes in the products or functions the system provides.
- **3rd choice: "economic allocation":** The economic value of the co-products (e.g. the selling price), represents the production objective. This allocation mode is common in LCA when there is no physical criterion that is relevant for both the product and the co-product(s). The drawback of this allocation method is that the impact of products is thus market-dependent, and can be highly variable from one year to the next, even if the production system is identical from one year to the next.
    - To mitigate this shortcoming, we have used economic data smoothed over 5 years, excluding the two extreme years (Olympic average). This approach enables us to represent the value of a product, and the evolution of the value attributed to it by the market, while avoiding the impact of strong price variations.

2.4.2.2.3. List of AGRIBALYSE® products / co-products

Table24 gives an overview of products/coproducts by type of production, as well as the methods used to allocate flows between products and coproducts. These choices are detailed in the following chapters (B.4.2.3 to B.4.2.5).

Table24: List of products / co-products generated in AGRIBALYSE® - Co-product management method selected.

	Production	Product / Co-product	Co-product management method
Plant production	Cereals / Protein crops	Grain / straw	Economical N.b. no value attributed to straw, 100% impacts attributed to grain
	Carrot	Marketable carrots Waste	100% Not considered
	Orchards / Vineyards	Fruits Dimension lumber	100% Not considered
	Meadows	Grazed grass Harvested grass	Massive
	Clementines	Clementine export Local clementine	Economical
	Café	Green coffee (main product) Pulp (composted on the farm)	Economical 96% 4%
Animal production	Suckling beef	Bull / Heifer Cull cow	Bio-physics
	Dairy cattle	Milk Cull cow Veal	Bio-physics
	Ovine meat	Lamb Wool Cull ewes	Bio-physics
	Dairy sheep	Milk Lamb Wool Cull ewes	Bio-physics
	Dairy goat	Milk Cull goat	Bio-physics

	Laying poultry	Egg Spent Poultry	Bio-physics
	Pork	Pork butcher Cull sows	Bio-physics

2.4.2.3. Crops in mainland France

2.4.2.3.1. Grain/straw (cereals, protein crops)

It was decided to use an economic allocation method for this product/coproduct pair. However, as the straw market is not very structured at present, data concerning the economic value of this co-product are not very reliable. Consequently, no value has been assigned to straw, meaning that 100% of the impacts are attributed to grain. An exception was made for biogenic CO_2, where a mass allocation was made to reflect the physical reality of the carbon flow.

Note: It is not impossible that the straw market will become more structured, or that more reliable and representative data will one day be available. Allocating straw according to an economic criterion will then enable this information to be taken into account when updating the AGRIBALYSE® database.

2.4.2.3.2. Marketable carrots - Waste carrots

In line with the allocation rules for other products, no allocation has been made to waste. Carrot yield includes first choice carrots (destined for the fresh market) and second choice carrots (destined for industrial processing). Not distinguishing between these two outlets is equivalent to a mass allocation, i.e. the two types of carrot have identical impacts.

2.4.2.3.3. Peach/nectarine, apple/cider apple - wood; Wine grape - wood

Since, in orchards, pruned wood and shoots are in most cases burnt in the field, the wood is not considered as a co-product leaving the field and therefore no allocation is required.

As with carrots, apple yields include 2nd choice apples for processing.

2.4.2.3.4. Preserved grass and grazed grass

The grassland inventories include five grazed (cattle) LCIs and twelve mown LCIs with a mixed regime (mowing/pasture). In the latter, part of the grass is conserved (hay, silage, haylage) and considered as the main product of the LCI. The other part is grazed for the duration of the inventory and considered as a co-product. A mass allocation has been applied to the flows linked to the establishment and fertilization of grassland, assuming that the protein and energy content of the grass is more or less the same whatever the fate of the grass (consumed by grazing or harvested for transformation into conserved grass). The flows linked to harvesting are entirely attributed to the grass harvested. Grazed grass, co-product" has not been included in the AGRIBALYSE® database, as the five LCIs for pure grazing (cattle) are used.

2.4.2.4. Tropical crops

2.4.2.4.1. Clementine export quality - Clementine local market quality

The allocation between clementines for the local market and clementines for export was made on an economic basis.

Pruning wood in Moroccan clementine orchards was not considered as a co-product leaving the plot. As it is generally crushed and returned to the soil between rows, no allocation was necessary in this context.

2.4.2.4.2. Coffee - wood

Pruning wood from coffee plantations is partly left on the plantation, and partly used as firewood. As they have no market value, no wood allocation has been considered.

2.4.2.5. Animal production

For animal production, impacts are allocated to co-products using a "bio-physical" model (Figure14). Initially, allocation is avoided by dividing the process into several unit processes, i.e. by breaking down the animal's life into characteristic physiological stages. For certain stages, there are always several products, so an allocation remains to be made, for example for the milk production phase in cattle. Here, a milk/calves allocation is necessary. This was done in proportion to the energy required for the various physiological functions of the animal and for the production of the product and co-products. Five functions have been distinguished: maintenance, activity, growth, lactation and gestation. Note that LCI "0-day animals" (e.g. "0-day calves") correspond to phases used to feed LCI "young beef animals" and herd renewal. Under no circumstances are they "complete" LCIs, at farm gate (e.g. veal calf).

It should be noted that the AGRIBALYSE® biophysical allocation methodology for dairy farming differs slightly from that recommended at European level by the PEF.

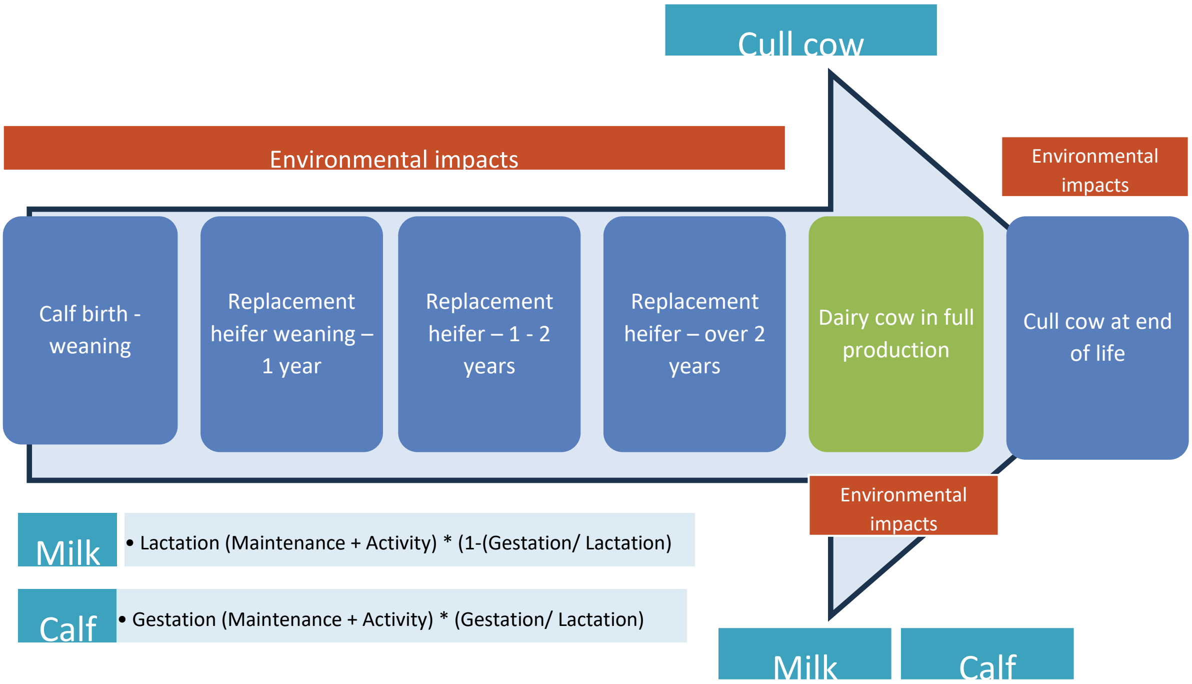

Figure14: Assigning impacts to co-products using a "Bio-physical" model for a dairy production plant. The workshop is divided: in blue, the physiological stages for which impacts are attributed to the cull cow; in green, the stages for which impacts are attributed to milk and calves. Impacts are allocated between milk and calves in proportion to the energy required to produce these two products.

AAppendix JJ presents the allocation factors used in AGRIBALYSE®.

2.4.2.5.1. Dairy cattle

Table25: Physiological stages, products and functions of dairy cattle, for the allocation of impacts according to the energy required for these functions.

Stadium	Outgoing products	Maintenance	Activity	Growth	Lactation	Gestation	Note
Calf 0-weaning	VL reform	X	X	X			Mass allocation, in proportion to live weight produced
	Veal (b)	X	X	X			
Heifer Weaning-1 year	VL reform	X	X	X			
Heifer 1-2 years	VL reform	X	X	X			
Heifer + 2 years	VL reform	X	X	X			

VL in production	Milk	X	X		X		$$Lactation + (Entretien + Activité) * \left(1 - \frac{Gestation}{Lactation}\right)$$
	Calf at birth	X	X			X	$$Gestation + (Entretien + Activité) * \frac{Gestation}{Lactation}$$
	VL reform						
Cull cow finishing	VL reform	X	X	X			

Cull VL = Cull dairy cow; X indicates the functions concerned for each physiological stage.

For the dairy cow phase in production, it was assumed that the animal's weight gain was negligible. Consequently, all impacts were allocated between calves and milk (Table25

2.4.2.5.2. Beef cattle - Allaitants

Table26: Physiological stages, products and functions of suckler cattle for the allocation of impacts according to the energy required for these functions.

Stadium	Outgoing products	Maintenance	Activity	Growth	Lactation	Gestation
Calf 0-1 year	Heifer and beef cattle	X	X	X		
Renewal heifer 0-1 year	VA reform	X	X	X		
Renewal heifer 1-2 years	VA reform	X	X	X		
Renewal heifer +2 years	VA reform	X	X	X		
Suckler cow	Calf at birth	X	X	X	X	X
Cull cow finishing	VA reform	X	X	X		
Breeding bull	VA reform	X	X	X		

VA cull = cull lactating cow; X indicates the functions concerned for each physiological stage.

In the suckler cow phase of production, the animal's weight gain is considered negligible. Consequently, impacts have been allocated 100% to the calf (**Table26**

2.4.2.5.3. Beef cattle - Fattening

The impacts of all animal classes were allocated to fattened cattle.

2.4.2.5.4. Milk goats

Table27: Physiological stages, products and functions of dairy goats for the allocation of impacts according to the energy required for these functions.

Stadium	Outgoing products	Maintenanc e	Activity	Growth	Lactation	Gestation	Note

Kid (0 - 8 days)	Chevreau	X	X	X			
Renewal clip 0-1 year	Cull goat	X	X	X			
Goats in production	Cull goat						
	Kid at birth	X	X	X		X	$Gestation + (Maintenance + Activity) * \frac{Gestation}{Lactation}$
	Milk	X	X	X	X		$Lactation + (Maintenance + Activity) * \left(1 - \frac{Gestation}{Lactation}\right)$

X indicates the functions involved for each physiological stage.

For the dairy goat phase in production, it was assumed that the animal's weight gain was negligible. Consequently, all impacts were allocated between kids and milk (Table27

2.4.2.5.5. Meat sheep

Cull ewe, lamb and wool co-products were identified. The breakdown of impacts is presented in**Table28**

Table28: Physiological stages, products and functions of meat sheep to determine the allocation of impacts according to the energy required for the functions.

Stadium	Outgoing products	Maintenance	Activity	Growth	Lactation	Gestation	Wool production	Note
0-weaning lamb	Cull ewes	X	X	X				Mass allocation, in proportion to live weight produced
	Lamb	x	x	x				
Renewal ewe lamb weaning-1 year	Cull ewes	X	X	X				
	Wool						X	
Weaning lamb for sale	Lamb	X	X	X				
Renewal ewe lamb 1 year-2 years	Cull ewes	X	X	X				
	Wool						X	
Ewes in production	Cull ewes	X	X	X				
	Lamb				X	X		
	Wool						X	

X indicates the functions involved for each physiological stage.

In the ewe-in-production phase, the animal's weight gain is <u>not negligible</u>. Consequently, impacts have been allocated between cull ewes, lambs and wool.

2.4.2.5.6. Dairy sheep

Milk, cull ewes, lamb and wool co-products were identified. The breakdown of impacts was carried out according to the modalities presented in

Table29

Table29: Physiological stages, products and functions of dairy sheep to determine the allocation of impacts according to the energy required for these functions.

Stadium	Outgoing products	Maintenance	Activity	Growth	Lactation	Gestation	Wool production	Note
Lamb (0-weaning)	Lamb	X	X	X				
Renewal ewe lamb 0-1 year	Cull ewes	X	X	X				
	Wool						X	
Renewal ewe lamb 1-2 years	Cull ewes	X	X	X				
	Wool						X	
Ewes in production	Cull ewes							
	Lamb	X	X			X		$Gestation + Maintenance + Activity) * \frac{Gestation}{Lactation}$
	Milk	X	X		X			$Lactation + (EMaintenance + Activity) * \left(1 - \frac{Gestation}{Lactation}\right)$
	Wool						X	

X indicates the functions involved for each physiological stage.

For the ewe in production phase, it was assumed that the animal's weight gain was negligible. Consequently, all impacts were allocated between lambs, milk and wool.

2.4.2.5.7. Laying poultry

Table30: Physiological stage, product output and percentage of stage impact allocated to each product for laying hens.

Stadium	Outgoing products	Percentage of impact allocated to product
Poultry - Future breeders	Spent Poultry	100
Poultry - Breeding	Spent Poultry	100
Poultry - Chicken	Spent Poultry	100

Poultry - Layers	Spent Poultry	0
	Egg	100

For the Poultry - Layers phase, it was assumed that the animal's weight gain was negligible. The environmental impacts of this phase were attributed 100% to eggs (Table30

2.4.2.5.8. Rabbit production

Table31: Physiological stages, products and functions of rabbit production to determine the allocation of impacts according to the energy required for these functions.

Stadium	Outgoing products	Maintenance	Activity	Growth	Lactation	Gestation
Rabbit - Maternity	Spent rabbit	X	X	X		
	Rabbit				X	X
Rabbit - Fattening	Rabbit	X	X	X		

2.4.2.5.9. Pig production

For pig production, the allocation of impacts between piglets and cull sows was based on the quantity of feed used (**Table32**).

Table32: Physiological stage, product and environmental impact distribution key for pigs.

Stadium	Outgoing product	Impact distribution
Pork - Sow workshop	Cull sows	0.75*Qte feed for pregnant sows + 0.4*Qte feed for suckling sows + 1*Qte feed for gilts
	Pork butchers (piglets)	0.25*Qte feed for pregnant sows + 0.6*Qte feed for suckling sows
Pig - Post-weaning	Charcutiers	100% for charcuterie pork
Pork - Fattening	Charcutiers	100% for charcuterie pork

Note: Qte = Quantity

2.4.3.Allocation of processes, inputs and outputs at crop succession level

2.4.3.1. AGRIBALYSE® elements and allocation s for crop succession:

It is difficult to re-attribute the impacts of a production system to each of the crops in the cropping succession for the following reasons:

- Certain practices can benefit several crops in a crop succession,
- Some emissions are a function of the practices and characteristics associated with a given crop, but also of the practices and characteristics associated with subsequent or previous crops.

The ILCD Handbook recommends treating nutrients remaining in the system after a crop has been harvested as a co-product of that crop, and therefore proceeding by system extension or allocation. Here are the allocation rules used in AGRIBALYSE®.

Table33: Allocation rules for crop succession.

Element	Comments	Allocation rule
Phosphorus (P) and potassium (K)	These elements are not very mobile in the soil. Some farmers use blockages, applying nutrients only to one crop, but the quantities applied also meet the needs of subsequent crops.	Impacts linked to the production of these inputs and to emissions (P,PO4, ETM) linked to their spreading are allocated to each crop in proportion to exports. Sources used: COMIFER farming practices survey and export tables
Organic nitrogen (organic N)	Only a fraction is directly available to the crop receiving the input. The remainder contributes to a stock of organic matter, which can benefit all crops in the rotation.	The nitrogen available for the crop receiving the input is allocated to it. The rest is allocated equally among all the crops in the rotation. Sources used: Survey of farming practices and mineralization kinetics of organic fertilizers from the CASDAR "Sustainable soil management" project.
Mineral nitrogen	The quantities of nitrogen supplied in mineral form are directly available to the crop receiving them.	The impact of production and the emissions of nitrogen supplied in mineral form to a crop are fully attributed to that crop.
Nitrate during intercropping	After the crop has been harvested, nitrate residues remain. These can be used by the following crop, but a fraction may also be washed away.	The impact of emissions during intercropping is attributed to the previous crop.
Nitrogen from crop residues	Crop residues can be a source of nitrogen for the following crop(s). They also induce N_2O emissions according to IPCC Tier 1 methodology.	The impact of nitrogen production from crop residues and the N_2O emissions induced by these residues are attributed to the crop that produced them.

2.4.3.2. Allocation of organic P, K and N inputs based on the Agreste cropping practices survey, 2006.

Organic P, K and N inputs have been allocated to all crops in the cropping succession. To make this type of allocation, it is necessary to know the details of inputs and yields for each crop in the cropping succession. However, few statistical data are available at crop succession level, and these do not cover the entire production of the various crops studied by AGRIBALYSE®. The Agreste 2006 cropping practices survey is based on a crop rather than a cropping succession. On the other hand, it has the advantage of covering most of the main production regions for around ten major crops. It also provides information on the history of the plot, and in particular details of previous cropping. The year 2006 was considered representative for fertilizer inputs over the period 2001-2005.

For the 14,000 plots surveyed, we know which crops were grown in succession between 2001 and 2005. Analysis of this data has identified almost 4,000 different rotations. This diversity of situations and the size of the sample mean that it is not possible to reconstruct fertilization practices for each rotation. However, to take this diversity into account, these rotations were grouped into "crop succession groups" using optimal matching statistical methods (Gabadinho *et al*, 2011). In this way, the 4,000 rotations were grouped into 34 major crop succession groups, according to dominant crops and production region (Jouy and Wissocq, 2011). This grouping made it possible to take into account differences in fertilizer inputs for the same crop, depending on the rotation and the region in which it is included, based on Agreste 2006 data. Once the allocation work had been carried out according to the principle set out in **Table33**for each crop within the crop groups, an average for France was calculated.

The implementation of this approach in the LCI is presented inAppendix BB -Sheet n°16: Allocation of basic manure and organic fertilizers in crop succession

3. Impact assessment

AGRIBALYSE® has not worked on the development of characterization methods.

Since the v1.2 update, it has been decided to no longer supply characterization methods with the LCI AGRIBALYSE® database. This will enable users to always work with the most up-to-date characterization methods best suited to their needs. However, users must ensure that AGRIBALYSE® covers the flows required for the chosen method (e.g. AGRIBALYSE® does not cover "particulate" flows).

In order to provide users without LCA software with LCA impact results, the midpoint indicators of the EF method have been retained in the summary Excel files.

CONCLUSION

This methodological report presents all the methodological choices made for the French agricultural data in the AGRIBALYSE® database. It is intended to provide a clear understanding of how the data were obtained, to facilitate the production of LCIs comparable to those of AGRIBALYSE® and to help interpret the results. It is not intended to serve as a methodological guide, although it may contribute to harmonizing methodological choices when carrying out LCAs of agricultural products in France or abroad. New versions of this report may be produced as the AGRIBALYSE® database evolves.

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List of abbreviations

ACTA	Agricultural Technical Coordination Association
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
ADEME	French Environment and Energy Management Agency
AFNOR	French Standards Association
AGRESTE	Agricultural statistics, evaluation and forecasting
AOX	Adsorbable Organic Halogen
ASTREDHOR	Technical Institute for Horticulture
BDAT	Soil Analysis Database
Bdd	Database
CASDAR	Special Allocation Account for Agricultural and Rural Development
CAT	Change of land use
Cd	Cadmium
CDT	Computerized Data Processing Chain
CH	Switzerland
CH_4	Methane
CIRAD	Center for International Cooperation in Agronomic Research for Development
CITEPA	Interprofessional Technical Center for the Study of Atmospheric Pollution
CN	China
CO_2	Carbon dioxide
COMIFER	French Committee for the Study and Development of Reasoned Fertilization
CORPEN	Comité d'Orientation pour des Pratiques Agricoles respectueuse de l'ENvironnement (Orientation Committee for Agricultural Practices that Respect the Environment)
Cr	Chromium
CTIFL	Interprofessional Technical Center for Fruit and Vegetables
Cu	Copper
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
EDIP	Environmental Design of Industrial Products (LCA impact characterization method)
EMEP/CORINAIR	Cooperative program for monitoring and assessment of long-range transfer of air pollutants in Europe/CORe INventory of AIR emissions
EMEP/EEA	Cooperative Programme for Monitoring and Evaluation of Long-range Transfer of Air Pollutants in Europe/European Environment Agency
ESA Angers	Angers School of Agriculture
et al	et collaborators (Latin: *et alii* = et d'autres)
ETM	Trace Metal Element / heavy metals
FAF	Farm Manufacturing
EN	France
GDC	Data Collection Guide
GGELS	Greenhouse Gas from the European Livestock Sector
IPCC	Intergovernmental Panel on Climate Change
GLO	GLObale, Ecoinvent® country code for marking inventories with a global scope
GWP	Global Warming Potential
h	Time
ha	Hectare
Hg	Mercury
LCI	Life Cycle Inventory
IDELE	Institut De L'ELEvage
IDF	International Dairy Federation
i.e.	I.e. (Latin: *id est*)
IES	Institute for Environment and Sustainability
IFV	French Institute of Vine and Wine
ILCD	International reference Life Cycle Data System
INRA	French National Institute for Agronomic Research

INRAE	Institut national de recherche pour l'agriculture, l'alimentation et l'environnement (institute created in 2020 from the merger of INRA and IRSTEA)
IRSTEA	French National Institute for Research in Science and Technology for the Environment and Agriculture
ISO	International Organization for Standardization
ITAB	Technical Institute of Organic Agriculture
ITAVI	Institut Technique de l'AVIculture
ITB	Beet Technical Institute
ITK	Technical itinerary
JRC	Join Research Center
K	Potassium
kg	Kilogram
km	Kilometer
L	Liter
m^2	Square meter
m^2.year	Square meter.year
MB	Gross Matter
MELODIE	Object Language Livestock Modeling for Determining Environmental Impacts
TSS	Suspended Solids
MP	Raw Material
MS	Dry Matter
MT	Transport Model
N	Nitrogen
N_2O	Nitrous oxide
NH_3	Ammonia
Ni	Nickel
NO	Nitrogen monoxide or nitric oxide
NO_3	Nitrate
Available N	Available nitrogen
Total N	Total nitrogen
CDT OIS(in French)	Computerized Input Tool
P	Phosphorus
P_2O_5	Diphosphorus penta oxide (form of phosphorus found in fertilizers)
PAS	"Publicly Available Specification" drawn up in accordance with the guidelines of the British Standards Institute
Pb	Lead
PO_4	Phosphate
RER	Europe, Ecoinvent® country code for marking inventories with a European scope
RMQS	Soil Quality Measurement Network
RUSLE	Revised Universal Soil Loss Equation
SA	Active substance
SALCA	Swiss Agricultural Life Cycle Assessment
SALCA-ETM-Fr	Swiss Agricultural Life Cycle Assessment, ETM emission model adapted to France
SALCA-N	Swiss Agricultural Life Cycle Assessment, Nitrate emission model
SALCA-P	Swiss Agricultural Life Cycle Assessment, Phosphorus emission model
SALCA-SM	Swiss Agricultural Life Cycle Assessment, ETM emission model
UAA	Useful agricultural area
SCEES	Service Central des Enquêtes et Etudes Statistiques
SFP	Main forage area
SQCB	Sustainable Quick Check for Biofuels
SSP	Statistics and Forecasting Department
STICS	Multidisciplinary Simulator for Standard Crops
t	Tonne
TAN	"Total Amoniacal Nitrogen" (total nitrogen in the form of ammonium)
TERRES INOVIA	Technical Institute for the Vegetable Oil and Protein Sector and the Hemp Sector
UC	Collection Unit
FU	Functional Unit
UMR-SAS	Joint Research Unit - Soil, Agro and Hydrosystem Spatialization

UNIFA	Union of Fertilization Industries
VBA	Visual Basic for Applications
VA	Allaitante Cow
VL	Dairy Cow
xml	eXtended Markup Language
Zn	Zinc

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REFERENCES TO DATA SETS

All documents relating to the AGRIBALYSE database® are available on the "AGRIBALYSE® - GIS REVALIM" dataverse in the AGRIBALYSE® collection on the open French public data platform data.gouv.fr.

Non-Agribalyse dataverse datasets cited in this report:

Auberger, Julie; Malnoë, Caroline, 2024, "Agricultural operations used in MEANS-InOut: characteristics useful for environmental assessment with LCA", https://doi.org/10.57745/TS0NTA, Recherche Data Gouv, V1

Auberger, Julie; Malnoë, Caroline, 2024, "Fertilisers used in MEANS-InOut: compositions and characteristics useful for environmental assessment", https://doi.org/10.57745/LPRJIH, Recherche Data Gouv, V1,

GLOSSARY

To facilitate understanding of this Methodological Report, the definitions of certain terms are given here, along with their source if the definition is taken from the literature. These definitions are not intended to be prescriptive, but are an integral part of this Methodological Report, for which they have been drawn up.

They are intended to avoid confusion within the AGRIBALYSE® program.

Terms specifically defined or having a particular meaning within AGRIBALYSE® are highlighted **in green**. Definitions of terms marked with an asterisk (*) are taken from ISO 14044 (ISO, 2006b).

Compound feed

Feed composed of several more or less processed raw materials, purchased or manufactured by the farmer and distributed to the animals.

Elementary food

Raw material or fodder served directly to animals. A priori, only feed rations for herbivores (cattle, sheep, goats) can contain basic feedstFUfs. For other types of production, only compound feeds are used (with the exception of pigs and fatty palmipeds, which can be fed wet grain corn directly).

*Allocation / assignment

Allocation of incoming or outgoing flows from a process or product system between the product system under study and one or more other product systems.

Life Cycle Impact Assessment (LCIA)

See "Life Cycle Impact Assessment".

*Life cycle assessment (LCA)

Compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system over its life cycle.

Shrub

Woody ornamental plants in containers.

Production shop

Part of a farm dedicated to one type of production. AGRIBALYSE® distinguishes between animal and crop production units. For livestock production, the workshop does not therefore refer to all the farm activities that contribute to the livestock activity. On-farm forage and feed production, particularly on mixed crop-livestock farms, are not considered.

Band (= batch)

Group of animals at the same physiological stage reared in a similar way. Within the same barn, several bands may follow one another during the same year.

Base Carbone

This database, developed by ADEME, complements the IMPACTS database® . It contains only information on greenhouse gas emissions.

AGRIBALYSE® database

Database of life cycle inventories of agricultural and food products destined for the French market in unit process format. This Methodology Report describes how the inventories of French agricultural production were constructed.

Biogenic carbon

Carbon stored or emitted by natural (short-cycle) sources, i.e. not derived from the use of fossil energy sources.

Case studies

Description, using a set of technical and economic indicators, of the operation of a particular farm or group of farms.

Case history

Description, using a set of technical, economic and even environmental indicators, of the coherent operation of a farm at cruising speed, for a given system and context. The case study illustrates the operation and performance of a given type of production system.

*Impact category

Class representing the environmental problems studied and to which the results of the life cycle inventory can be assigned.

Data processing chain (CDT)

A software tool initially based on SALCA, a Swiss calculation tool and database for life-cycle analyses, and adapted to the needs of AGRIBALYSE® for LCI calculations. It was used to generate and update the AGRIBALYSE® database from versions 1 to 1.3, before being replaced by MEANS-InOut.

Animal class

Component of animal production systems, used for data collection in AGRIBALYSE®. Each animal class represents a group of animals run with the same input parameters, i.e. feed, building space use, manure and technical data. In animal production, Life Cycle Inventories (LCIs) are therefore mostly made up of several "classes".

Example of the six classes making up the dairy cattle LCI:

- Calf (birth - "8 days")
- Calf ("8 days" - Weaning)
- Renewal dairy heifers weaning-1 year old
- Dairy heifers 1-2 years old
- Dairy heifers +2 years
- Dairy cows in production

Consistency check

A procedure for checking that hypotheses, methods and data are applied consistently throughout the study, in accordance with the definition of the objectives and scope of the study. This approach also serves to compare AGRIBALYSE® results with bibliographical references.

*Product

One of two or more products from an elementary process or system of products.

*Cut-off criteria / cut-off rule

Specification of the quantity of material or energy flows or level of environmental significance associated with the elementary processes or product system to be excluded from a study.

Intermediate crop

A crop whose purpose is to occupy a plot of land with plant cover during the intercropping period. Often not harvested, it has no economic function. In the AGRIBALYSE® program, the intermediate crop preceding the inventoried crop with no economic function is included in the system under consideration. When it is harvested or has an economic function, it is considered as such and not as an intermediate crop.

*Lifecycle

Consecutive and linked phases of a product system, from the acquisition of raw materials or the generation of natural resources to final disposal.

*Waste

Substances or objects that the holder intends to dispose of or is required to dispose of.

Declination

Specific form of a production system distinguished by particular parameters (e.g. production region, technical itinerary, etc.). Products from several variations of the same production system form a product group.

Background data

Pre-existing inventory data (LCI) in publicly available databases used to compile AGRIBALYSE® inventories.

Ecospold

Data exchange format (xml) frequently used for life cycle inventories.

Direct emissions (primary)

Flows of potentially polluting substances into the environment, directly associated with animal and plant production on the production site in question.

Indirect (background) emissions

Flows of potentially polluting substances into the environment associated with the production of inputs used on the production site in question. These flows are proportional to the quantity of input used. They are modeled as background processes in the databases.

*Life Cycle Impact Assessment = Analyse de l'Impact du Cycle Vie (ALCI)

Phase of the Life Cycle Assessment (LCA) method designed to understand and evaluate the magnitude and significance of the potential impacts of a product system on the environment during its life cycle.

*Extrant (also called outgoing)

Flow of product, material or energy from an elementary process.

NOTE: Products and materials include raw materials, intermediate products, co-products and emissions.

*Characterization factor

Factor established from a characterization model that is used to convert life cycle inventory results into a common category indicator unit.

NOTE: The common unit allows results to be grouped together in the same category indicator.

Fertigation

This technique combines irrigation (water) with soluble fertilizers.

*Product flow

Products entering or leaving one product system in the direction of another.

*Reference flow

Measurement of process outputs, in a given product system, required to fulfill the function as expressed by the functional unit.

System boundary

A set of criteria specifying which elementary processes are part of the product system. In order to guarantee the comparability of the different products, AGRIBALYSE® has defined spatial and temporal boundaries common to the agricultural systems studied:

The "cradle to gate" rule was adopted, i.e. from the cradle to the end of the field for plant production, and to the end of the production workshop for animal production.

The temporal limits for plant systems run from "harvest to harvest", with the exception of short-cycle and perennial species, for which the temporal limits extend from January 1 to December 31. For livestock production, time limits run from January 1 to December 31.

Product groups

Group bringing together comparable products through the notion of declination.

Data Collection Guide (DCG)

A document (Biard *et al*, 2011a) developed as part of AGRIBALYSE® with the aim of clarifying data collection, explaining "good modeling practices" for systems and ensuring the comparability of inventories.

LCI phantom

A life-cycle inventory that contains neither inputs nor outputs. It is an "aide-memoire" and its aim is to provide a better understanding of the logic of a flow balance.

*Final impact by category

Attribute or aspect of the natural environment, human health or resources that identifies an environmental problem area.

*Impact category indicator

Quantifiable representation of an impact category.

Interculture

Period between two main crops. It begins with the harvesting of the previous crop and ends with the sowing of the following crop.

*Input

Flow of product, material or energy into an elementary process.

NOTE: Products and materials include raw materials, intermediate products and co-products.

*Life cycle inventory (LCI)

Phase of life cycle assessment involving the compilation and quantification of inputs and outputs, for a given product system over its life cycle.

National inventory

Nationally representative inventory, inventory with national scope = "national inventory". This representativeness was achieved by integrating farming practices from different ITKs: either by direct data entry in a single inventory, indicating the frequency of each cropping practice (by means of "area concerned"), or by aggregating several sub-inventories.

Technical itinerary (ITK)

A technical itinerary is a logical, ordered combination of cultivation techniques used on a plot of land, which, by controlling the ecological environment, enables a given production objective to be achieved, in terms of quantity and quality (Sebillotte, 1974).

Batch

See band.

Median

The median is the value that divides an ordered numerical series into two parts with the same number of elements (i.e. each part contains 50% of the elements).

Metadata

Additional information about the data entered.

Optimal matching method

The Optimal Matching Method is a statistical method based on the measurement of similarity or dissimilarity between sequences. It is used to obtain distances between sequences, which can then be grouped together using classification methods. This method can be used to build typologies.

Characterization model

Mathematical model used to define characterization factors. These are then used to characterize system inputs and outputs, *i.e.* convert inventory results into impact indicator results, according to their degree of contribution to the impacts considered by the characterization model.

Arithmetic mean

The arithmetic mean is the "ordinary" mean, i.e. the sum of the numerical values (of a given list) divided by the number of these numerical values.

Olympic average

Average obtained from a list of values, by removing its largest and smallest elements.

Computerized Input Tool (OIS)

Computerized data entry tool developed by AGRIBALYSE® v.1® , used to enter the data needed to compile life cycle inventories.

Reference period

Time period covered by life cycle inventories in terms of data representativeness. It was defined as being recent at the time of data collection (so that LCIs represent current agricultural practices) and covering several years (to avoid bias in LCI results due to an exceptional year)

*Processes

A set of correlated or interactive activities that transform inputs into outputs.

*Elementary process / unit process

The smallest part of the life cycle inventory for which input and output data are quantified. In LCA practice, the notion of "unit process" covers two situations:

- processes that are no longer really sub-divisible from a technical/physical point of view
- processes that can be subdivided but are treated as "black boxes" (JRC and IES, 2010a).

System process

The system process is a technical concept in LCA software. A system process contains the aggregated results of the life cycle calculation of a unit process. A system process is opaque (black box).

*Product

Any good or service.

NOTE 1: There are four product categories:

- services (e.g. transport)
- intangible products (e.g. computer programs, dictionaries)
- material products (e.g. a mechanical engine part)
- process materials (e.g. lubricants)

NOTE 2: Services include both tangible and intangible elements. The provision of a service may involve, for example:

- an activity carried out on a tangible product supplied to a customer (e.g. car repairs)
- an activity carried out on an intangible product supplied to a customer (e.g. the tax return required to trigger the tax)
- the supply of an intangible product (e.g. information in the context of knowledge transfer)
- creating an ambience for the customer (e.g. in hotels and restaurants)
- An intangible product is made up of information, and can take the form of processes, transactions or procedures.
- A material product is generally tangible, and its quantity is a countable characteristic.
- Process materials are generally tangible and their quantity is a continuous characteristic.

Downgraded product

Product showing deterioration or deviations from the commercial standard. These products are not necessarily unfit for consumption and can be valorized in other, lower value-added channels.

Intermediate product

Semi-finished (i.e. intermediate) product, often a flow between two stages of a production system.

Proxy

Process that is used as a substitute for a process that is not available, usually due to a lack of data.

Ration

In AGRIBALYSE®, the ration refers to a feeding scenario (compound feed + basic feed) for the animals in a class. The composition of the ration is defined by the possible choice of one or more compound feeds and all elementary feeds.

The sum of all rations thus represents the annual ration, i.e. the total feed provided to this class of animal for one year.

*Lifecycle inventory results

The result of a life-cycle inventory that catalogs the flows crossing the system's boundaries and provides the starting point for life-cycle impact assessment.

*Critical review

Process designed to ensure consistency between a life cycle assessment study and the principles and requirements specified by international standards dealing with life cycle assessment.

NOTE 1: The principles are described in ISO 14040, 4.1 (ISO, 2006a).

NOTE 2: The requirements are described in international standard ISO 14044 (ISO, 2006b).

Outgoing

See Output.

Active substance

Component of a preparation (crop protection product) to which all or part of its efficacy is attributed.

*Product system

A set of elementary processes comprising product flows and elementary flows, fulfilling one or more defined functions, which serves as a model for a product's life cycle.

Collection unit (CU)

Unit, designed to facilitate data collection, in which the reference flow can also be expressed.

*Functional unit (FU)

Quantified performance of a product system intended to be used as a reference unit in a life cycle assessment.

*Verification

Element of the life cycle interpretation phase used to assess confidence in the results of the life cycle assessment study.

NOTE: Verification includes checks for completeness, sensitivity, consistency and any other validation that may be required in accordance with the definition of the study's objectives and scope.

APPENDICES

APPENDIX AA: CALCULATION OF NATIONAL LCI ("AVERAGE FRANCE")

PLANT INDUSTRY

- **Carrot, conventional - Moyenne France**

Table34: Composition of the national conventional core inventory.

Inventory	Share of "national inventory" (%)
Early carrot, conventional, Aquitaine	27,4
Carrot in season, conventional, Aquitaine	25,2
Winter carrot, conventional, Aquitaine	15,4
Autumn carrot, conventional, Créances	7,7
Winter carrot, conventional, Créances	11,6
Autumn carrot, conventional, Val de Saire	1,8
Winter carrot, conventional, Val de Saire	4,1
Autumn carrot, conventional, Mont St Michel	5,4
Winter carrot, conventional, Mont St Michel	1,4

English name: Carrot, conventional, national average, at farm gate {FR}

Data obtained from experts during data collection for carrot inventories under the AGRIBALYSE® program. The "average conventional carrot in France for fresh consumption" inventory is a weighted average of the above basic inventories.

- **Alfalfa, conventional - Average France**

Table35: Composition of the national conventional alfalfa inventory.

Inventory	Share of national inventory (%)
Alfalfa for dehydration	30
Alfalfa on farms with livestock	70

Name in English: Alfalfa, conventional, national average, at farm gate {FR}

Data obtained from experts during data collection for alfalfa inventories under the AGRIBALYSE® program. The "conventional alfalfa France average" inventory is a weighted average of the two basic inventories above.

- **Feed barley, conventional - Average France**

Table36: Composition of the national feed barley inventory.

Inventory	Share of national inventory (%)
Downgraded spring barley, conventional	15
Feed barley, winter, conventional	66

Malting barley, winter, conventional	19

English name: Barley, feed grain, conventional, national average, animal feed, at farm gate {FR}

Data obtained from experts during data collection for barley inventories as part of the AGRIBALYSE® program. The "France average conventional feed barley" inventory is a weighted average of the above basic inventories.

- **Table apple, conventional - Average France**

Table37: Composition of the national conventional table apple inventory (scab-tolerant and non-tolerant varieties).

Inventory	Share of national inventory (%)
Non scab tolerant apple, conventional - Average France	90
Scab tolerant apple, conventional - Average France	10

English name: Apple, conventional, national average, at orchard {FR} U

Data obtained from experts during data collection for apple inventories under the AGRIBALYSE® program. The "Average conventional table apple France (scab-tolerant and non-scab-tolerant varieties)" inventory is a weighted average of the two basic inventories above. Both inventories are composed of several growth phase inventories.

- **Potatoes, conventional - Average France**

Table38: Composition of the national potato inventory.

Inventory	Share of national inventory (%)
Starch potatoes, conventional - Average France	20
Ware potatoes for industry, conventional	28
Potatoes for the fresh market, other varieties, conventional	52

English name: Ware potato, conventional, variety mix, national average, at farm gate {FR} U

Data obtained from experts during data collection for potato inventories under the AGRIBALYSE® program. The "Pomme de terre moyenne France" inventory is a weighted average of the above basic inventories.

- **Cut flowers above ground - Moyenne France**

Table39: Composition of the national cut rose inventory (soilless production).

Inventory	Share of national inventory (%)
Cut flower rose above ground, integrated pest management and low heating	12
Cut flower rose above ground, integrated pest management, heated and lit	53
Cut flower rose above ground, conventional control and low heating	19
Cut flower rose, conventional control, heated and lit	16

English name: Rose (cut flower), conventional, national average, at greenhouse {FR} U

Data obtained from experts during data collection for "rose" inventories as part of the AGRIBALYSE® program. The "Cut flower rose, France average (off-ground production)" inventory is a weighted average of the above basic inventories.

- **Conventional tomatoes under cover for food processing - France average**

Table40: Composition of the national inventory of conventional tomatoes under cover for fresh consumption.

Inventory	Share of national inventory (%)
Tomato for food processing, conventional, under cold cover - Average France	100%

English name: Processed tomatoes, consumption mix {FR} U = 100% Tomato, average basket, conventional, soil based, non-heated greenhouse, at greenhouse {FR} U + transport.

This inventory is a consumption mix for France. Imports are divided into 45.9%, 36.5% and 17.6% for Italy, Spain and France respectively. Italian and Spanish production is approximated by French production.

Data obtained from experts during data collection for tomato inventories under the AGRIBALYSE® program.

- **Sugar beet, conventional - Average France**

Table41: Composition of the national inventory of conventional sugar beet.

Inventory	Share of national inventory (%)
Sugar beet, conventional, 2005 production year	20
Sugar beet, conventional, 2006 production year	20
Sugar beet, conventional, 2007 production year	20
Sugar beet, conventional, 2008 production year	20
Sugar beet, conventional, 2009 production year	20

Name in English: Sugar beet roots, conventional, national average, animal feed, at farm gate, production {FR} U

Data from national statistics (Agreste 2009). The "Average conventional sugar beet France" inventory is a weighted average of the above basic inventories.

ANIMAL SECTOR

- **Cow's milk, conventional - Average France**

Table42: Composition of the national LCI inventory for cow's milk.

AGRIBALYSE® classification	Institut de l'Elevage Observatoire de l'Alimentation des Vaches Laitières study, 2011							
Inventory	Ranking	System no.	System name	Number of farms	Reference milk quantity / farm	Total system qty = farm workforce X milk qty per farm	% of total national production	% in average AGRIBALYSE® milk
Cow's milk, conventional, specialized western lowland system, maize dominant (>30% maize/SFA), workshop output	AGRIBALYSE®	2	Specialized lowland > 30% w	9226	307 983	2 841 451 158	12,3%	**61.5%**
Cow's milk, conventional, Specialized western lowland system, grass-corn (10-30% corn / SFP), workshop output	AGRIBALYSE®	4	Specialized lowland 10-30% w	3536	251 236	888 370 496	3,8%	**19.2%**
Cow's milk, conventional, Specialized lowland system, grass (5 to 10% corn/SFP), workshop output	AGRIBALYSE®	5	Specialized lowland <10	2615	200 801	525 094 615	2,3%	**5.7%**

Cow's milk, organic, specialized western lowland system, grass (5 to 10% corn/SFP), workshop output	AGRIBALYSE®							
Cow's milk, conventional, specialized mountain system, Massif Central, grass, workshop output	AGRIBALYSE®	8	Grass mountains - Massif Central	4003	156 694	627 246 082	2,7%	**13.5%**
Average cow's milk France, workshop output	Display					TOTAL:	21,1%	**100%**

English name: Cow milk, conventional, national average, at farm gate {FR} U

- **Beef, conventional - Average France**

Table43: Composition of the national beef LCI inventory.

AGRIBALYSE® classification **Inventory**	**Ranking**	**Title**	**Share of meat production in France (large cattle) Key figures 2010- Institut de l'Elevage, GEB**	**in average AGRIBALYSE® beef**
Cull dairy cow, conventional, specialized western lowland system, maize dominant (>30% maize/SFA), workshop output	AGRIBALYSE®	Cow - dairy origin	26%	**18.9%**
Cull dairy cow, conventional, Specialized western lowland system, grass-corn (10-30% corn / SFP), workshop output	AGRIBALYSE®			**5.9%**
Cull dairy cow, conventional, Specialized western lowland system, grass-corn (5-10% corn / SFP), workshop output	AGRIBALYSE®			**1.8%**
Cull dairy cow, conventional, Specialized mountain system, Massif Central, grass, workshop output	AGRIBALYSE®			**4.2%**
Dairy bull, conventional, Specialist dairy bull feeder, workshop output	AGRIBALYSE®	Young dairy cattle	8%	**10%**

Suckler cull cow, conventional, Specialized farmer, Charolais system < 1.2 LU/ha, workshop output	AGRIBALYSE®	Cow - suckling origin	22%	**11.6%**
Suckler cull cow, conventional, Specialized farmer, Charolais system ≥ 1.2 LU/ha, workshop output	AGRIBALYSE®			**11.6%**
Meat-breed heifer, conventional, beef or meat-breed heifer fattener. Receiving grazers from the Charolais breeder system ≥ 1.2 LU/ha, workshop output	AGRIBALYSE®	Heifer - suckling origin	10%	**10.6%**
Taurillon meat breed, conventional, Fattening. Receiving grazers from the Charolais breeder system ≥ 1.2 LU/ha, workshop output	AGRIBALYSE®	Young cattle - suckler origin	24%	**12.7%**
Taurillon meat breed, conventional, specialized feeder. Receiving grazers from the Charolais breeder system < 1.2 LU/ha, workshop output.	AGRIBALYSE®			**12.7%**
Average beef cattle France, workshop output	display			**100%**

English name: Beef cattle, conventional, national average, at farm gate {FR} U

- **Eggs, conventional - Moyenne France**

The "Average Egg France" inventory is a weighted average of the basic inventories below.

Table44: Composition of the national LCI average egg inventory.

Inventory	Share of national production (%)
Caged eggs	85
Egg sol	5
Free-range eggs	10

English name: Egg, conventional, national average, at farm gate {FR} U

Data from AGRESTE poultry survey (2008).

- **Broiler chicken, conventional - Average France**

The "Average broiler France" inventory is a weighted average of the above basic inventories.

Table45: Composition of the national average broiler inventory.

Inventory	Share of national production (%)
Conventional broiler chicken	87,5
Label Rouge broiler chicken	12
Organic broiler chicken	0,5

English name: Broiler, national average, at farm gate {FR} U

Data from AGRESTE poultry survey (2008).

APPENDIX BB: PARAMETERIZATION OF DIRECT EMISSIONS CALCULATION MODELS USED IN THE AGRIBALYSE PROGRAM ®

1. Sheet n°1: Ammonia (NH_3)

General information

Table46: Models selected by emission item.

NH_3 emission item	Model selected
Dejecta in the building	**CORPEN 1999a-1999b-2001-2003-2006**: for calculating quantities of nitrogen excreted by animals
	EMEP/EEA 2019 Level 2: for emission factors
Dejecta during storage	**EMEP/EEA 2019 Level 2:** for emission factors
Organic fertilization	EMEP 2019
Mineral fertilization	EMEP 2019
Rice Thailand	IPCC 2006b Level 2 based on Yan *et al*, 2003b
Special crops	EMEP/EEA 2019 Level 2

For emissions linked to animal manure, it is necessary to calculate the quantities of nitrogen excreted. This calculation is based on the CORPEN method (2006, 2003, 2001, 1999a and 1999b) and is described in data sheet no. 2.

References:

CORPEN, 2006. Estimation des rejets d'azote, phosphore, potassium, calcium, cuivre, zinc par les élevages avicoles - Influence de la conduite alimentaire et du mode de logement des animaux sur la nature et la gestion des déjections. Ed CORPEN, Paris, France. 55 p.

CORPEN, 2003. Estimation des rejets d'azote, phosphore, potassium, cuivre et zinc des porcs - Influence de la conduite alimentaire et du mode de logement des animaux sur la nature et la gestion des déjections. Ed CORPEN, Paris, France. 41 p.

CORPEN, 2001. Estimation of nitrogen, phosphorus and potassium flows associated with suckler cattle and growing or fattening cattle from suckler and dairy herds and their forage systems. Ed CORPEN, Paris, France. 34 p.

CORPEN, 1999a. Estimation of nitrogen, phosphorus and potassium flows associated with dairy cows and their forage system - Influence of feed and production level. Ed CORPEN, Paris, France. 18 p.

CORPEN, 1999b. Estimation des rejets d'azote et de phosphore par les élevages cunicoles. 17 p.

CORPEN 1991. Interculture. Ed CORPEN, Paris, France. p 40.

EMEP/EEA, 2019. Air pollutant emission inventory guidebook. Ed European Environment Agency (EEA), Copenhagen, Denmark.

Gross A., Boyd C.E. and Wood C.W., 1999. Ammonia Volatilization from Freshwater Fish Ponds. Journal of Environmental Quality, Vol 28 - No 3: 793-797.

Joya R. and Mathias E., 2012. Minutes of the meeting of the working group on the improvement of national emission inventories for crop production. CITEPA, January 04, 2012.

Yan X., Akimoto H. and Ohara T., 2003b. Estimation of nitrous oxide, nitric oxide and ammonia emissions from croplands in East, Southeast and South Asia. Global Change Biology, 9: 1080-1096.

Parameters for the livestock sector: buildings, storage and grazing land

The approach proposed by EMEP/EEA (2019) Level 2 is based on monitoring material flows. This model can be used to calculate overall emissions as well as emissions for each emission item:

- To the building
- Storage
- On the course (yard)

The EMEP model includes Tier 2 emission factors for 12 animal types (11 of which are present in AGRIBALYSE®). As the AGRIBALYSE® program distinguishes between 23 animal types and 40 animal classes, an assignment to the EMEP categories is necessary. **Table47** for details of this assignment.

Fish are not included in the EMEP guide. This emission item has therefore not been considered, even though fish farming can be the source of significant NH3 emissions (Gross *et al,* 1999) .

Table47: Correspondence between AGRIBALYSE® animal classes and EMEP animal types (n.a.= not available).

AGRIBALYSE® animal class	Type of animal (Table 3.8, EMEP)
Suckler cattle - Renewal heifers +2 years old	Other Cattle (young cattle, beef cattle and suckling cows)
Suckler cattle - 0-1 year old replacement heifers	Other Cattle (young cattle, beef cattle and suckling cows)
Suckler cattle - Renewal heifers 1-2 years old	Other Cattle (young cattle, beef cattle and suckling cows)
Suckling cattle - Breeding bulls	Other Cattle (young cattle, beef cattle and suckling cows)
Suckling cattle - Suckling cows	Other Cattle (young cattle, beef cattle and suckling cows)
Suckler cattle - Calf 0-1 year old	Other Cattle (young cattle, beef cattle and suckling cows)
Fattening cattle - Male or fat heifer + 2 years old	Other Cattle (young cattle, beef cattle and suckling cows)
Fattening cattle - Male or fat heifer 1-2 years old	Other Cattle (young cattle, beef cattle and suckling cows)
Fattening cattle - Calf <1 year old	Other Cattle (young cattle, beef cattle and suckling cows)
Dairy cattle - Dairy replacement heifers +2 years old	Other Cattle (young cattle, beef cattle and suckling cows)
Dairy cattle - Dairy heifers 1-2 years old	Other Cattle (young cattle, beef cattle and suckling cows)
Dairy cattle - Weaning-1 year old dairy heifers	Other Cattle (young cattle, beef cattle and suckling cows)
Dairy cattle - Dairy cows in production	Dairy cows
Dairy cattle - Calf ("8 days" - Weaning)	Other Cattle (young cattle, beef cattle and suckling cows)
Dairy cattle - Calf (birth - "8 days")	Other Cattle (young cattle, beef cattle and suckling cows)
Caprin lait - Goats in production	Sheep (and goats)
Caprin lait - 0-1 year old replacement kids	Sheep (and goats)
Caprin lait - Renewal kids 1-2 years old	Sheep (and goats)
Rabbit - Fattening	Fur animals
Rabbit - Maternity	Fur animals

Ovin lait - Lambs (0-weaning)	Sheep (and goats)
Ovin lait - Renewal ewe lambs 0-1 year old	Sheep (and goats)
Ovin lait - Renewal ewe lambs 1-2 years old	Sheep (and goats)
Ovin lait - Ewes in production	Sheep (and goats)
Ovin viande - Lamb farming	Sheep (and goats)
Palmipède gras - Force-feeding	Other poultry (geese)
Palmipède gras - PAG	Other poultry (geese)
Fish - Sea Bass/Dorado Hatchery	n.a.
Fish - Trout hatchery	n.a.
Fish - Sea bass and sea bream magnification	n.a.
Fish - Trout enlargement	n.a.
Pork - Sow workshop	Sows (and piglets to 8 kg)
Pork - Fattening	Fattening pigs (8-110 kg)
Pig - Post-weaning	Fattening pigs (8-110 kg)
Veal	Other Cattle (young cattle, beef cattle and suckling cows)
Poultry - Meat	Broilers (broilers and parents)
Poultry - Future breeders	Laying hens (laying hens and parents)
Poultry - Layers	Laying hens (laying hens and parents)
Poultry - Pullets	Broilers (broilers and parents)
Poultry - Breeding	Laying hens (laying hens and parents)

NH_3 emission factors are applied to the total ammonia nitrogen (TAN) content of animal manure. These have therefore been calculated on the basis of excreted manure quantities and the following factors, proposed by EMEP/EEA, 2019 (**Table48**

Table48: Percentage of TAN in manure by type of manure (EMEP/EEA, 2009).

Type of animal EMEP		% TAN/total nitrogen mass
Broilers (broilers and parents)		70%
Dairy cows		60%
Fattening pigs (8-110 kg)		70%
Fur animals		60%

Laying hens (laying hens and parents),		70%
Other Cattle (young cattle, beef cattle and suckling cows)		60 %
Other poultry (ducks)		70%
Other poultry (geese)		70%
Other pultry (turkeys)		70%
Sheep (and goats)		50%
Sows (and piglets to 8 kg)		70%

NH_3 emissions are finally calculated for liquid and solid manure in buildings (EF_bât), on grazing land (EF_parc) and during storage (EF_stock). For missing values, average factors were used as default factors.

Poultry droppings have been considered as solid manure. The**Table49** summarizes the emission factors used.

Table49: N_NH_3 emission factors for buildings (EF_bât), rangeland (EF_parc) and storage (EF_stock) used in AGRIBALYSE®.

Type of animal EMEP	Dejection form	Emission station	EF N_NH_3
Broilers (broilers and parents)	liquid	EF_bât	0, 21
	solid	EF_bât	0, 21
	liquid	EF_stock	0, 30
	solid	EF_stock	0, 30
		EF_park	0.3 0
Dairy cows	liquid	EF_bât	0.2 4
	solid	EF_bât	0,08
	liquid	EF_stock	0.2 5
	solid	EF_stock	0,32
		EF_park	0.3 0
Fattening pigs (8-110 kg)	liquid	EF_bât	0,27
	solid	EF_bât	0,23
	liquid	EF_stock	0,11
	solid	EF_stock	0,29
		EF_park	0,53
Fur animals	liquid	EF_bât	0,27
	solid	EF_bât	0,27

	liquid	EF_stock	0,09
	solid	EF_stock	0,09
		EF_park	
Laying hens (laying hens and parents),	liquid	EF_bât	0,41
	solid	EF_bât	0, 20
	liquid	EF_stock	0,14
	solid	EF_stock	0, 08
		EF_park	
Other Cattle (young cattle, beef cattle and suckling cows)	liquid	EF_bât	0.2 4
	solid	EF_bât	0,08
	liquid	EF_stock	0.2 5
	solid	EF_stock	0,32
		EF_park	0,53
Other poultry (ducks)	liquid	EF_bât	0,34
	solid	EF_bât	0,24
	liquid	EF_stock	0,34
	solid	EF_stock	0,24
		EF_park	0,34
Other poultry (turkeys)	liquid	EF_bât	
	solid	EF_bât	0,35
	liquid	EF_stock	
	solid	EF_stock	0,24
		EF_park	
Sheep	liquid	EF_bât	
	solid	EF_bât	0,22
	liquid	EF_stock	
	solid	EF_stock	0,32
		EF_park	0,75

Sows (and piglets to 8 kg)	liquid	EF_bât	0,35
	solid	EF_bât	0,24
	liquid	EF_stock	0,11
	solid	EF_stock	0,29
		EF_park	0,25
Goats	liquid	EF_bât	
	solid	EF_bât	0,22
	liquid	EF_stock	
	solid	EF_stock	0,28
		EF_park	0,75
Average factor	liquid	EF_bât	0,25
	solid	EF_bât	0,28
	liquid	EF_stock	0,16
	solid	EF_stock	0,28
		EF_park	0,48

PARAMETERS FOR ANIMAL AND PLANT PRODUCTION: ORGANIC FERTILIZATION, GRAZING, ETC.

To calculate emissions from grazing or spreading organic fertilizers, the EMEP/EEA approach proposes the use of different emission factors (EF). Factors for grazing (EF_grazing) and spreading organic fertilizers (EF_fertorg) have been distinguished. These factors apply to the quantity of TAN (Total Ammoniacal Nitrogen) and depend on the type of organic fertilizer, its state of aggregation, as well as the "emission station" (grazing or not) and the form of application (see**Table50**). In the absence of specific emission factors, a generic factor has been used for organic fertilizers not produced by the animal workshop ("Miscellaneous" line). TAN quantities are presented **in**Appendix EE (column N-NH_4^+) for organic fertilizers from animal production and inTable51 for non-animal fertilizers.

Table50: Emission factors used in AGRIBALYSE® for organic fertilizers.

Type of animal EMEP	Fertilizer form	Transmitter station	EF N_NH_3
Broilers (broilers and parents)		EF_pasture	0,10
	liquid	EF_fertorg	0,38
	solid	EF_fertorg	0,38
Dairy cows		EF_pasture	0,14
	liquid	EF_fertorg	0,55
	solid	EF_fertorg	0,68
Fattening pigs (8-110 kg)	liquid	EF_fertorg	0,40
	solid	EF_fertorg	0,45
Fur animals		EF_pasture	
	liquid	EF_fertorg	
	solid	EF_fertorg	
Laying hens (laying hens and parents),	liquid	EF_fertorg	0,69

	solid	EF_fertorg	0,45
Other Cattle (young cattle, beef cattle and suckling cows)		EF_pasture	0,14
	liquid	EF_fertorg	0,55
	solid	EF_fertorg	0,68
Other poultry (ducks)		EF_pasture	
	liquid	EF_fertorg	
	solid	EF_fertorg	0,54
Other poultry (geese)		EF_pasture	
	liquid	EF_fertorg	
	solid	EF_fertorg	0,45
Other poultry (turkeys)		EF_pasture	
	liquid	EF_fertorg	
	solid	EF_fertorg	0,54
Sheep and goats		EF_pasture	0,09
	liquid	EF_fertorg	
	solid	EF_fertorg	0,90
Sows (and piglets to 8 kg)		EF_pasture	0,31
	liquid	EF_fertorg	0,29
	solid	EF_fertorg	0,45
Miscellaneous	liquid	EF_fertorg	0,4
	solid	EF_fertorg	0,81
Average factor		EF_pasture	0,09
	liquid	EF_fertorg	0,48
	solid	EF_fertorg	0,55

It is possible to adjust these emission factors by using abatement coefficients according to the mode of application. However, the lack of data on the mode of application for all the products encountered meant that these adjustment factors could not be taken into account.

Table51: TAN content for organic fertilizers not derived from animal production.

Organic fertilizers not produced by the animal workshop	kg TAN/t or m3
Limed municipal sludge	0,1
Liquid urban sludge	0,27
Urban sludge paste	0,5
Dry urban sludge	0,8
Slurry/manure compost	0,83
Urban compost (household waste)	0,62
Urban plant compost	0,4
Sugar skimmings (basic amendment)	0,96
Feather meal	1,5
Vegethumus	0,92
Concentrated beet vinasse	0,96
Distillation vinasses	0,96

Unspecified organic fertilizer (=Mixtures of organic fertilizers) (per t N)	50,00

Parameters for the plant sector: Mineral fertilization

Early versions of AGRIBALYSE® used the EMEP/CORINAIR (2006) tier2 method. AGRIBALYSE® version 3.2 uses the model updated in 2019, which applies an emission factor to the amount of mineral N supplied. The emission factor is dependent on fertilizer type, three temperature classes (cold, temperate and hot) and two soil pH classes (below or above 7).

The temperature class depends on the average annual temperature of the area studied.

An average parameterization (based on expert opinion) was applied for mainland France: 100% of France in a "Cold" climate, 50% of soils with a pH<=7 and 50% of soils with a pH>7.

Table52: Emission factors for mineral fertilizers (in g NH_3/kgN mineral).

	Climate (annual average temperature)					
	Cool: <15°C		Temperate: between 15 and 26°C		Warm: >=26°C	
	pH<=7	pH>7	pH<=7	pH>7	pH<=7	pH>7
Anhydrous ammonia (AH)	19	35	20	36	25	46
Ammonium nitrate (AN)	15	32	16	33	20	41
Ammonium phosphate (MAP and DAP)	50	91	51	94	64	117
Ammonium sulfate (AS)	90	165	92	170	115	212
Calcium ammonium nitrate (CAN)	8	17	8	17	10	21
NK mixtures	15	32	22	33	20	41
NPK mixtures	50	91	67	94	64	117
NP mixtures	50	91	67	94	64	117
Urea ammonium nitrate (N solution)	98	95	100	97	126	122
Calcium nitrate (Other straight compounds)	10	19	14	20	13	25
Urea	155	164	159	168	198	210

From EMEP/EEA air pollutant emission inventory guidebook

Note: these emission factors are expressed in gNH_3/kgN applied (not gN-NH_3).

Plant sector settings: Rice Thailand

Assumptions:

Rice growing period = 120 days

In the systems studied, rice is not transplanted. However, urea is applied approximately one month after sowing, which corresponds to the transplanting period. This is the emission factor considered here.

According to FAO statistics (2002) and in line with observations made over the 2010-2011 period in the areas studied, urea and ammonia-based fertilizers account for 85% of all nitrogen fertilizers applied to rice fields in northern and northeastern Thailand.

Yan et al (2003b) focused their literature review on NH3 emissions induced by urea fertilization, the form most widely used in Southeast Asia. The timing and mode of application have a strong influence on the rate of volatilization. Yan et al (2003b) suggest considering a volatilization of: 20% of the nitrogen applied when incorporation takes place during plot preparation; 36% when urea is applied after transplanting: 12% when applied at panicle initiation. Equation 5 details the emission model. Considering the following distribution of inputs: 30% during plot preparation, 30% after planting and 40% during panicle initiation, an average emission factor of 22% of the nitrogen input can be determined.

N-NH3 kg.ha-1 related to urea fertilization = (Uinc * 0.46 * 0.2) + (Utrans * 0.46 * 0.36) + (Upan * 0.46 * 0.12)
(Equation 1)

Where:

0.46: Conversion factor from N-urea to urea

Uinc: Quantity of urea added and incorporated into the soil during plot preparation.

Utrans: Quantity of urea added during the vegetative phase of transplanting.

Upan: Amount of urea applied at panicle initiation stage

The lack of experimental data makes it impossible to define specific emission factors for other forms of fertilizer. Yan et al (2003b), based on EEA recommendations, therefore suggest using the NH3 emission factors presented inTable53 . They also recommend considering a basic emission of 1.5 kg N-NH3.ha-1.year-1.

Table53: Emission factors for mineral fertilizers applied to rice paddies.

Type of fertilizer	Emission factor (% kg NH3-N/kg total N supplied)
Ammonia bicarbonate	33
Ammonia sulfate	22
Ammonia phosphate	5
Other shapes	2
Compound fertilizers (NPK)	2

Total NH3 emissions can be calculated according to Equation 2.

N-NH3 kg.ha-1 = [N-NH3 kg.ha-1 related to urea fertilization] + (N-AB * 0.33) + (N-AS * 0.22) + (N-AP * 0.05) + (N-Other * 0.02) + (1.5 kg N-NH3.ha-1.year-1 * D/365) (Eq 2)

Where:

N-NH3 kg.ha-1: N units related to urea fertilization (see Equation 1)

N-AB: Units of N in the form of ammonium bicarbonate (kg.ha-1)

N-AS: Units of N in the form of ammonium sulphate (kg.ha-1)

N-AP: Units of N in the form of ammonium phosphate (kg.ha-1)

N-Other: Units of N in other nitrogen form (kg.ha-1)

D: Effective duration of cultivation period

(1.5 kg N-NH3.ha-1.year-1 * D/365): Basal emission, adjusted to period D

17/14: Conversion factor from N- NH3 to NH3

2. Sheet n°2: Nitrogen excreted by livestock

General information

Table54: Models selected by emission item.

Transmitter station	Model selected
Dairy cows	CORPEN 1999(a)
Suckling, growing or fattening cattle (suckling and dairy)	CORPEN 2001
Pigs	CORPEN 2003 with RMT 2016 for calculation of fixed N
Poultry	CORPEN 2006 with ITAVI 2013 for fixed N factors
Rabbits	CORPEN 1999(b)

General principle of models:

CORPEN (1999a, 1999b, 2001, 2003, 2006) proposes a methodology for calculating total nitrogen excreted by animals, based on a mass balance. First, the total nitrogen ingested by the animal is calculated. Secondly, the nitrogen fixed by the animals is determined. Finally, the amount of total nitrogen excreted is determined by the difference between the two parameters. Equation (Eq 1) for calculating nitrogen excretion is therefore written as follows:

$N_{excreted} = N_{ingested} - N_{(fixed}$ (Eq 1)

Based on the description of compound feeds and rations distributed to the animals, as well as INRA (1988, 1989, 2007, 2018) and Sauvant *et al* (2004) tables, the quantities of nitrogen ingested per day per animal were calculated.

References:

CORPEN, 2006. Estimation des rejets d'azote, phosphore, potassium, calcium, cuivre, zinc par les élevages avicoles - Influence de la conduite alimentaire et du mode de logement des animaux sur la nature et la gestion des déjections. Ed CORPEN, Paris, France. 55 p.

CORPEN, 2003. Estimation des rejets d'azote, phosphore, potassium, cuivre et zinc des porcs - Influence de la conduite alimentaire et du mode de logement des animaux sur la nature et la gestion des déjections. Ed CORPEN, Paris, France. 41 p.

CORPEN, 2001. Estimation of nitrogen, phosphorus and potassium flows associated with suckler cattle and growing or fattening cattle from suckler and dairy herds, and their forage systems. Ed CORPEN, Paris, France. 34 p.

CORPEN, 1999a. Estimation of nitrogen, phosphorus and potassium flows associated with dairy cows and their forage system - Influence of feed and production level. Ed CORPEN, Paris, France. 18 p.

CORPEN, 1999b. Estimation des rejets d'azote et de phosphore par les élevages cunicoles. 17 p.

INRA, 2018. INRA feeding system for ruminants. Wageningen Acedemic Publishers, Wageningen, the Netherlands, 640pp.

INRA, 2007. Feeding cattle, sheep and goats. Besoins des animaux - Valeurs des aliments. Ed Quae, Versailles, France. p307.

INRA, 1989. L'alimentation des animaux monogastriques: porc, lapin, volaille- 2(ème) édition. Ed INRA, Paris, France. p282.

INRA, 1988. L'alimentation des bovins, ovins et caprins. Ed INRA, Paris, France. p471.

ITAVI, 2013. Estimation des rejets d'azote, phosphore, potassium, calcium, cuivre et zinc par les élevages avicoles. Update of CORPEN 2006 references. 63p.

RMT, 2016. Dourmad J.Y. (coord.), Levasseur P.(coord.), Daumer M., Hassouna M., Landrain B., Lemaire N., Loussouarn A., Salaün Y., Espagnol S., 2015. Assessment of nitrogen, phosphorus, potassium, copper and zinc discharges from pigs. RMT Elevages et Environnement, Paris, 26 pages.

Sauvant D., Perez J.-M. and Tran G., 2004. Tables de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage - 2(ème) édition. Ed INRA, Paris, France. 301 p.

PARAMETERS FOR THE ANIMAL SECTOR: CATTLE

The quantities of nitrogen fixed by animals in AGRIBALYSE® are presented in**Table55**

Table55: Nitrogen fixed by the different classes of cattle considered in AGRIBALYSE® (CORPEN, 1999a).

Animal class	N (g) fixed per kg of weight gain or kg of milk produced for dairy cows
Dairy cattle - Dairy replacement heifers +2 years old	24
Dairy cattle - Dairy heifers 1-2 years old	24
Dairy cattle - Weaning-1 year old dairy heifers	24
Dairy cattle - Cull cows finishing	16
Dairy cattle - Calf ("8 days" - Weaning)	29
Dairy cattle - Calf (birth - "8 days")	29
Suckler cattle - Renewal heifers +2 years old	29
Suckler cattle - 0-1 year old replacement heifers	29
Suckler cattle - Renewal heifers 1-2 years old	29
Suckling cattle - Breeding bulls	29
Suckling cattle - Suckling cows	29
Suckler cattle - Cull cows for finishing	16
Suckler cattle - Calf 0-1 year old	18
Fattening cattle - Male or fat heifer + 2 years old	18
Fattening cattle - Male or fat heifer 1-2 years old	18
Fattening cattle - Calf <1 year old	29
Veal	29
Dairy cattle - Dairy cows in production	5,1

In accordance with the recommendations of CORPEN (1999a), the quantities of nitrogen fixed by dairy cows in production (meat, bone, hair, etc.) have been neglected.

PARAMETERS FOR THE ANIMAL SECTOR: PIGS

Body nitrogen retention by pigs was calculated according to equation 1:

$$N_{fixé} = \frac{e^{-0,9559-0,0145\times TMP}\times(0,96PV)^{0,7417+0,0044\times TMP}}{6,25} \qquad \text{(Eq 1)}$$

With:

N_{fixed} = amount of nitrogen fixed (kg)

PV = Animal live weight (kg)

TMP= Piece Muscle Rate (%)

The following TMPs were considered (**Table56**).

Table56: TMP of the different pig classes considered in AGRIBALYSE® (Source:

RMT, 2016. Dourmad J.Y. (coord.), Levasseur P.(coord.), Daumer M.,

Hassouna M., Landrain B., Lemaire N., Loussouarn A., Salaün Y., Espagnol S., 2015.

Evaluation of nitrogen, phosphorus, potassium, copper and zinc discharges from pigs. RMT

Elevages et Environnement, Paris, 26 pages).

Animal class	TMP (%)
Pork - Sow workshop (Gilts)	60.8
Pork - Sow workshop (Sows)	60.8
Pig - Post-weaning	60.8
Pork - Fattening	60.8

PARAMETERS FOR THE ANIMAL SECTOR: POULTRY

The quantities of nitrogen fixed by the animals considered in AGRIBALYSE® are presented in**Table57**

Table57: Nitrogen fixed by the different poultry classes considered in AGRIBALYSE® (ITAVI, 2013. Estimation des rejets d'azote, phosphore, potassium, calcium, cuivre et zinc par les élevages avicoles. Mise à jour des références CORPEN 2006. 63p.).

Type of animal	N (g) fixed per kg live weight gain resp. kg egg
Chicken	29
Turkey	35.8
Duck	28
Organic chicken	29.3
Label chicken	29.3
Label turkey	35.8
Fattened duck	33.3

Egg	18.4

Parameters for the animal sector: Rabbits

The quantities of nitrogen fixed by animals in AGRIBALYSE® are presented in**Table58**

Table58: Nitrogen fixed by the different classes of rabbits considered in AGRIBALYSE® (CORPEN, 1999b).

Type of animal	N (g) fixed per kg live weight gain/kg live weight
Rabbit	36,25
Lapereau	32,48
Fattened animals	29,05

Parameters for the animal sector: Sheep and goats

The quantities of nitrogen fixed by animals in AGRIBALYSE® are presented in**Table59**

Table59: Nitrogen fixed by the different classes of sheep and goats considered in AGRIBALYSE®.

Type of animal	N fixed	Unit
Caprin lait - Kids (0 - 8 days)	26	g/kg live meat
Caprin lait - 0-1 year old replacement kids	26	g/kg live meat
Caprin lait - Renewal kids 1-2 years old	26	g/kg live meat
Ovin lait - Lambs (0-weaning)	26	g/kg live meat
Ovin lait - Renewal ewe lambs 0-1 year old	26	g/kg live meat
Ovin lait - Renewal ewe lambs 1-2 years old	26	g/kg live meat
Ovin viande - 0-weaning lambs	26	g/kg live meat
Ovin viande - Weanling lambs for sale	26	g/kg live meat
Ovin viande - Renewal ewe lambs 1yr-2yrs	26	g/kg live meat
Ovin viande - Agnelles de renouvellement sevrage-1an	26	g/kg live meat
Ovin viande - Ewes in production	26	g/kg live meat
Ovin viande - Lamb breeding	26	g/kg live meat
Caprin lait - Goats in production	5	g/l milk
Ovin lait - Ewes in production	8,5	g/l milk

Nitrogen fixed by ewes and goats in production (bone, meat, hair, etc.) was neglected. Only nitrogen exported through milk has been taken into account.

3. Sheet n°3: Carbon dioxide (CO_2)

General information

Table60: Models selected by emission item.

Transmitter station	Model selected
Absorption by plants	Ecoinvent® v2 (Nemecek and Kägi, 2007)
Lime and urea inputs	IPCC 2019 Level 1[14]

References:

ANSES, 2008. Table Ciqual - Nutritional composition of foods. http://www.afssa.fr/TableCIQUAL

IPCC, 2006b. Guidelines for national greenhouse gas inventories. Vol No 4: Agriculture, forestry and other land use (AFOLU). Ed Eggleston S., Buendia L., Miwa K., Ngara T. and Tanabe K., Kanagawa, Japan.

INRA, 2007. Feeding cattle, sheep and goats. Besoins des animaux - Valeurs des aliments. Ed Quae, Versailles, France. p307.

INRA, 1989. L'alimentation des animaux monogastriques: porc, lapin, volaille- 2nd edition. Ed INRA, Paris, France. p282.

INRA, 1988. L'alimentation des bovins, ovins et caprins. Ed INRA, Paris, France. p471.

Nemecek T. and Kägi T., 2007. Life Cycle Inventories of Swiss and European Agricultural Production Systems - Data v2.0 (2007). Ecoinvent® report No. 15a. Ed Swiss Center for Life Cycle Inventories, Zurich and Dübendorf, Switzerland. p360.

Sauvant D., Perez J.-M. and Tran G., 2004. Tables de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage - 2ème édition. Ed INRA, Paris, France. 301 p.

Teuscher R., Cariolle M., Koch P., Lansche J., Nemecek T., and Gaillard G., 2013. Programme AGRIBALYSE®:Uncertainty and sensitivity analysis. Production of sugar beet raciness. Ed Agroscope ART, Zürich, Switzerland. p47.

Parameters for the plant industry: Carbon fixed by plants

The quantities of carbon fixed by the crops are calculated using the method proposed by Nemecek and Kägi (2007), based on the quantity of dry matter produced by the crops and the carbohydrate, lipid, protein and fiber contents. The latter are taken from INRA tables (1988, 1989, 2007), Sauvant et al (2004) and nutritional composition tables published by ANSES (2008). The various plant biomass components are multiplied by the carbon content factors presented inTable61 . This carbon is considered neutral in terms of climate change.

Table61: Carbon content of different biochemical fractions. (Vertregt and Penning de Vries, 1987).

Biochemical fraction	C content (g/kg DM)
Carbohydrates	0,444
Protein	0,535
Lipids	0,774

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[14] NB: the document IPCC 2019 (Refinement to the 2006 IPCC guidelines for national greenhouse gas inventories) makes no changes to the IPCC 2006 model. The IPCC 2019 model is quoted here to highlight the fact that the CO2 emission model for lime and urea application in ANGRBALYSE® is as up-to-date as possible.

PARAMETERS FOR THE PLANT SECTOR: EMISSIONS LINKED TO LIME INPUTS

The quantities of carbonates added in the form of pulverized limestone ($CaCO_3$) or dolomite ($CaMg(CO_{(3)})_2$), are multiplied by emission factors specific to each of these substances (IPCC 2006b, volume 4 chapter 11.3). Fertilizers containing added carbonate (e.g. calcium ammonium nitrate, but not "calcium nitrate" corresponding to $CaNO_3$) have been considered with conversion factors in kg $CaCO_3$ (see IPCC 2006b note on calculating M, p. 11.27).

Equations considered:

$$(1)\ CO_2 - C\ Emissions = (M_{Calcaire} * FE_{Calcaire}) + (M_{Dolomie} * FE_{Dolomie})$$

With:

CO_2-C Emissions = annual C emissions due to lime application (tC/year)

M = annual quantity of calcium limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$), (t/year)

EF = emission factor, (tC): **$EF_{Limestone}$ = 0.12** / **$EF_{Dolomite}$ = 0.13**

$$(2)\ CO_2\ Emis = (1) * \left(\frac{44}{12}\right)$$

With:

CO_2 Emitted = quantity of CO_2 emitted per year

Lime inputs are only considered for carrots, cider apples and alfalfa, and were not considered for other crop production due to lack of time and readily available data. A sensitivity analysis highlighted the significant impact of liming sugar beet on climate chagment (Teuscher et al., 2013).

PARAMETERS FOR THE PLANT SECTOR: EMISSIONS LINKED TO UREA INPUTS

According to IPCC 2006b, emissions from the application of urea or urea ammonium nitrate are calculated by multiplying the quantity of urea (CO(NH2)2) by a specific emission factor.

Equations considered:

$$(1)\ CO_2 - C\ Emissions = (M * FE)$$

With:

CO2-C Emissions = annual C emissions due to urea fertilizer application (tC/year)

M = annual quantity of urea fertilizer (t/year)

EF = emission factor, (tC): EF = 0.20

$$(2)\ CO_2\ Emis = 1 * 44/12$$

With:

CO2 Emitted = amount of CO2 emitted per year

In the absence of information on the type of fertilizer used (i.e. the "average French fertilizer"), CO2 emissions have been calculated on the basis of the percentage of urea considered for this average fertilizer (seeAppendix FF

4. Sheet no. 4: Metal Trace Elements (MTE)

General information

Seven heavy metals are included in the ETM model: cadmium, copper, zinc, lead, nickel, chromium and mercury.

Table62: Models selected by emission item.

Transmitter station	Model selected
Leaching: Mainland crops	SALCA-SM partly adapted to France (Freiermuth, 2006 , SOGREAH, 2007, and Levasseur et al., 2021))
Runoff (by erosion): Mainland crops	
Accumulation or loss in the soil: Mainland crops	
Specialty crops in mainland France	
Tropical crops	Not taken into account

References:

Arvalis, 1998. Synthèse des résultats de l'enquête sur les ETM du blé tendre, du blé dur, du pois protéagineux et de la pomme de terre récoltés en 1997 et 1998.

Baize D., Deslais W. and Saby N., 2007. Teneurs an huit éléments traces (Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn) dans les sols agricoles en France - Résultats d'une collecte de données à l'échelon national. Simplified final report. Ed ADEME, Angers France. p 49.

Harmanescu M., Alda L.M., Bordean D.M., Gogoasa I. and Gergen I, 2011. Heavy metals health risk assessment for population via consumption of vegetables grown in old minig area; a case study: Banat County, Romania. Chemistry Central Journal 2011, 5:64.

Levasseur P., Foray S., Blazy V., 2021. Teneurs en 10 éléments tRACes des déjecTIONs animales brut et transformés (TRACTION). Study report ADEME/Ministère de l'Agriculture et de l'Alimentation, 53p.

Terres Inovia, 2013. Personal communication.

Freiermuth R., 2006. Modell zur Berechnung der Schwermetallflüsse in der Landwirtschaftlichen Okobilanz. Agroscope FAL Reckenholz, Zürich, Switzerland. http://www.agroscope.admin.ch/oekobilanzen/01194/

Houba V.J.G. and Uittenbogaard J., 1994. Chemical composition of various plant species. International Plant Analytical Exchange (IPE). Department of Soil Science und Plant Nutrition, Wageningen Agricultural University The Netherlands.

Menzi H. and Kessler J., 1998. Heavy metal content of manures in Switzerland. In Martinez J. an d Maudet M.N. (eds): Proc. 8th International Conference on the FAO ESCORENA. Network on Recycling of Agricultural, Municipal and Industrial Residues in Agriculture (RAMIRAN 98), Rennes (F) May 26-29 1998, vol. 1, 495-506.

Perkow W. and Ploss H., 1994. Wirksubstanzen der Pflanzenschutz - und Schädlingsbekämpfungsmittel. Ed Blackwell Wissenschafts Verlag, Berlin, Germany. p314.

RMQS, 2013. Base de Données d'Analyses de Terres. http://www.gissol.fr/programme/rmqs/rmqs.php

Schultheiss U., Roth U., Döhler H. and Eckel H, 2004. Erfassung von Schwermetallströmen in landwirtschaftlichen Tierproduktionsbetrieben und Erarbeitung einer Konzeption zur Verringerung der Schwermetalleinträge durch Wirtschaftsdünger tierischer Herkunft in Agrarökosysteme, 2004. Umweltbundesamt: Berlin. p130.

SOGREAH, 2007. Bilan des flux de contaminants entrants sur les sols agricoles de France métropolitaine. Ed ADEME, Angers, France. p330.

Thöni L. and Seitler E., 2004. Deposition von LFUtschadstoffen in der Schweiz. Moosanaly- sen 1990-2000. Umwelt-Materialien Nr. 180. Bern: Bundesamt für Umwelt, Wald und Landschaft BUWAL.

Wolfensberger and Dinkel, 1997. Beurteilung nachwachsender Rohstoffe in der Schweiz in den Jahren 1993 - 1996. Im AFUtrag des Bundesamtes für Landwirtschaft. Eidgenössische Forschungsanstalt für Agrarwirtschaft und Landtechnik, Tänikon.

PARAMETERS FOR THE PLANT INDUSTRY

The SALCA-ETM model calculates three types of ETM flows:

- The accumulation of TMEs in the soil (paragraph 3 of this data sheet),
- ETM leaching (paragraph 4 of this data sheet),
- ETM loss to surface water (runoff) (paragraph 5 of this data sheet).

PARAMETERS FOR ETM ACCUMULATION IN SOILS

The accumulation of ETMs in the soil is based on a flux balance by subtracting from the incoming ETM flows (ETMs contained in the seed, fertilizers and plant protection products, as well as atmospheric deposition), the outgoing flows (the harvested product, co-products exported from the plot, leaching and soil erosion into surface waters,**Figure15**). The difference between these flows is considered to be emitted to the soil. By calculation, this emission can be negative, if the estimated outflows are greater than the estimated inflows. In reality, this is rarely the case. If the model returns a negative value for ETM flux to soil, it was decided to set the flux value to 0.

Only flows that actually leave the field are included in this balance sheet: TMEs contained in crop residues left in the field (e.g. non-exported cereal straw, pruning wood, wood from fruit trees) have not been counted, as they are considered as coming from the soil and returning to the soil.

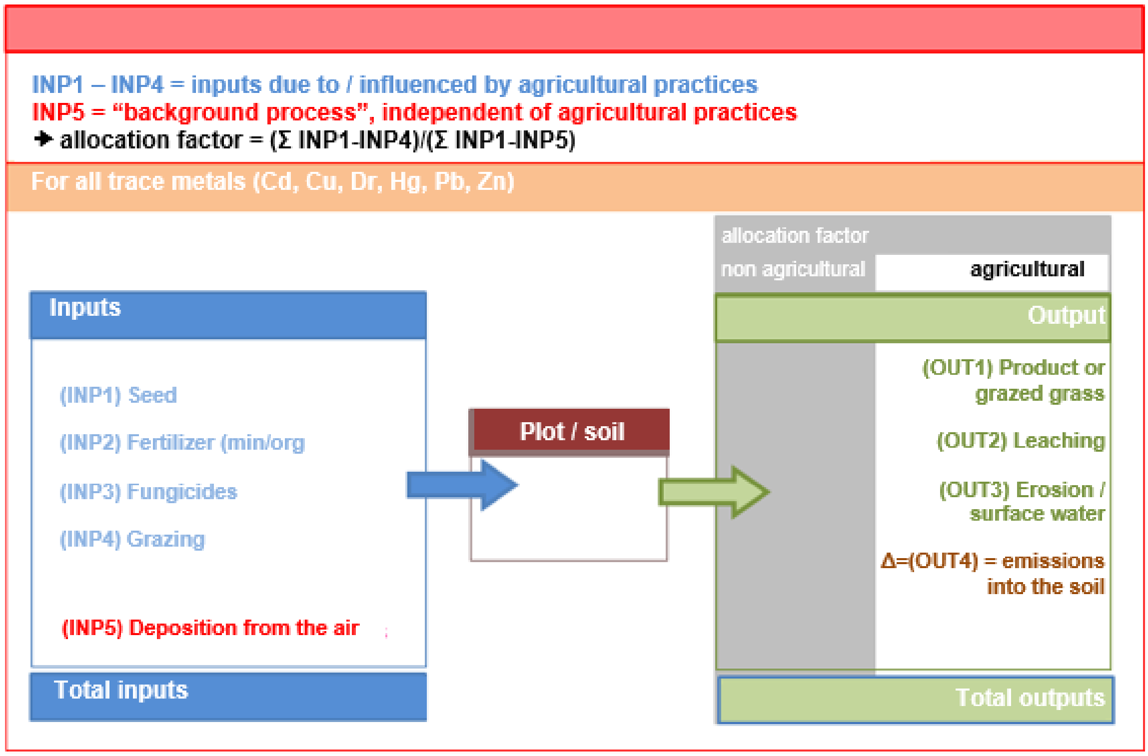

Figure15: Schematic representation of the ETM emission model used in AGRIBALYSE®.

ETM emissions have been calculated for the various stations according to the equations presented in**Table63**

Table63: Simplified formulas and main input data required to implement the SALCA-ETM-F model.

	SALCA-ETM-F models
Formulas	Flow balance: $$\Delta F_{ETMx} = \sum\nolimits_{SEPIy} IN_y * T_{y_x} - \left(\sum\nolimits_{PPLREz} OUT_z * T_{z_x}\right) * Alloc_x$$ $\forall\ x = \mathrm{Cd, Cu, Zn, Pb, Ni, Cr, Hg}$
	With ΔFETMx Flux to soil of the resulting substance "ETM x" where x = specific trace metal element (seven are considered: Cd, Cu, Zn, Pb, Ni, Cr, Hg) INy Quantity of input "SEPI y" containing ETM x With "SEPI" including inputs such as 1. Seeds 2. Fertilizers (mineral, organic, farmyard, sludge) 3. Crop protection products 4. Miscellaneous inputs (grazing manure) Tyx Heavy metal content "ETM x" of input "SEPI y OUTz Quantity of outgoing "PLR z" carrying heavy metal "ETM x". With "PLR" including outgoing members such as 1. Harvested products (including exported co-products and/or residues) 2. Leaching to groundwater 3. Runoff to surface water through erosion Tzx Heavy metal content "ETM x" of outgoing "PLR z Allocx ETM x" outflow allocation factor. This allocation factor takes into account only a portion of the outflow from heavy metal deposition. The allocation is calculated per heavy metal: $$Alloc_x = \frac{\sum_{EPIFy} IN_y * T_{y_x}}{\left(\sum_{EPIFy} IN_y * T_{y_x} + Dep_x\right)} -$$ $\forall\ x = \mathrm{Cd, Cu, Zn, Pb, Ni, Cr, Hg}$ with Depx = Deposition of "ETM x" (atmospheric deposition)

The ETM content of organic fertilizers and data sources can be found in the Means platform dataverse "Fertiliser_Means_data_v0_1.tab"[15]

The TME content of mineral fertilizers is taken from the SOGREAH report (2007), Menzi and Kessler (1998) and the TRACTION report (Levasseur et al., 2021). For solid mineral fertilizers, the amount of TME was calculated on the basis of Gross Matter and not Dry Matter. This is an acceptable approximation, given that the uncertainties in ETM composition are much greater than the difference in MB/MS for solid fertilizers.

TheTable64 presents the copper and zinc content of plant protection products (SOGREAH 2007, Perkow and Ploss, 1994).

Table64: Copper and zinc content of active ingredients in plant protection products. For phytosanitary treatments based on copper and zinc, the phytosanitary products model, and not SALCA-ETM, has been applied to estimate copper and zinc

[15] Auberger, Julie; Malnoë, Caroline, 2024, "Fertilisers used in MEANS-InOut: compositions and characteristics useful for environmental assessment", https://doi.org/10.57745/LPRJIH, Recherche Data Gouv, V1,

emissions into the environment. The substances below are considered in both models, given their more complex composition (ETM plus active compound).

Active substance	Content (g/g)		
	Cu	Zn	Source
Mancozeb		0,025	SOGREAH (2007) p 53
Metiram zinc		0,18	SOGREAH (2007) p 53
Propinèbe		0,22	Perkow and Ploss (1994)
Zineb		0,24	Perkow and Ploss (1994)
Ziram		0,21	Perkow and Ploss (1994)

ETM contents for seeds, products and co-products harvested and exported from the field are based on Schultheiss *et al* (2004) or, if available, on more recent data from partner technical institutes. The ETM content of seeds was assimilated to that products. If no information was available, average values (differentiated into product and co-product) were used (**Table65**). If the measured values did not exceed the detection limit, the detection limit was taken as the value (if known).

Table65: ETM content of products and co-products. For seeds, the same contents as for products were used, except for corn.

Product	Content (in mg/kg MS)								
	Cd	Cu	Zn	Pb	Ni	Cr	Hg	MS	Source
Sugar beet	0,4	12	36,4	1,16	1,08	1,775	0,095	23	Houba and Uittenbogaard (1994)
Durum wheat	0,069	4,54	22	0,014	0,06	0,045	0,001	85	Arvalis (1998)
Durum wheat - straw	0,2	2,5	9,6	0,6	0,6	0,7	0	85	Schultheiss *et al* (2004)
Soft wheat	0,048	3,76	17,17	0,13	0,16	0,2	0,012	85	Arvalis (1998)
Soft wheat - straw	0,2	2,5	9,6	0,6	0,6	0,7	0	85	Schultheiss *et al* (2004)
Carrot	0,1	7,18	19,9	0,58	0,39	0	0	10,3	Hermanescu *et al* (2011)[1)]
Rapeseed	0,047	4,74	39	0,035	0,57	0,22	0,007	91	Terres Inovia (2013)
Alfalfa	0,13	8,6	40	1,2	1,68	1,09	0,15	30	Houba and Uittenbogaard (1994)
Silage corn	0,1	5	34,5	1,61	0,48	0,7	0,01	81	Houba and Uittenbogaard (1994)

Grain corn	0,03	2,5	21,5	0,3	1,16	0,32	0	72	Houba and Uittenbogaard (1994)
But seed	0,03	2,5	21,5	0,3	1,16	0,32	0	85	Houba and Uittenbogaard (1994)
Barley	0,03	4,3	26,6	0,2	0,1	0,1	0	85	Schultheiss *et al* (2004)
Barley-straw	0,1	4,8	11,1	0,6	0,8	1,2	0	85	Schultheiss *et al* (2004)
Peas	0,018	6,65	24,71	0,15	1,73	0,82	0,002	85	Arvalis (1998)
Potatoes	0,029	0,82	2,87	0,029	0,076	0,01	0,008	20	Arvalis (1998)
Permanent meadow	0,13	8,6	40	1,2	1,68	1,09	0,15	16,6	Houba and Uittenbogaard (1994)
Temporary meadow	0,13	8,6	40	1,2	1,68	1,09	0,15	16,6	Houba and Uittenbogaard (1994)
Sunflower	0,358	17,1	47,1	0,047	1,9	0,18	0,0056	91	Terres Inovia (2013)
Triticale	0,1	4,3	28,4	0,2	0,2	0,1	0	85	Schultheiss *et al* (2004)
Triticale - straw	0,1	2,5	13,1	0,7	0,4	0,8	0	85	Schultheiss *et al* (2004)
Grape	0,11	6,48	29,05	0,58	0,91	0,58	0,06	18	Average ETM values used
Product, average	0,11	6,48	29,05	0,58	0,91	0,58	0,06	48	Average
Co-produced, average	0,14	4,92	20,56	0,82	0,96	0,93	0,15	60	Average

for Cd, Cu, Zn, Ni and Pb (values from the reference core "Carrot Root (ref)", cf. Hermanescu *et al* (2011)). For Cr and Hg, mean values were taken.

Atmospheric deposition is also taken from SOGREAH (2007).

Table66: Atmospheric deposition of ETM in mg per hectare in France and Switzerland.

Country	Content (mg/ha and year)							
	Cd	Cu	Zn	Pb	Ni	Cr	Hg	Source
France	200	8000	55000	8000	3000	2000	90	SOGREAH (2007) p 296; Metropolitan France - rural environment
Switzerland	700	2400	90400	18700	5475	3650	50	Thöni und Seitler (2004)

All ETM emissions (leaching, runoff and soil emissions) are multiplied by an allocation factor so that the LCIs only include ETM emissions due to agricultural practices. This allocation factor is calculated by dividing the sum of inputs due to agricultural practices (seeds, fertilizers, plant protection products) by the total sum of inputs (including atmospheric deposition).

For crops grown in greenhouses (tomatoes), atmospheric deposition has not been taken into account, as greenhouses prevent it from being deposited on the cultivated soil.

CALCULATION OF LEACHED TMEs

The leaching of ETMs into the water table was estimated by multiplying the average leaching per hectare per year (Table67) with the duration of the crop (Table116) and the surface area occupied. The Allocx factor (calculation described in paragraph 3 of this data sheet) was then applied to this leaching.

In the absence of specific French data, Swiss data, taken from the original SALCA-ETM model, were used for France. As ETMs are strongly linked to soil geology, Swiss data should be treated with caution for their use in the average French setting (Baize et al, 2007).

Table67: Average leaching per ha per year

Country	**Average leaching (in g per hectare per year)**							
	Cd	Cu	Zn	Pb	Ni	Cr	Hg	Source
CH	0,05	3,6	33	0,6	0	21,2	0,0113	Wolfensberger und Dinkel, 1997

CALCULATION OF ETM RUNOFF

The quantities of TMEs emitted by runoff and erosion into surface waters were calculated using:

- Quantity of soil eroded, in kg per hectare per year. This quantity is calculated by the erosion model according to the crop grown (see data sheet 4). If the duration of the crop is longer than one year (e.g. orchard, meadows), two eroded soil values (for year 1 and subsequent years) are provided by the erosion model,
- Length of time the land has been occupied (calculation see data sheet 11,Table116
- Average ETM content per kg of soil. These contents depend on the category of the crop in place: "arable crop", "permanent grassland", "intensive special crops" and vines. The data used correspond to "total" levels and are taken from the BDAT (RMQS, 2013). As only data for arable crops were available for mercury, this value was used for all soil uses (Table68
- An enrichment factor for eroded soil particles of 1.86 and a factor for eroded soil reaching the watercourse of 0.2 (Freiermuth R., 2006).

The Allocx factor (calculation described in paragraph 3 of this data sheet) was then applied.

Table68: Average TME content of soils in France according to use.

Type of crop	**Content (in mg/kg of soil)**							
	Cd	Cu	Zn	Pb	Ni	Cr	Hg	Source
Permanent meadows es	0,299	20,402	87,188	36,69	28,923	63,389	0,068	RMQS (2013)
Arable crops s	0,318	20,939	69,745	29,461	24,121	55,162	0,068	RMQS (2013)

Intensive crops	0,299	53,443	82,448	36,702	27,98	47,295	0,068	RMQS (2013)
Grapes/vines s	0,178	87,244	63,703	27,368	23,088	50,363	0,068	RMQS (2013)

SETTINGS FOR GRAZING EXCRETIONS

MTE emissions from grazing manure have been taken into account, using an approach similar to that for livestock effluent spreading. Since for the grazed grass inventories, the grazing animal was assumed to be a bovine (see chapter B.3.3.8), the contents of a bovine manure (**Erreur ! Source du renvoi introuvable.**) were used.

SETTINGS FOR TROPICAL CROPS

As no data were available for ETM levels in tropical soils or for atmospheric deposition, ETM flows could not be calculated for tropical crops.

PARAMETERS FOR THE ANIMAL SECTOR

Possible emissions during storage (in headlands, pits, etc.) have not been taken into account, assuming that most of the time dejecta are stored in impermeable structures.

5. Sheet n°5: Land erosion

GENERAL INFORMATION

The RUSLE model (Foster, 2005) was selected and parameterized. The R and K parameters of the initial model were converted International System (SI) units for greater consistency. SI and imperial (US) units for R and K parameters are equivalent.

To switch from one to the other:

- R(SI) = 17.02 * R(US)
- K(SI) = 0.1317 * K(US)

References:

AGRESTE, 2006. Enquête sur les pratiques culturales en 2006. http://agreste.agriculture.gouv.fr/page-d-accueil/article/donnees-en-ligne.

Foster G. R., 2005. Revised Universal Soil Loss Equation - Version 2 (RUSLE2). USDA - Agricultural Research Service, Washington D.C., p286.

Néboit-Guillot R., 1991. L'homme et l'érosion: L'érosion des sols dans le monde. Ed Presses Universitaires Blaise Pascal, Clermond-Ferrand, France. p269.

Foster G.R., McCool D.K., Renard K.G., Moldenhauer W.C., 1981. Conversion of the universal soil loss equation to SI Metric Units. J Soil Water Conserv 36:355-359

PARAMETERS FOR THE PLANT INDUSTRY

The "eroded soil" model applies only to field crops. For soilless crops, erosion defaults to 0. The quantities of eroded soil were calculated according to the equation presented in**Table69**

Table69: RUSLE erosion calculation model.

RUSLE formula according to USDA
A = R * K * LS * C * P
Where
A = average amount of soil eroded: t/(ha.an)
R= runoff erosivity factor: (MJ.mm)/(ha.h.an)
K= soil erodibility factor: (t.ha.h)/(ha.MJ.mm)
LS= slope factor aggregating length and degree of
C= soil cover management factor
P= farming practices

For **the R factor,** the values retained were determined on the basis of the map by Néboit-Guilhot, 1991. In analyzing it, a regional approach was considered and six major regions were formed (**Table70**

Table70: R and K factor values for each of the defined regions. The K factor has been calculated (see explanations in next paragraph). Values are given here in units of the international system.

Region	French region	R factor	K factor
Center	R11 - Ile-de-France, R24 - Centre, R26 - Bourgogne, R74 - Limousin, R83 - Auvergne	680,8	0,03951
North	R21 - Champagne-Ardenne, R22 - Picardie, R23 - Haute-Normandie, R25 - Basse-Normandie, R31 - Nord - Pas-de-Calais	510,6	0,046095
Northeast	R41 - Lorraine, R42 - Alsace, R43 - Franche-Comté, R82 - Rhône-Alpes	851	0,038193
West	R53 - Brittany	510,6	0,046095
South	R73 - Midi-Pyrénées, R91 - Languedoc-Roussillon, R93 - Provence-Alpes-Côte d'Azur, R94 - Corsica	1702	0,03951
Southwest	R52 - Pays de la Loire, R54 - Poitou-Charentes, R72 - Aquitaine	1361,6	0,040827

The **K factor** was calculated on the basis of average soil composition (sand 0.05-2mm, silt 0.002-0.05mm, clay<0.002mm) by region. For the calculations, RUSLE2 software was used, exploiting the GisSol database for soil composition and INRA information for regional precipitation. The procedure was as follows:

In the RUSLE2 software, for each of the six defined "erosion regions", a regional climate profile (with temperature/precipitation data 2005-2009) and a regional soil profile (**Table74** to**Table76**) were constructed.

Average erosion was calculated in RUSLE2 software using the region's R factor, a fixed slope of 2% and default values for other parameters (e.g. "contour farming" for support, see P factor below),

The amount of soil eroded from the software was compared with the result of the AGRIBALYSE® model. The K factor was modified until the quantities of the two models corresponded.

Table71 to**Table73** show the aggregation procedure for calculating regional soil composition. The**Table71** shows for each canton available in GisSol, the useful agricultural area (UAA) and the average contents (abbreviation "avg") of clay, silt and sand. Weighting factors were then calculated **(Table72**) by dividing the canton's UAA by the region's UAA. The weighted contents were then added together (**Table73**

Table71: Extract from the GisSol database: Utilised agricultural area concerned (in ha) and average sand, silt and clay content by canton (in g/kg).

Extract from the GISSOL database					
Period:	Period from early 2000 to late 2004				
Unit:	Values in g/kg of soil				
Nb lines (=cantons):	2731				
Version:	version 3.3.0.0 dated 09/07/2012.				
Canton	num_cant	UAA (ha)	Sand	Silt	Clay
AMBERIEU-EN-BUGEY	101	4174	210,23	439,25	306,09
BAGE-LE-CHATEL	102	6572	415,48	384,94	112,8
BELLEGARDE-SUR-VALSERINE	103	0	261,75	0	167,91
BELLEY	104	6777	391,53	416,73	170,66

BRENOD	106	5401	205,93	430,14	250,25
CEYZERIAT	107	0	167,91	0	208,22
CHALAMONT	108	7653	244,39	594,33	144,61
CHAMPAGNE-EN-VALROMEY	109	6905	253,43	479,22	211,7
CHATILLON-SUR-CHALARONNE	110	16857	236,22	506,69	161,11
COLIGNY	111	9043	319,33	476,17	211,41
COLLONGES	112	4259	359,98	344,69	219,36
And 2720 other lines...					

Table72: Calculation of weighting factors by canton.

Canton	Region	Weighting factor	Sand	Silt	Clay
AMBERIEU-EN-BUGEY	Northeast	0,001281815	0,2694759	0,563037183	0,392350715
BAGE-LE-CHATEL	Northeast	0,002018229	0,8385337	0,776897026	0,227656218
BELLEGARDE-SUR-VALSERINE	Northeast	0	0	0	0
BELLEY	Northeast	0,002081183	0,8148457	0,867291547	0,355174755
BRENOD	Northeast	0,001658621	0,3415597	0,713439039	0,415069790
CEYZERIAT	Northeast	0	0	0	0
CHALAMONT	Northeast	0,002350199	0,5743650	1,396793573	0,339862229
CHAMPAGNE-EN-VALROMEY	Northeast	0,002120492	0,5373961	1,016181958	0,448908060
CHATILLON-SUR-CHALARONNE	Northeast	0,005176702	1,2228405	2,622983037	0,834018428
And 2,722 other lines...					

Table73: Aggregation by region (in g/kg).

"Erosion region	Total surface area (ha)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)
Center	6 200 572	333	426	218
North	5 556 017	208	574	213
Northeast	3 256 320	279	448	265
West	1 277 126	278	546	172

South	2 570 232	347	416	234
Southwest	4 896 927	365	423	205

Average monthly temperatures and precipitation between 2005 and 2009 were calculated by INRA Rennes (Emmanuelle Garrigues) using data from the INRA weather station network (Climatik). To calculate the average values, data from a station close to the capital of the French administrative regions is taken into account. Weighting factors were then calculated by dividing the useful agricultural area of the administrative region by the area of the "erosion region" (**Table76**

Table74: Weather stations used to calculate average temperatures and precipitation, classified by six erosion regions.

"Erosion region	Administrative region	Surface area (km2)	Weight	Data origin	Station name
CENTER	Auvergne	26013	20,7%	CLIMATIK	Clermont-Ferrand
CENTER	Burgundy	31582	25,1%	NASA	
CENTER	Center	39151	31,1%	CLIMATIK	Champhol
CENTER	Ile-de-France	12011	9,6%	CLIMATIK	Versailles
CENTER	Limousin	16942	13,5%	NASA	
NORTH	Basse-Normandie	17589	20,1%	NASA	
NORTH	Champagne-Ardenne	25606	29,3%	CLIMATIK	Courcy
NORTH	Upper Normandy	12317	14,1%	CLIMATIK	Mons-en-Chaussée
NORTH	Nord-Pas-de-Calais	12414	14,2%	NASA	
NORTH	Picardie	19399	22,2%	NASA	
NORTHEAST	Alsace	8280	9,9%	CLIMATIK	Entzheim
NORTHEAST	Franche-Comté	16202	19,4%	CLIMATIK	Meythet
NORTHEAST	Lorraine	23547	28,2%	CLIMATIK	Tomblaine (Nancy)
NORTHEAST	Rhône-Alpes	43698	52,4%	CLIMATIK	Romans-sur-Isère
WEST	Brittany	27208	100,0%	CLIMATIK	St Jacques de la Lande
SUD	Corsica	8680	7,7%	CLIMATIK	Lucciana
SUD	Languedoc-Roussillon	27376	24,3%	CLIMATIK	Mauguio
SUD	Midi-Pyrénées	45348	40,2%	CLIMATIK	Blagnac
SUD	Provence-Alpes-Côte d'Azur	31400	27,8%	CLIMATIK	Fourques
SOUTHWEST	Aquitaine	41309	41,6%	CLIMATIK	Cestas

SOUTHWEST	Pays de la Loire	32082	32,3%	CLIMATIK	Beaucouze
SOUTHWEST	Poitou-Charentes	25810	26,0%	CLIMATIK	Lusignan

Table75: Average monthly precipitation by erosion region from 2005 to 2009.

RR/month	CENTER	NORTH	NORTHEAST	WEST	SUD	SOUTHWEST
January	54,3	43,5	48,6	76,2	54,8	67,4
February	47,7	49,2	54,0	66,2	31,4	54,9
March	66,5	57,6	68,4	72,8	37,6	77,0
April	61,4	38,9	79,9	53,0	61,2	57,1
May	76,5	84,7	92,4	77,9	74,3	71,3
June	64,7	56,5	66,7	44,5	32,2	56,7
July	64,5	75,6	63,1	58,7	15,7	43,5
August	67,2	67,7	96,7	47,9	24,5	48,8
September	51,2	40,3	90,0	45,0	74,1	52,1
October	57,1	50,5	99,6	68,4	76,7	66,7
November	59,8	52,2	85,7	104,9	62,0	90,6
December	60,7	55,7	64,2	87,0	48,9	71,7
Total	732,2	673,0	909,8	803,1	594,0	758,2
% surface area	20,61	23,39	26,10	13,71	10,82	5,38

Table76: Average monthly temperatures by erosion region from 2005 to 2009.

Celcius	CENTER	NORTH	NORTHEAST	WEST	SUD	SOUTHWEST
January	3,3	3,9	3,5	6,5	6,5	5,5
February	3,7	4,0	4,1	6,1	7,2	5,8
March	6,2	6,2	7,8	7,9	10,0	8,2
April	10,6	10,5	12,7	10,4	13,5	11,2
May	14,8	14,3	17,5	13,6	17,6	15,0
June	18,0	17,1	21,4	16,5	21,5	18,5
July	20,0	19,2	23,4	17,9	23,6	19,8

August	18,4	17,9	21,3	17,0	22,5	18,6
September	15,8	15,9	17,9	15,6	19,4	16,3
October	12,2	12,3	13,7	13,2	15,8	13,4
November	6,9	7,6	7,9	9,4	10,5	8,6
December	2,8	3,4	3,2	5,7	6,1	4,6
% surface area	20,61	23,39	26,10	13,71	10,82	5,38

With this information, the K factors per region could be calculated (**Table70** last column). For the crop inventories, different weighting approaches were made possible:

a) "Average France" factors: the R and K factors have been weighted on the basis of agricultural area by region

b) regional weighting: the R and K factors were weighted according to the average UAA from 2005 to 2009 by region and crop, based on data from annual agricultural statistics (AGRESTE, 2005-2009) and according to the representativeness of the particular regions selected for the inventory,

c) values for a particular region: certain crops have been characterized for specific regions (e.g. Aquitaine carrot, Auvergne meadow). In these cases, the factors for the region concerned have been used without modification.

For the **LS factor**, the length of the slope was set at 30 m. For the slope, a fixed value of 2% was used, giving an LS factor of 0.27 (**Table77**

Table77: Matrix for determining the LS factor, based on data originally calculated for Michigan (http://www.iwr.msu.edu/rusle/lstable.htm).

	Length of slope in feet (first line) and meters (second line))														
	3	6	9	12	25	50	75	100	150	200	250	300	400	600	800
Slope	1	2	3	4	8	15	23	30	46	61	76	91	122	183	244
0,2%	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,06	0,06
0,5%	0,07	0,07	0,07	0,07	0,08	0,08	0,08	0,09	0,09	0,09	0,09	0,09	0,1	0,1	0,1
1%	0,11	0,11	0,11	0,11	0,12	0,13	0,14	0,14	0,15	0,16	0,17	0,17	0,18	0,19	0,2
2%	0,17	0,17	0,17	0,17	0,19	0,22	0,25	0,27	0,29	0,31	0,33	0,35	0,37	0,41	0,44
3%	0,22	0,22	0,22	0,22	0,25	0,32	0,36	0,39	0,44	0,48	0,52	0,55	0,6	0,68	0,75
4%	0,26	0,26	0,26	0,26	0,31	0,4	0,47	0,52	0,6	0,67	0,72	0,77	0,86	0,99	1,1
5%	0,3	0,3	0,3	0,3	0,37	0,49	0,58	0,65	0,76	0,85	0,93	1,01	1,13	1,33	1,49
6%	0,34	0,34	0,34	0,34	0,43	0,58	0,69	0,78	0,93	1,05	1,16	1,25	1,42	1,69	1,91
8%	0,42	0,42	0,42	0,42	0,53	0,74	0,91	1,04	1,26	1,45	1,62	1,77	2,03	2,47	2,83
10%	0,46	0,48	0,5	0,51	0,67	0,97	1,19	1,38	1,71	1,98	2,22	2,44	2,84	3,5	4,06
12%	0.47	0.53	0.58	0.61	0.84	1.23	1.53	1.79	2.23	2.61	2.95	3.26	3.81	4.75	5.56

14%	0.48	0.58	0.65	0.7	1	1.48	1.86	2.19	2.76	3.25	3.69	4.09	4.82	6.07	7.15
16%	0.49	0.63	0.72	0.79	1.15	1.73	2.2	2.6	3.3	3.9	4.45	4.95	5.86	7.43	8.79
20%	0.52	0.71	0.85	0.96	1.45	2.22	2.85	3.4	4.36	5.21	5.97	6.68	7.97	10.23	12.2
25%	0.56	0.8	1	1.16	1.81	2.82	3.65	4.39	5.69	6.83	7.88	8.86	10.65	13.8	16.58
30%	0.59	0.89	1.13	1.34	2.15	3.39	4.42	5.34	6.98	8.43	9.76	11.01	13.3	17.37	20.99

Factor C was calculated as a product of factors C1 and C2, i.e. as a function of:

- Type of crop,
- The most erosive type of tillage, using the following factors (**Table78**). If, in an average inventory, several ITKs have been integrated and tillage has been carried out using different methods, the C2 factor has been weighted according to the percentages of surface area involved.

For crops grown in soil under cover, the C1 factor is assumed to be identical to that used for orchards/fruit trees.

Table78: Definition of C1 and C2 factors, depending on crop type and tillage method, source http://www.omafra.gov.on.ca/english/engineer/facts/00-001.htm.

Factor C1 Crop type	**C1 factor**
Fruit trees (including vines)	0,10
Cereals (spring and autumn)	0,35
Arable crop, not listed	0,42
Soil culture under shelter/greenhouse	0, 05
Seasonal horticultural crops	0,50
Hay and pasture	0,02
Beans, rapeseed, silage maize	0,50
Grain corn	0,40
Factor C2 Tillage method	C2 factor
Stubble ploughing	0,60
Autumn ploughing	1,00
Spring ploughing	0,90
Direct seeding (value also for no tillage)	0,25
Strip tillage	0,25
Soil cultivation on ridges	0,35

The P factor, representing the way in which the farmer orientates his interventions in the plot according to the relief: in the direction of the slope or perpendicular to it, was set at 0.5, which is the value for "contour farming". Contour farming" means working the soil at right angles to the slope (**Table79**) and reduces the risk of erosion by runoff.

Table79: Definition of the P factor according to the spatial orientation of the crop, source: http://www.iwr.msu.edu/rusle/lstable.htm.

Support Practice (USLE)	P Factor
Contour farming	0,50
Cross Slope	0,75
Strip cropping, contour	0,25
Strip cropping, cross slope	0,37
Up & Down Slope	1,00

Special features

a) Multi-annual crops

The same approach was used for multi-annual crops (alfalfa, temporary grassland, orchards, grapes, coffee and clementines). As crop establishment (sowing/tilling) only takes place in the first year, the amount of soil eroded is recalculated separately for years 2 to x, with a C2 factor adjusted to 0.25 (equivalent to "no tillage").

b) Calculation of the R factor for clementines

For clementine, the R factor was calculated using average regional rainfall data (Table80), giving a factor of 1021.2. The K factor is 0.042144 based on the silty-clay texture of the soil. For the other parameters (slope, C1, C2 and P factors), values for mainland France were used.

Table80: Monthly rainfall in Morocco. Source: CIRAD (2013).

JAN	FEV	MARCH	APRIL	MAY	JUNE	JUIL	AUGUST	SEVEN	OCT	NOV	DEC
36,5	33,1	39,5	18,5	2,6	0,4	0,1	2,1	3,5	16,7	36,6	67,1

c) Erosion for rice, coffee, mango, cocoa and palm oil

As the data required for the calculations was not available, the quantity of soil eroded could not be calculated and was considered to be zero for coffee (Brazil) and rice (Thailand).

d) Soilless crops

In the case of soilless cultivation, there is no erosion, so the amount of soil eroded is zero.

6. Sheet n°6: Combustion gases

GENERAL INFORMATION

The model proposed by Marylis Pradel, INRAE has been selected for the majority of operations carried out with tractors fitted with pollution control systems to reduce emissions from diesel combustion. For other machines, the Ecoinvent model is used.

References:

Pradel, Marilys, 2023, "Life Cycle Inventory of agricultural tractors", https://doi.org/10.57745/JYXPHZ , Recherche Data Gouv, V12

Nemecek T. and Kägi T., 2007. Life Cycle Inventories of Swiss and European Agricultural Production Systems - Data v2.0 (2007). Ecoinvent report No. 15a. Ed Swiss Center for Life Cycle Inventories, Zurich and Dübendorf, Switzerland. p360.

PARAMETERS FOR THE PLANT AND ANIMAL SECTORS

The quantities of substances emitted according to fuel type are listed in the table below.

For AGRIBALYSE®, all emissions have been calculated using fixed emission factors per kg of fuel, assuming average speed and power.

Table81: Emissions of various substances for diesel (with and without pollution control) and petrol.

Substance	DIESEL with pollution control system (kg/kg) (Pradel, 2023)	DIESEL (kg/kg) (Ecoinvent)	GASOLINE (g/kg) (Ecoinvent)
Ammonia	2,02E-5	2,00E-5	0,0400
Benzene	1,06E-6	7,30E-6	9,4800
Benzo(a)pyrene)	3,04E-8	3,00E-8	4,0E-05
Cadmium	1,01E-8	1,00E-8	1,0E-05
Carbon dioxide, fossil	3,16E0	3,12	3000
Carbon monoxide, fossil	4,38E-4	5,4300	633
Chromium	5,06E-8	5,00E-8	5,0E-05
Copper	1,72E-6	1,70E-6	0,0017
NMVOC, non-methane volatile organic compounds	1,53E-4	0,00265	10,9
Methane	1,86E-5	0,000129	2,92
Nickel	7,08E-8	7,00E-8	7,0E-05
Nitrogen oxides	8,11E-4	0,0418	20,000
Dinitrogen monoxide	1,21E-4	0,00012	0,1300

Particulates, < 2.5 um	8,16E-5	0,	3,0200
Sulfur dioxide	1,02E-3	0,00101	0,0720
Zinc	1,01E-6	1,00E-6	0,0010
Heat, waste		45.4 MJ	45.1 MJ
PAH, polycyclic aromatic hydrocarbons	3,33E-6		
Selenium (IV)	1,01E-8		

Emissions due to heating (in greenhouses and animal buildings) were included by multiplying the fuel quantity with pre-existing Ecoinvent® LCIs (**Table82**). Since greenhouse heating systems are included in the AGRIBALYSE® greenhouse LCI, the Ecoinvent® "heating" LCIs had to be adapted by removing the boiler input.

Table82: Heating systems and assignment to pre-existing LCIs or adapted LCIs.

Fuel	LCI Ecoinvent®	Note
Animal sector		
Fuel	Heat, central or small-scale, other than natural gas {CH}| heat production, light fuel oil, at boiler 100kW condensing, non-modulating | Cut-off	
Natural Gas	Heat, central or small-scale, natural gas {Europe without Switzerland}| heat production, natural gas, at boiler condensing modulating <100kW | Cut-off	
Propane/butane	Heat, central or small-scale, natural gas {Europe without Switzerland}| heat production, natural gas, at boiler condensing modulating <100kW | Cut-off	
Plant industry		
Wood waste	Logs, softwood, burned in furnace of greenhouse {CH} U	Without boiler (includes greenhouse LCI)
Coal	Hard coal, burned in furnace of greenhouse{RER}	
Heating oil	Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	
Heavy fuel oil	Heavy fuel oil, burned in furnace 1MW of greenhouse{RER}	
Natural gas	Natural gas, burned in furnace >100kW of greenhouse{RER}	
Propane gas	Natural gas, burned in furnace >100kW of greenhouse{RER}	
Diesel	Diesel, burned in cogen 200kWe of greenhouse{CH}	

Note on "waste wood" fuel: There is no LCI available for "waste wood burning", nor is there an LCI for "waste wood" in Ecoinvent® 2.0. As waste wood has to be conditioned (e.g. shredded), we have chosen to use the "softwood" LCI as a first approximation, even though its impacts are probably greater than those of waste wood.

7. Sheet n°7: Methane (CH_4)

GENERAL INFORMATION

Table83: Models selected by emission item.

CH4 emission station	Model selected
Enteric emissions **Cattle** **Sheep** **Goats**	INRA Feeding System for Ruminants 2018
Enteric emissions **Pigs**	IPCC 2019 Level 1
Dejecta in the building and during storage	IPCC 2019 Level 2
Manure on pastures and rangelands	IPCC 2019 Level 2
Rice Thailand	IPCC 2019 Level 2

References:

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Parameters for the animal sector: Enteric emissions

- Definition of animal categories

Table84: Correspondence between AGRIBALYSE® animal classes and IPCC categories. Level of precision used to calculate enteric methane emissions.

AGRIBALYSE® categories	Categories IPCC-Enteric CH4	Method
Suckler cattle - Renewal heifers +2 years old	other cattle	Level 3
Suckler cattle - 0-1 year old replacement heifers	other cattle	Level3
Suckler cattle - Renewal heifers 1-2 years old	other cattle	Level3
Suckling cattle - Breeding bulls	other cattle	Level 3
Suckling cattle - Suckling cows	other cattle	Level 3
Suckler cattle - Cull cows for finishing	other cattle	Level 3
Suckler cattle - Calf 0-1 year old	other cattle	Level 3
Fattening cattle - Male or fat heifer + 2 years old	cattle feedlot	Level 3
Fattening cattle - Male or fat heifer 1-2 years old	cattle feedlot	Level 3
Fattening cattle - Calf <1 year old	cattle feedlot	Level 3
Dairy cattle - Dairy replacement heifers +2 years old	dairy cow	Level 3
Dairy cattle - Dairy heifers 1-2 years old	dairy cow	Level 3
Dairy cattle - Renewal dairy heifers weaning-1 year old	dairy cow	Level 3
Dairy cattle - Cull cows finishing	other cattle	Level 3
Dairy cattle - Dairy cows in production	dairy cow	Level 3
Dairy cattle - Calf ("8 days" - Weaning)	dairy cow	Level 3
Dairy cattle - Calf (birth - "8 days")	dairy cow	Level 3
Caprin lait - Kids (0 - 8 days)	goat	Level 3
Caprin lait - Goats in production	goat	Level 3
Caprin lait - 0-1 year old replacement kids	goat	Level 3
Caprin lait - Renewal kids 1-2 years old	goat	Level 3
Rabbit - Fattening		No enteric emission calculated
Rabbit - Maternity		No enteric emission calculated

Ovin lait - Lambs (0-weaning)	lamb < 1 year	Level 3
Ovin lait - Renewal ewe lambs 0-1 year old	lamb < 1 year	Level 3
Ovin lait - Renewal ewe lambs 1-2 years old	sheep	Level 3
Ovin lait - Ewes in production	sheep	Level 3
Ovin viande - 0-weaning lambs	lamb < 1 year	Level 3
Ovin viande - Weanling lambs for sale	lamb < 1 year	Level 3
Ovin viande - Renewal ewe lambs 1yr-2yrs	lamb > 1 year	Level 3
Ovin viande - Agnelles de renouvellement sevrage-1an	lamb > 1 year	Level 3
Ovin viande - Ewes in production	lamb > 1 year	Level 3
Ovin viande - Lamb farming	lamb < 1 year	Level 3
Palmipède gras - Force-feeding	poultry	No enteric emission calculated
Palmipède gras - PAG	poultry	No enteric emission calculated
Fish - Sea Bass/Dorado Hatchery		No enteric emission calculated
Fish - Trout hatchery		No enteric emission calculated
Fish - Sea bass and sea bream magnification		No enteric emission calculated
Fish - Trout enlargement		No enteric emission calculated
Pork - Sow workshop	suidae	Level 1
Pork - Fattening	suidae	Level 1
Pig - Post-weaning	suidae	Level 1
Veal	cattle feedlot	Level 3
Poultry - Meat	poultry	No enteric emission calculated
Poultry - Future breeders	poultry	No enteric emission calculated
Poultry - Layers	poultry	No enteric emission calculated
Poultry - Pullets	poultry	No enteric emission calculated
Poultry - Breeding	poultry	No enteric emission calculated

- Level 1 IPCC 2019: emission factors

Table85: Enteric methane emission factors for Tier 1 animal categories.

Type of animal - GIEC name	Emission factor for developed countries - kg CH4/head/year
Suidae (pigs)	1,5
Suidae (procins)	1,5

- Level 3: INRA Feeding System for Ruminants 2018

A detailed description of the model can be found on pages 209 to 212 of (INRA, 2018).

The first step is to calculate the digestibility of the organic matter in the ration (MOD_ration).

This calculation is based on the composition of the ration and the organic matter digestibility values of each ration component, as described in the INRA red tables.

Three correction factors per ration are applied to this digestibility value taken from the tables, depending on the level of intake, the proportion of concentrate and the rumen protein balance.

These organic matter digestibility calculations are described on pages 44 to 49 of (INRA, 2018).

The next step is to calculate the digestible organic matter of the ration.

$$MOD\_ration = dMO\_ration \times 10 \times MO\_ration/MS\_ration$$

MOD_ration: Ration digestible organic matter (gMOD/kgMS)

dMO_ration: digestibility of organic matter in the ration (% of OM)

MO_ration: ration organic matter (kgMOingerate)

MS_ration: ration dry matter (kg MSingerate)

Next, it is possible to calculate the amount of CH4 emitted by MOD

If the ration contains only forage:

$$CH4/MOD = 34{,}95 - 4{,}05 * NI_{ration} + 0{,}027 * NDF_{ration} - 0{,}010 * MOD_{ration}$$

If the ration does not contain forages

$$CH4/MOD = 45{,}42 - 6{,}66 * NI\_ration + 0{,}75 * NI\_ration^2 + 19{,}65 * PCO\_ration - 35 * PCOration^2 - 2{,}69 * NI\_ration * PCO\_ration$$

CH4/MOD: CH4 emitted per kg of MOD (gCH4/kgMOD)

NI_ration: Intake level (kgMSI/100kg body weight/day)

PCO_ration: Proportion of concentrate in the ration (ratio)

NDF_ration: Neutral Detergent Fiber (g/kgMS)

MOD_ration: Ration digestible organic matter (gMOD/kgMS)

It is then possible to calculate the quantity of CH_4 emitted by the entire herd during ration distribution:

$$CH4\_ration = MS\_ration * 0{,}001 * MOD\_ration * CH4/MOD * durée\ de\ la\ ration\ (jours) * nombre\ d'animaux\ présent$$

CH4_ration: CH4 emitted by the herd over the duration of the ration (gCH4)

MS_ration: ration dry matter (kg MSingerate)

MOD_ration: Ration digestible organic matter (gMOD/kgMS)

CH4/MOD: CH4 emitted per kg of MOD (gCH4/kgMOD)

PARAMETERS FOR THE ANIMAL SECTOR: MANURE MANAGEMENT

- Definition of manure management systems

On-farm manure management must be considered as part of the life cycle of the farming system. The following paragraphs explain how to take this into account on the farm.

Table86: Correspondence between manure produced by animals in AGRIBALYSE® and the manure management systems envisaged by the IPCC.

Type of dejection AGRIBALYSE® (harmonized list)	IPCC Management Systems 2019	System definition
-Chicken droppings **-Turkey droppings** **-Laying droppings** **-Duck droppings** **To be defined**	Pastures/rangelands/plots	Manure from animals grazing on pastures or rangelands remains on site and is not managed.
-Medium cattle manure **-Soft cattle manure from cubicles** **-Goat manure** **-Broiler manure** **-Horse manure** **-Sheep manure** **-Straw cattle manure compost** **-Straw cattle manure compost** **Straw-based pig manure compost** **-Sheep manure compost** **-Hog manure compost on straw**	Solid storage	Storage of manure in piles or stacks outdoors, usually for several months. Manure can be stacked if it contains enough bedding material or loses enough moisture through evaporation.
-Medium cattle slurry **-Diluted cattle slurry** **-Undiluted cattle slurry** **Duck slurry (for roasting or force-feeding)** **-Rabbit manure** **-Mixed pig slurry** **-Veal calf slurry** **-Mixed effluents with low loadings**	Liquid/ice	Storage of effluent as excreted by the animal or with minimal addition of water or bedding, either in bins or in pits outside livestock buildings, generally for less than a year. The effluent is removed or spread once or several times a year.
	Liquids, slurry, stored in pre-pits under livestock buildings	Collection and storage of effluent, generally with little or no added water, under a slatted floor in an enclosed barn, usually for periods of less than a year. Slurry may be pumped to a secondary storage tank several times a year, or stored and spread directly on fields. It is assumed that the removal rate of volatile solids when the tank is emptied is greater than 90%.
-Cattle manure from accumulated litter **Straw-based pig manure**	Accumulated litter cattle and swine	As manure accumulates, bedding is continuously added to absorb moisture throughout the production cycle, up to 6 to 12 months. This in-building management system can be combined with stockyards or grazing.

-Turkey manure **Manure from ducks ready to force-feed**	Poultry manure with litter	Similar to cattle and swine litter, except that it is not usually combined with stockyards or pasture. Generally used for all poultry farms except layers.
-Dried laying hen droppings **-Laying hen manure**	Poultry manure without litter	Can resemble open pits in closed livestock buildings, or can be created to dry manure as it accumulates. Some farms install manure belts under the cages, where the manure is dried inside the building.

- Emission factors (Level 2)

Equation considered:

$$FE_{(T)} = \sum (sur\ i)\left(SV_{(T,i)} * durée\ de\ distribution\_i\right) * \left[B_{0(T)} * 0{,}67 kg \Big/ m^3 * \sum_{S,k} \frac{FMC_{S,k}}{100} * GF_{(T,S,k)}\right]$$

With:

- $EF_{(T)}$ = emission factor for the *T* category in kg CH_4/head/year
- $SV_{(T)}$ = volatile solids excreted daily by category *T* in kg DM/head/day, for ration i
- distribution time= distribution time of ration i
- $B_{o(T)}$ = maximum CH_4 production capacity for the manure produced by the category *T* in m^3 CH_4/kg SV excreted
- $FMC_{(S,k)}$ = conversion factor from SV to CH_4 for the management system *S* considered per climatic region *k*, in %.
- $GF_{(T,S,k)}$ = fraction of manure of category *T* treated with management system *S* in climate region *k*

Table87: $B_{o(T)}$ retained for AGRIBALYSE® animal classes (Values for Western Europe). Source: IPCC 2019 page 10.72 .

AGRIBALYSE® categories	Categories IPCC-CH4 dejections	$B_{o(T)}$ (m^3 CH_4/kg SV excreted)
Suckling cattle	other cattle	0,18
Fattening cattle	cattle feedlot	0,18
Dairy cattle	dairy cow	0,24
Dairy goat	goat	0,18
Dairy sheep	sheep	0,19
Ovine meat	lamb < 1 year	0,19
Palmipède gras	poultry	0,36
Pork	suidae	0,45
Veal	cattle feedlot	0,18

Poultry - Meat	poultry	0,36
Poultry - Future breeders	poultry	0,375
Poultry - Layers	poultry	0,39
Poultry - Pullets	poultry	0,39
Poultry - Breeding	poultry	0,375

Table88: FMC values according to manure management systems, values for the "Temperate, Warm temperate moist" zones in which France is classified, and values calculated for France using the tool provided by the IPCC and average monthly temperatures from 2018 to 2021.

IPCC Management Systems 2019	For slurry: storage time	FMC (%) France	FMC (%), Warm Temperate Moist
Pastures/rangelands/plots		0,47	0,47
Solid storage		4	4
Liquid/ice	Less than a month	12	13
	Between 1 and 3 months	21	24
	Between 3 and 4 months	26	29
	Between 4 and 6 months	33	37
	Between 6 months and 1 year	41	55
Liquids, slurry, stored in pre-pits under livestock buildings	Less than one month	16	16
	Between 1 and 3 months	44	44
	Between 3 and 4 months	50	50
	Between 4 and 6 months	60	60
	Between 6 months and 1 year	67	67
Accumulated litter cattle and swine		37	37
Poultry manure with litter		1,5	1,5
Poultry manure without litter		1,5	1,5

- Calculation of quantities of volatile solids excreted daily (calculated for each ration).

Equation considered:

$$SV = \left[EB * \left(1 - \frac{DA\%}{100}\right) + (EU * EB)\right] * \left[\left(\frac{1 - CENDRE}{18{,}45}\right)\right]$$

With:

- SV = volatile solids excreted daily on the basis of dry OM, in kg DM/head/day
- EB = gross energy consumption, MJ/day
- DA% = energy digestibility of feed
- (EU*EB) = urinary energy expressed as a fraction of EB
- ASH = ash content of ingested ration
- 18.45 = conversion factor for EB diet per kg DM, in MJ/kg

=> EB = gross energy consumption

Calculated from data: feed raw materials/ration composition:

EB of MP -> source = Tables INRA (2018) + Sauvant et al (2004) + internal data IDELE

EB consumed = ∑ of the EB of the MP making up the ration

=> DA% = energy digestibility of feed (dE Tables INRA)

Calculated from data: feed raw materials/ration composition:

DA% of MP -> source = Tables INRA (2018) + Sauvant et al (2004) + internal data IDELE

DA% consumed = ∑ of the DA% of the MP making up the ration

=> (EU*EB) = urinary energy expressed as a fraction of EB

Table89: Urinary energy considered by animal type. Source: IPCC (2019), volume 4.10, pages 10.70

Animal category	Urinary energy
Ruminants	0.04*EB
Ruminants with cereals > 85% of feed ration	0.02*EB
Other animals	0.02*EB

=> ASH = ash content of ration

Calculated from data: feed raw materials/ration composition:

MP ash -> source = Tables INRA (2018) + Sauvant et al (2004)

Ash consumed = ∑ of MP ash in the ration

PARAMETERS FOR THE PLANT SECTOR: METHANE EMISSIONS FROM RICE PADDIES

Assumptions:

- Rice growing period = 120 days
- Water regime during rice-growing period = permanently flooded
- Irrigated: straw buried less than 30 days before planting
- Rain: straw buried more than 30 days before planting

Thailand is the only country in Southeast Asia to use specific emission factors for methane. These recently developed standards may be appropriate at country level assessing total emissions, but do not reflect the importance of field conditions, cropping systems and water , which are key determinants of CH4 emissions.

The IPCC guidelines (2006b) propose a model for calculating daily emissions, based on a basic emission factor EFc (Equation 1).

$$EF_i = EF_C \cdot SF_w \cdot SF_p \cdot SF_0 \cdot SF_{s,r}$$ (Equation 1)

Where:

EF_i = daily emission factor, adjusted for region, kg-CH4.ha-1.d-1

EF_C = base emission factor for continuously flooded fields with no organic matter input

SF_w = corrective factor to take into account differences in water regime during the growing period

SF_p = corrective factor to take account of differences in water regime in the period preceding cultivation

SF_0 = corrective factor to take into account the type and quantity of organic matter added

$SF_{s,r}$ = corrective factor for soil type, cultivar, etc., if available

EFc refers to the following conditions for a given cultivation situation:

- The pre-season without flooding of the plots is less than 180 days before the rice crop (or the plot was replanted less than 180 days after the previous flooded crop, resulting in an intermediate situation of multiple cropping conditions).
- Continuous immersion during the cultivation period
- No organic fertilization or incorporation of residues

Basic emission factor EFc

The IPCC (2006b) suggests a default factor of 1.30 kg-CH_4.ha^{-1}.day^{-1}, for an actual factor estimated at between 0.8 and 2.2. It was decided to adjust EFc to Thai conditions, due to high soil, air and water temperatures, as well as high solar radiation, factors known to have a determining importance on CH_4 emissions (increased emissions). Based on the recommendations of IPCC (2006b) and the experimental results of Yan *et al* (2003a), specific emission factors were determined as presented in**Table90**

Table90: EFc methane emission factors for the two Thai regions studied (kg-CH_4.ha^{-1}.d^{-1}).

Region	EFc
North	2,04
Northeast	3,12

Source: Yan *et al* (2003a).

All corrective factors were determined on the basis of average values recommended by the IPCC (2006b).

Corrective factors for water regime (SFw and SFp)

SFw accounts for differences in water regime during the growing season. The IPCC (2006b) suggests using the values presented in**Table91**

Table91: Corrective factors for water regime during the growing season, SFw.

Continuous barneting	Intermittent fogging (single aeration)	Intermittent fogging (multiple vents)	Rain (ordinary)	Rainy (subject to drought)
1	0,6	0,52	0,28	0,25

Source: IPCC (2006b) Note: Rainfed conditions refer here to lowland rice that is cropped under flooding conditions, yet with no full control of water. Rainfall, and not controlled irrigation, provides ponding conditions to paddy fields. Upland rice is not considered in the study.

The two regions studied (North and North-East) have similar factors, and the calculations consider both growing periods in both regions, i.e. dry and wet seasons. Specific conditions were also considered. For example, due to dry conditions, permanent flooding of plots is common in the North-East, while rain-fed cultivation is not optimal, even in the wet season, as the area is prone to droughts.

SFp refers to differences in water regime prior to rice cultivation. The IPCC (2006b) suggests using the values presented inTable92

Table92: Corrective factors for pre-season water regime, SFp.

Unflooded pre-season > 180 days	Unflooded pre-season < 180 days	Flooded pre-season > 30 days
0,68	1	1,90

Source: IPCC (2006b). Short flooding periods (< 30 days) for land preparation are not considered.

Correction factor for organic amendments

SFo is the corrective factor that takes into account the type and quantity of organic matter added. Equation 2 is used to determine SFo (IPCC, 2006b).

$$SF_0 = \left(1 + \sum_i ROA_i \cdot CFOA_i\right)^{0.59}$$ (Equation 2)

Where:

SF_0 = corrective factor for the type and quantity of organic matter applied.

ROA_i = quantity of organic matter added, tonne MS Rice straw.ha-1).

$CFOA_i$ = conversion factor for an organic amendment i, in terms of its relative effect compared with straw applied shortly before cultivation (IPCC, 2006b)

As observed in the areas studied, organic amendments are limited to the rice straw remaining on the plot. The literature generally considers a dry grain/straw ratio of 1:1. Assuming that the previous year's dry grain yield had reached average values in each region, it has been suggested that dry straw weights are 3.4 and 2.7 tonnes.ha-1 in the North and North-East, respectively. These straws are returned and buried.

These inputs correspond to the basic value of the ROA parameter. TheTable93 presents alternative values, in cases where the straw is burnt or grazed before incorporation. These scenarios, although probable in the areas studied, have been ignored for AGRIBALYSE®.

Table93: Rates of application of organic amendments ROA, straw returned and buried (tonnes.ha-1).

Incorporate all residues into the soil	Grazing	Straw burnt in the field

North: 3.4 **North-east: 2.7**	0,5	0,3

Source: authors' data and assumptions, on account of field observations. Note: in-field burning is never complete and leaves at least rice rooting systems.

The conversion factors for the organic amendment CFOA are presented inTable94

Table94: Conversion factors for the organic amendment CFOA.

Straw incorporated less than 30 days before planting	Straw incorporated more than 30 days before planting
1	0,29

Source: IPCC (2006b)

Table95: Emission factors and correction factors, based on IPCC (2006b) and Yan et al (2003) recommendations for conditions in Northern Thailand.

Factors affecting emissions	Corrective emission factors for each condition											
1.) Agro-ecological region	North											
2.) Cultivation period	Wet season						Dry season					
3.) Growing system	Pluvial		Irrigated				Irrigated					
Default base emission factor (kg-CH_4.ha^{-1}.d^{-1})	2,04		2,04				2,04					
3.1) Water regime before planting	Unflooded pre-season > 180d		Unflooded pre-season < 180 d				Unflooded pre-season < 180 d					
	0,68		1				1					
3.2) Water regime during the growing season	Ordinary rainwater		Continuous barneting		Intermittent ventilation (single aeration)		Continuous barneting		Intermittent ventilation (single aeration)		Intermittent fogging (multiple vents)	
	0,28		1		0,6		1		0,6		0,52	
4.) Organic fertilization	Straw < 30 d	Straw > 30 d	Straw < 30 d	Straw > 30 d	Straw < 30 d	Straw > 30 d	Straw < 30 d	Straw > 30 d	Straw < 30 d	Straw > 30 d	Straw < 30 d	Straw > 30 d
4.1) Conversion factor	*1*	*0,29*	*1*	*0,29*	*1*	*0,29*	*1*	*0,29*	*1*	*0,29*	*1*	*0,29*
4.2) Average application rate (tonne ha^{-1})	*3,4*											

4.3) Correction factors for organic amendments	2,40	1,50	2,40	1,50	2,40	1,50	2,40	1,50	2,40	1,50	2,40	1,50
Adjusted daily emission factor (kg CH_4 ha^{-1} d^{-1})	**0,932**	**0,583**	**4,896**	**3,060**	**2,938**	**1,836**	**4,896**	**3,060**	**2,938**	**1,836**	**2,546**	**1,591**

Table96: Emission factors and correction factors, based on IPCC (2006b) recommendations for conditions in Northeast Thailand.

Factors affecting emissions	Emissions correction factors for each condition											
1.) Agro-ecological region	Nod-Estt											
2.) Cultivation period	Wet season								Dry season			
3.) Growing system	Pluvial				Irrigated				Irrigated			
Default base emission factor (kg-CH_4.ha^{-1}.d^{-1})	3,12				3,12				3,12			
3.1) Water regime before planting	Unflooded pre-season > 180 d				Unflooded pre-season < 180 d				Unflooded pre-season < 180 d			
	0,68				1				1			
3.2) Water regime during the growing season	Ordinary rainwater		Pluvial subject to periods of drought		Continuous barneting		Intermittent ventilation (single aeration)		Intermittent ventilation (single aeration)		Intermittent fogging (multiple vents)	
	0,28		0,25		1		0,6		0,6		0,52	
4.) Organic fertilization	Straw < 30 d	Straw > 30 d	Straw < 30 d	Straw > 30 d	Straw < 30 d	Straw > 30 d	Straw < 30 d	Straw > 30 d	Straw < 30 d	Straw > 30 d	Straw < 30 d	Straw > 30 d
4.1) Conversion factor	*1*	*0,29*	*1*	*0,29*	*1*	*0,29*	*1*	*0,29*	*1*	*0,29*	*1*	*0,29*
4.2) Average application rate (tonne ha^{-1})	*2,7*											
4.3) Correction factors for organic amendments	2,16	1,41	2,16	1,41	2,16	1,41	2,16	1,41	2,16	1,41	2,16	1,41

Adjusted daily emission factor (kg CH_4 ha^{-1} d^{-1})	**1,283**	**0,838**	**1,146**	**0,748**	**6,739**	**4,399**	**4,044**	**2,640**	**4,044**	**2,640**	**3,504**	**2,288**

8. Sheet n°8: Nitrogen monoxide (NO)

General information

The EMEP 2019 NO emission model provides emission factors that express NO emissions "as NO_2". Thus, the flows expressed in the AGRIBALYSE® LCIs correspond to NOx.

Table97: Models selected by emission item.

Transmitter station	Model selected
Dejecta in the building	**EMEP/EEA 2019, Level 1**
Dejecta during storage	**EMEP/EEA 2019, Level 1**
Mineral and organic fertilization	**EMEP/EEA 2019, Level 1**
Rice Thailand	**Yan *et al*, 2003(b)**

References:

EMEP/EEA, 2019. Air pollutant emission inventory guidebook. Ed European Environment Agency (EEA), Copenhagen, Denmark.

Yan X., Akimoto H. and Ohara T., 2003b. Estimation of nitrous oxide, nitric oxide and ammonia emissions from croplands in East, Southeast and South Asia. Global Change Biology, 9: 1080-1096.

Parameters for the animal sector: manure in buildings and in storage facilities

The emission factors proposed by the EMEP/EEA (2019) method depend on the type of animal and the type of effluent (**Table98**). They apply to the effective annual number of animals (AAP = Annual Average Population). Consequently, the number of animals per class has been weighted by the length of time the class has been present.

The assignment of AGRIBALYSE® animals to the EMEP animal type is identical to that used to calculate NH_3 emissions (see data sheet 1).

The breakdown between solid and liquid manure is based on the information provided in the inventories and calculated in the NH_3 model.

Table98: NO as NO_2 emission factors used in AGRIBALYSE® (AAP = Annual Average Population).

Type of animal	Feces	Factor (kg NO, as NO_2/AAP)
Other cattle (young cattle, beef cattle and suckling cows)	liquid	0.003
Other cattle (young cattle, beef cattle and suckling cows)	solid	0.217
Sheep (and goats)	liquid	0
Sheep (and goats)	solid	0.012
Fur animals	liquid	0
Fur animals	solid	0.001
Broilers (broilers and parents)	liquid	0.027
Broilers (broilers and parents)	solid	0,027
Fattening pigs (8-110 kg)	liquid	0.002
Fattening pigs (8-110 kg)	solid	0.017
Laying hens (laying hens and parents),	liquid	0.0001
Laying hens (laying hens and parents),	solid	0.014
Sows (and piglets to 8 kg)	liquid	0.005
Sows (and piglets to 8 kg)	solid	0.471
Other poultry (turkeys)	liquid	0.027
Other poultry (turkeys)	solid	0.027
Dairy cows	liquid	0.01
Dairy cows	solid	0.752
Other poultry (ducks)	liquid	0.022
Other poultry (ducks)	solid	0.022

Plant industry parameters: Organic and mineral fertilization

The single emission factor of 0.04 kg NO_2/kg N was applied to the quantity of nitrogen supplied, after deduction of the quantity of NH_3 volatilized, for both mineral fertilizers and organic manures.

PLANT SECTOR SETTINGS: RICE THAILAND

Assumptions: Rice growing period = 120 days

Following a similar approach to that used for N_2O (rice) emissions, but with fewer experimental results, Yan *et al*, (2003b) carried out a literature review of NO_x emissions. They identified: i) an emission factor for fertilization of 0.13% for each fertilizer unit applied, and ii) a basal emission factor of 0.57 kg N- NO.ha^{-1}.yr^{-1}. Equation 1 presents the NO emission calculation model implemented for Thai rice crops within the AGRIBALYSE® framework. However, this model does not take into account periods of intermittent flooding, during which nitrification-denitrification processes occur, leading to higher NO emissions.

$$N\text{-}NO\ kg.ha^{-1} = [0.0013 * Nf] + [0.57 * D/365] \qquad \text{(Equation 1)}$$

Where:

Nf: Total number of units of chemical fertilizer applied per hectare during the growing season.

0.0013: Average emission factor linked to fertilization (0.13%)

D: Effective duration of cultivation period

0.57 N kg.ha^{-1}: Basic N-NO emission averaged over the year

30/14: Conversion factor from N- NO to NO

9. Sheet n°9: Nitrate (NO_3^-)

GENERAL INFORMATION

Table99: Models selected by emission item.

Transmitter station	Model selected
Annual crops in mainland France	COMIFER 2001 adapted (Tailleur *et al*, 2012)
Grassland	DEAC (Cariolle, 2002)
Perennial and specialty crops in mainland France	SQCB (Faist *et al*, 2009)
Soilless or fertigated crops	This report
Tropical crops	IPCC 2006b, Level 1
Rice Thailand	This report
Animal production: Pathways	Basset-Mens *et al*, 2007

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PARAMETERS FOR THE ANIMAL SECTOR: STORAGE OF MANURE AT THE END OF THE FIELD

This emissions item could not be taken into consideration. In fact, although work to document the subject is underway, no data that could be used to parameterize the calculation model was available.

PARAMETERS FOR THE ANIMAL INDUSTRY: PATHWAY

Based on the work carried out by Basset-Mens *et al* (2007), an emission factor common to all crops of 17.5% of nitrogen input was calculated.

PLANT SECTOR PARAMETERS: ARABLE CROPS IN MAINLAND FRANCE

ARVALIS has developed a model specifically for the needs of AGRIBALYSE® based on the COMIFER grid (2001).

This grid proposes a qualitative approach applicable at plot level to qualify the risk of leaching. It takes into account a "crop" risk and an "environment" risk (a function of the drainage layer (CORPEN, 1991)) and conditions of high mineralization. On the other hand, the COMIFER grid does not take into account the match between nitrogen inputs and crop requirements. The COMIFER grid is based on the assumption that there is no excess nitrogen fertilization from the previous crop, leading to an excessive increase in nitrogen residue.

As the model requires additional data (information on cropping practices for subsequent crops, soil-climate data), ARVALIS also applied the model to estimate nitrate emissions from different field crops, using statistical data on cropping practices and an in-house soil database. These emissions were first estimated at plot level, then averaged across administrative regions. Finally, for each crop, average emissions for France were obtained by weighting these regional averages by production volume. In addition, a sensitivity analysis was carried out to assess the influence of taking into account fertilization management not adapted to crops on the estimates of average leached quantities for each crop.

The main input data required to implement the adapted COMIFER (2001) grid are presented in**Table100**

The approach taken to developing and implementing the model is described in more detail in the following paragraphs.

Table100: Main input data required for model implementation.

Model	Input data
Methodology based on the COMIFER grid	Crop production volume by region
	Next crop

	Planting of intermediate crops in the intercrop following the crop studied
	Organic input in autumn
	Residue management
	Pedo-climatic data: soil water properties (characteristic moisture content, crop rooting depth), meteorological data (rainfall, ETP), organic matter content, etc.

General principle of the model

- *Culture" risk characterization*

The COMIFER grid (2001) suggests a hierarchy of situations based on the following criteria, listed in order of importance.

1. Length of time without the presence of a plant capable of absorbing nitrogen (depending on the following crop and the establishment of intermediate crops)
2. Nitrogen uptake capacity in autumn of following crop (depending on following crop)
3. Fall application of organic fertilizers (C/N ratio < 8)
4. Quantity of nitrogen returned by crop residues (function of crop and residue management)

It also presents a risk classification for different crop situations.

Table101: Example of a diagnosis of "crop" risk excluding the effect of organic inputs

Example of previous/following pair	Length of time without absorption of nitrogen by plant cover	Residues from previous crop		Capacity of the following crop to absorb nitrogen in the fall	**"Crop" risk**
		quantity of biomass	%N		
Sugar beet/wheat	Very short	+	+++	+	**slight**
Grain maize/wheat		+++	+	+	**moderate**
Wheat (straw exported)-rapeseed	Short	+	+	++ to +++ (1)	**very slight to slight**
Wheat (straw plowed in)-rapeseed		+++	+	++ to +++ (1)	**very slight to slight**
Sunflower-wheat		++	+	+	**moderate**
Rapeseed (without regrowth) - wheat	Long	+++	++	+	**moderate to high**
Peas - wheat		++	++	+	
Wheat (straw plowed in) - wheat		+++	+	+	**moderate**
Potatoes - wheat		+	++	+	**high**
Spinach - wheat		++	+++	+	**very high**

Wheat (straw plowed in)-spring crop (maize, peas sunflower) Flageolet beans - maize Grain maize - maize	Very long	+++	+	0	**very high**
		++	++	0	**very high**
		+++	+	0	**high**

(1) very slight to slight depending on when the rapeseed starts growing and its subsequent growth

The additional risk from the application of organic matter is as follows

A weighting system for these different criteria has been established on the basis of these elements in order to estimate the risks for crop situations not covered in the classification proposed by COMIFER.

- ***Environmental risk characterization***

According to the COMIFER grid, "environmental" risk is defined by the combination of two criteria: i) the drainage index and ii) the organic matter content of the soil's mineralizing layer.

- ***Allocation of leaching quantities to each "environment" risk x "crop" risk combination***

The COMIFER grid provides a risk classification based on different combinations of "crop" risk x "environment" risk. Each situation was assigned a quantity of nitrate nitrogen leached on average during the period from the start of winter drainage, which takes place after the harvest of the crop studied, to the start of winter drainage the following year, based on available experimental data and expert opinion. The matrix obtained has also been validated by experimental results obtained on different sites characterized by contrasting "environmental" and "crop" risks, or for certain situations not represented by estimates from the DEAC model (Cariolle, 2002; Jolivel, 2003).

Table102: Amount of nitrate (kg N-$NO3^-$/ha per crop year) associated with each combination of crop risk and environmental risk.

		Culture risk				
		1	**2**	**3**	**4**	**5**
Environmental risk	1	5	10	20	25	30
	2	10	15	25	30	40
	3	15	20	30	40	50
	4	20	30	40	55	60
	5	30	40	40	60	80

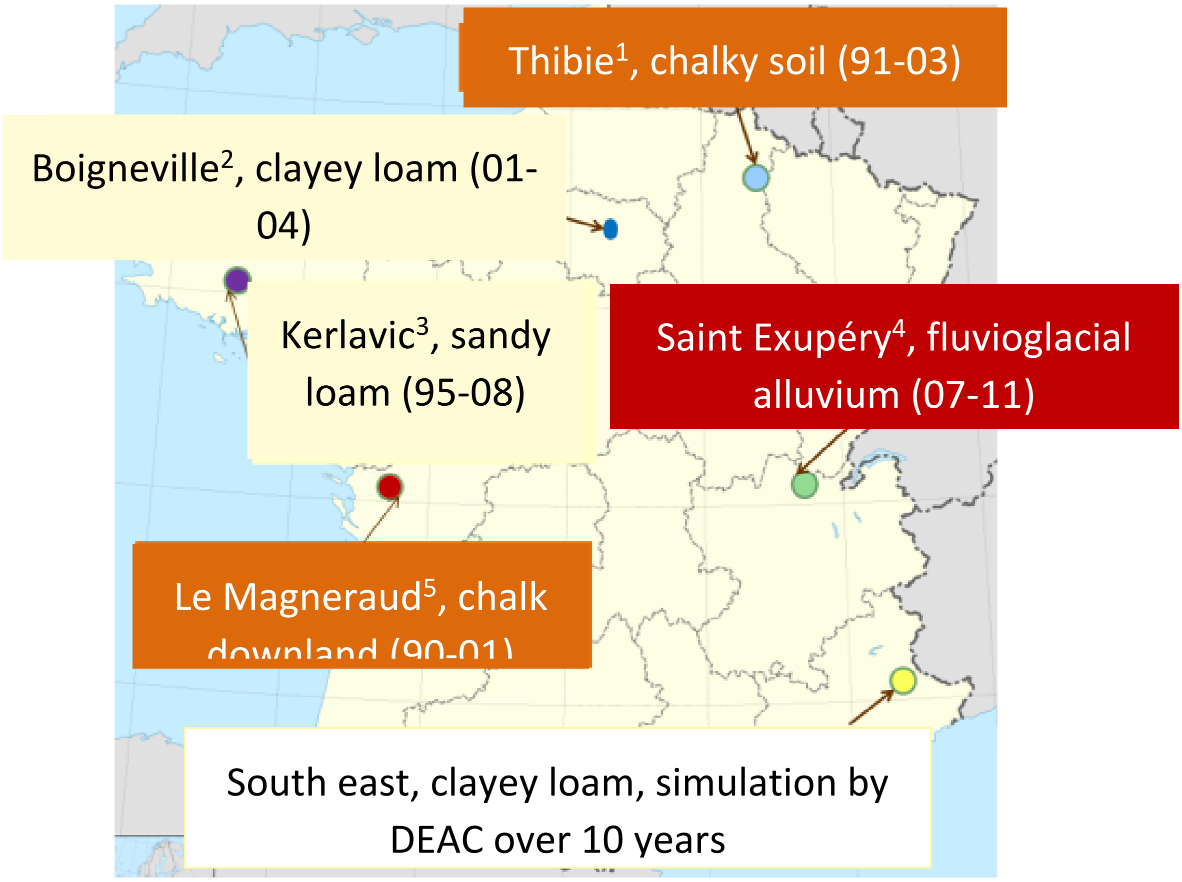

Figure16: Experimental sites used to validate the matrix (years of experimentation in brackets), e.g. Le Magneraud 1990-2001. [1] AREP, [2] ARVALIS, [3] CRB/ARVALIS, [4] ARVALIS/CREAS, [5] ARVALIS

Implementing the model as part of the AGRIBALYSE® program

- *Estimating "culture" risks*

(i) For the "national inventories" of field crops, the "crop" risk was estimated for the 10,000 plots surveyed by the SSP during the 2006 cropping practices survey, using the following information:

- management of residues from the previous crop,
- whether or not an intermediate crop has been planted, as well as sowing and harvesting dates in order to estimate the length of time without the presence of a plant capable of absorbing nitrogen,
- autumn spreading of organic matter: only spreading in the form of liquid manure has been taken into account, since this is the main form of manure applied, with a C/N ratio of less than 8.

(ii) Still based on the cropping practices survey, by administrative region and by crop, the percentages of surface area occupied by each of the crop segments - following crop - were estimated on the basis of the 5 previous cropping seasons. It was decided to use the data available for the previous 5 years in order to avoid any year effect.

For example, in the Centre region, 27% of soft wheat acreage is followed by barley, 25% by soft wheat, 17% by rapeseed,...

(iii) For each crop and each administrative region, the average risks obtained for each of the crop-following crop segments were estimated (cf.Table103 for the example of soft wheat in the Centre region). The average risks per crop and per administrative region were obtained from these segment risks weighted by the frequency of the segments estimated in (ii).

Table103: Average soft wheat risk for each soft wheat-following crop segment observed in the Centre region

Crop segment x following crop	% segment area / total soft wheat area in the Centre region	Crop risk note
Soft wheat x Durum wheat	1	4
Soft wheat x Soft wheat	25	4
Soft wheat x Rapeseed	17	1
Soft wheat x Feed corn	2	5
Soft wheat x Grain corn	10	4
Soft wheat x Barley-squash	27	4
Soft wheat x Peas	3	4
Soft wheat x Sunflower	6	4
Weighted average		3

The estimates of percentages of previous crop - following crop by administrative region obtained were compared with data from the agricultural census (2005-2009 period) to check for any inconsistencies. A sensitivity analysis showed that estimates of "crop" risk were similar based on the cropping practices survey and the agricultural census.

Example:

In Picardy, it has been estimated on the basis of the SSP survey that 8% of soft wheat plots have peas as a following crop. However, as the average area under soft wheat in Picardy is 521,000 ha and that under peas 31,600 ha, the percentage of soft wheat plots following peas cannot exceed 6%.

For the "national inventories" of non-surveyed field crops (triticale and faba beans), risk was estimated on the basis of expert opinion and extrapolation from previous crops.

For organic crops (soft wheat, triticale, faba bean), the data are taken from the selected test cases.

- *Environmental risk assessment*

The geographic database of French soils managed by INRA's Soil Science Unit in Orléans was used to estimate "environmental" risks. It describes a set of Unités Typologiques de Sol (UTS), characterizing distinct soil types. The UTS are described by attributes specifying the nature and properties of the soil (e.g. texture, water regime, parent material, etc.).

The "environmental" risk was estimated for each UTS on the basis of its water retention capacity and climatic data, derived from an ARVALIS database comprising 84 weather stations and 30 years of data. Each administrative region was then characterized by the surface area corresponding to each risk category, from which an average risk was estimated.

For other uses of the nitrate emission model (Table102), particularly on a regional scale, it is possible to estimate the "environmental" risk using the drainage index presented in the work of Butler et al. (2012, see Table 9 and Figure 39) and COMIFER (2001).

- *Estimation of leached quantities*

For each crop, the average "crop" and "environment" risks for each administrative region were used to estimate the quantities leached on the basis of the matrix (Table67). The results obtained were compared with various available bibliographical references at watershed scale (Thieu et al, 2010; Ducharne et al, 2007 and Ledoux et al, 2007) in order to validate them.

These regional estimates were then weighted by the volume of crop production in each region to derive the average nitrate leached for each crop across France.

Consideration of nitrogen inputs not adapted to crops

In the absence of any information enabling us to estimate the frequency of "over-fertilization" practices, or the quantities of surplus nitrogen to be considered, we proceeded on the basis of expert opinion. We therefore considered a surplus of 50 kg N/ha compared with crop requirements, and took into account a frequency that could vary from 5 to 20%.

The relationship between the deviation of inputs from the optimum nitrogen dose and the post-harvest nitrate nitrogen stock was determined during a COMIFER study and then refined on the basis of subsequent ARVALIS data. The post-harvest nitrate nitrogen supplement resulting from a 50 kg N/ha surplus was modeled for each crop. Leaching factors to estimate the quantities leached from the post-harvest nitrate nitrogen surplus were defined for each soil risk level. For each crop, leached nitrogen supplements were estimated for "over-fertilized" plots in each administrative region, from the post-harvest nitrate nitrogen supplement multiplied by the leaching factor corresponding to the average "soil" risk for the administrative region. Depending on the environmental risk, estimates of additional leaching for cereal and rapeseed plots range from 7 to 12 kg N-NO_3^-/ha, and from 12 to 22 kg N- NO_3^-/ha for maize and sugar beet plots.

For each crop, the average regional leaching quantities were estimated on the assumption of a surplus of 50 kg N/ha at different frequencies (5, 10, 15 and 20%). The results for national average references are shown in figure 17. Depending on the frequency considered, an increase in leaching of 0 to 2 kg N-NO_3^-/ha was noted on cereals and rapeseed, and 1 to 3 kg N-NO_3^- on maize and sugar beet compared with initial estimates.

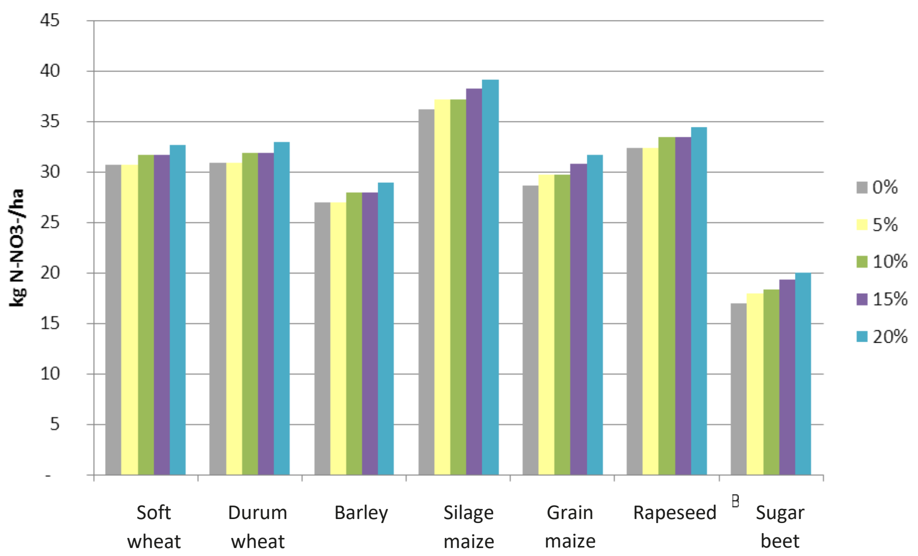

Figure17: Impact of taking into account the effect of a 50 kg N/ha nitrogen surplus at different frequencies on national average estimates.

According to these results, the inclusion of surplus nitrogen has little impact on the estimated quantities leached per crop on average across France. However, there is still room for improvement (no reliable estimate of the frequency of surplus nitrogen inputs, nor of the quantities involved, and factors influencing the leaching of surplus nitrate nitrogen need to be consolidated).

PARAMETERS FOR THE PLANT SECTOR: GRASS / MEADOWS

The DEAC model (Cariolle, 2002) was used. It takes into account the following parameters:

Table104: Main input data required for model implementation.

Model	Input data
DEAC	Drainage blade

	Quantity of effective nitrogen applied
	Input greater than 100 N units after June 20 (yes / no)
	Legume content
	Grazing share
	Nitrogen fertilization practices on the previous crop

In the case of grasslands with legumes, as the legume content is relatively low (30%), the effect of legumes on leaching has not been taken into account.

Table105 shows the annual N-NO_3 leaching for different types of grassland and alfalfa. For temporary grassland and the two alfalfa plants, a one-off additional leaching due to turning has been considered (see column 3).

Table105: Nitrate leaching (in kg N-NO_3 per hectare per year) under grassland and alfalfa, calculated with the DEAC model.

Example: under one hectare of grazing on temporary grassland, without legumes in the North-West region (see line "08 grazed grass..."), leaching amounts to 23.5 kg N-NO_3 per hectare and year (equals 15 kg + 34 kg /4 year - given that the duration of the temporary grassland is 4 years).

LCI / crop	Annual leaching	Leaching after turning
Grazed grass, permanent meadow, without clover, Auvergne	6	0
Herbe conservé, enrubannage, prairie permanente, sans trèfle, Auvergne	2,7	0
Preserved grass, silage, permanent grassland, without clover, Auvergne	3,6	0
Preserved grass, hay, permanent meadow, no clover, Auvergne	2,7	0
Grazed grass, permanent meadow, no clover, North-West	20	0
Permanent grassland, clover-free, North-West, conserved grass, wrapping	18	0
Preserved grass, hay, permanent grassland, no clover, Northwestern	23	0
Grazed grass, temporary meadow, no clover, Northwestern	15	34
Preserved grass, wrapping, temporary grassland, no clover, North-West	16	20
Preserved grass, hay, temporary meadow, no clover, Northwestern	21	20
Grazed grass, permanent meadow, with clover, Northwestern	19	0
Permanent grassland, with clover, North-West France	12	0
Preserved grass, hay, permanent meadow, with clover, Northwestern	12	0
Grazed grass, temporary meadow, with clover, Northwestern	13	34

Retained grass, wrapping, temporary meadow, with clover, North-West	11	20
Preserved grass, silage, temporary meadow, with clover, Northwestern	11	20
Preserved grass, hay, temporary meadow, with clover, Northwestern	11	20
Alfalfa for dehydration	18,75	21
Alfalfa on farms with livestock	18,75	28

PARAMETERS FOR THE PLANT SECTOR: PERENNIAL AND SPECIAL CROPS IN MAINLAND FRANCE

The nitrate model proposed by SQCB (Faist *et al*, 2009) was selected for orchards, vines and special crops grown in soil without fertigation (carrots). This model was originally developed by De Willigen (2000) and adapted by SQCB. It is a regression model using the following formula:

$$N = \left[21.37 + \frac{P}{c * L}\left[0.0037 * S + 0.000060\,N_{org} \quad {}_{org} - 0.00362 * U\right]\right]\frac{1}{y}\frac{1}{1000}$$

N = quantity of nitrogen leached, in kg N/kg yield

S = quantity of nitrogen applied, including crop residues, in kg N/ha

U = the quantity of nitrogen absorbed by the plant, in kg N/ha ("uptake")

N_{org}= the amount of nitrogen in soil organic matter, in kg N/ha

P= precipitation and watering, in mm per year

C= clay content, base 100

L= root depth, in metres

Y= yield, in t MB/ha ("Yield")

The model can be used under the following conditions:

- ✓ rainfall between 40-2000 mm
- ✓ clay content between 3% and 54
- ✓ root depth between 0.25 and 2 m

Settings:

The sources for calculating clay content (C) and precipitation (P) are identical to those used for the erosion model (see Sheet 5). An exception was made for carrots, which are grown mainly on sandy soils with an average clay content of 5%.

The yield (Y), the amount of nitrogen applied (S) and the amount of water for irration (P) are taken from the data entered at the time of collection for each inventory.

For the other parameters (U, L and Norg), the values shown inTable106 were used.

Table106: Values used to calculate nitrate leaching under metropolitan special crops and orchards.

Culture	Root depth (=L) in m	Nitrogen withdrawal (=U) in kg N/t MB	Norg in kg N /ha
Carrot	0,6	1,45	2750
Cauliflower	0.6	3.936	5500
Zucchini	0.6	2.144	5500
Endive	0.7	3.125	5500
Strawberry (fruit production)	0.6	1.2	5500
Strawberry (seedling production)	0.4	1.15	5500
Melon	0.6	1.136	5500
Nuts (nursery)	0.5	5	2750
Nuts (non-productive)	0.8	5	2750
Nuts (productive)	1.1	17	2750
Onion	0.5	2	5500
Peach/nectarine (nursery)	0,8	4	5500
Peach/nectarine (non-productive)	0,8	5	5500
Peach/nectarine (productive)	1,1	6	5500
Apple and cider apple (nursery)	0,8	4	5500
Apple and cider apple (non-productive)	0,8	4,5	5500
Apple and cider apple (productive)	1,1	5	5500
Pear (nursery)	0,8	5	2750
Pear (non-productive)	0,8	5	2750
Pear (productive)	1,1	0.616	2750
Leek (open field)	0.6	3.328	5500
Leek (seed production under cover)	0.4	3.328	5500
Grapes/vine plants (nursery)	0,3	5	3500
Grapes/vine plants (non-productive)	0,4	5	3500
Grapes/vine plants (productive)	0,9	7	3500
Salad	0.4	2.144	5500

Tomatoes	0.6	1.28	5500

PARAMETERS FOR THE PLANT SECTOR: SPECIALTY SOILLESS OR FERTIGATED CROPS

For soilless tomatoes, leaching was calculated on the basis of water discharged due to closed-loop water circulation, by multiplying the quantity of water discharged with its nitrate content (0.25 g N-NO_3/l water).

For fertigated crops, minimal leaching has been assumed. Although the risk of leaching is much lower in greenhouses and tunnels (due to rain protection), in reality it cannot be considered zero (the theoretical case of an ideal fertigation regime). Thus, for tomatoes grown in open ground under tunnels with fertigation, a leaching rate of 5% of applied nitrogen has been set according to expert opinion. For shrubs, the leaching rate was set at 5% in phase 1, 45% in phase 2 and 1% for roses.

PARAMETERS FOR THE PLANT SECTOR: CLEMENTINE, MANGO, COCOA

Nitrogen leaching is considered nil for clementine, mango and cocoa plantations located in "dry" areas, in line with the latest IPCC recommendations (2013 update of 2007 report, table 11.3). Indeed, the IPCC specifies that the fracLEACH factor only applies in situations where the soil's water holding capacity is exceeded, otherwise no leaching is to be considered.

PARAMETERIZATION FOR THE PLANT SECTOR: COFFEE, OIL PALM

For these crops, the IPCC (2007) Level 1 method was applied, i.e. the nitrate leaching factor is 30% of the applied nitrogen.

PLANT SECTOR SETTINGS: RICE THAILAND

Assumptions:

- ✓ Rice growing period = 120 days
- ✓ NO_3 / rainwater = 0.70 mg/l or 0.007g per ha per mm of rainfall
- ✓ NO_3 / irrigation water = 0.11 mg/l or 0.0011g per ha per mm of irrigation

Nitrogen is at the heart of rice fertilization. Plants consume significantly more nitrogen in ammonia form than in nitrate form, which is why most fertilization is carried out with ammonia and urea. Nitrate losses are therefore due to biochemical processes (e.g. denitrification), rather than direct fertilizer losses.

The principles underpinning the calculation of nitrate emissions are therefore: i) nitrate is a remaining component of the nitrogen mass balance, the other components of which have been calculated elsewhere; ii) most of this nitrate is leached via drainage and deep percolation, and iii) these two processes are linked to the proportion of water not used by the plant, i.e. water use efficiency.

Consequently, the estimation of leached nitrate is modeled by coupling a N mass balance with a water balance, as proposed by Pathak *et al* (2004). Nitrogen inputs include: fertilization, precipitation, irrigation water and soils (soil N stock, immobilization). Nitrogen outputs include: runoff, leaching, exports, soil losses (erosion), mineralization, volatilization and denitrification processes.

Nitrogen mass balance

The mass balance of nitrogen can be expressed as follows (Equation 1):

$$0 = N_{en} - N_{sor} - N_{diff\ soil} \text{ (Equation 1)}$$

The components of N_{en} (inputs) and N_{sor} (outputs) are presented in**Table107** . $N_{diff\ soil}$ represents nitrogen residue. Considering an identical cropping system over several years, the assumption was made that soils have a stable nitrogen content over the long term, so this item was considered negligible. Similarly, soil organic matter dynamics were assumed to be constant, with mineralization equal to immobilization. The other components: symbiotic nitrogen fixation, groundwater inputs and weed exports are ignored (Pathak *et al*, 2004).

All**Table107** parameters are known, assumed or neglected, with the exception of soluble nitrate losses through percolation and drainage.

N inputs are calculated on the basis of fertilizer composition and application rates.

N inputs from precipitation and irrigation water are calculated using the respective average N contents, as well as precipitation and irrigation water quantities over the time period under consideration (cropping period).

Plant nitrogen exports were calculated on the basis of exported grain and straw yields, as well as their N content. In the event of straw being exported, burnt or grazed, the nitrogen it contains was considered lost.

Losses of nitrogen in the form of N_2O, NO and NH_3 were calculated as described in the data sheets for these substances.

The N_2 emitted during the denitrification process does not constitute a pollutant emission. However, it must also be quantified in order to complete the mass balance. Brentrup *et al* (2000) propose an emission factor linked to nitrogen fertilization (Equation 2):

$$N\text{-}N_2\ (kg/ha) = (0.09 * \text{Total N units supplied per ha}) \qquad \text{(Equation 2)}$$

It has been assumed that the other components are mostly nitrates (Nt), which result from the nitrification ammonia. If they are not absorbed by the plant, via the evapotranspiration flux, they are likely to be emitted as a pollutant into the water compartment, via percolation and drainage (Nl).

Table107: Components of nitrogen mass balance in rice fields.

N inputs (kg N ha-1)	N output (kg N ha-1)
+ N fertilizer	- N net exports by plants
+ N precipitation **+ N irrigation water** **+ N mineralization of organic matter**	- N lost through N2O, NO and NH3 emissions - N lost through N2 - N lost through leaching - N lost through drainage - N immobilized by organic matter
∑ entries	∑ outputs
Balance N = 0 = ∑ inputs - ∑ outputs - Ndiff soil	

Water balance

A water balance was required to determine the water use efficiency coefficient Ei. It is assumed that the proportion of nitrate leached (Nl) or drained during the growing season is correlated to the proportion of water not used by plants: [1 - Ei].

$$Nl = Nt * [1 - Ei] \qquad \text{(Equation 3)}$$

The water balance equation can expressed as follows, to determine the leaching and drainage components of the components:

$$DPR + R = I + P - ET \quad \text{(Equation 4)}$$

Where:

DPR = percolated water in mm

R = Runoff from the plot, which can be expressed as drainage area, in mm

I = Irrigation water supplied daily in mm

P = Precipitation in mm

ET = Evapotranspiration in mm

Note: runoff is considered zero under normal conditions. This is because the rice paddies are flat and managed in such a way that water does not overflow. The water level is maintained between 0 and 15 mm. However, particularly at the end of the cultivation period, it is not uncommon for excess water to be released.

Irrigation efficiency, or water use efficiency, has been defined as follows:

$$Ei = ET / [P + I] \qquad \text{(Equation 5)}$$

This parameter can also be set as a function of the DPR and R parameters:

$$1 - Ei = [DRP + R] / [P + I] \qquad \text{(Equation 6)}$$

Whatever the method of calculation, it is essential to use a water balance to calculate the proportion of nitrate lost through drainage or leaching. Equation 6 requires fewer parameters and is therefore simpler to implement. Average monthly precipitation and ET data supplied by meteorological services can be used, as can irrigation data collected in the study areas. This is the method used in AGRIBALYSE®.

10. Sheet n°10: Occupation (m^2.an) and land use change (m^2)

General information

Table108: Models selected by emission item.

Transmitter station	Model selected
Land use	**Ecoinvent® v2** (Frischknecht *et al*, 2007)
Direct transformation land use	**Not considered**

This flow is independent of soil or biomass carbon dynamics. It is only the notion of land use that is addressed here.

References:

BSI, 2012. PAS 2050-1:2012 Assessment of life cycle greenhouse gas emissions from horticultural products. British Standards Institution, London.

Bossard M., Feranec J. and Otahel J., 2000. CORINE land cover technical guide. Addenum 2000. 40. Ed European Environment Agency (EEA), Copenhagen, Denmark, from,

Frischknecht R., Jungblut N., Althaus H-J., Doka G., Dones R., Heck T., Hellweg S., Hischier R., Nemecek T., Rebitzer G., Spielmann M. and Wernet G., 2007. Overview and methodology - Data v2.0 (2007). Ecoinvent® report No. 1. Ed Swiss Center fo Life Cycle Inventories, Dübendorf, Switzerland. p77.

Parameters for the plant sector: Land use

The method used is that described in the Ecoinvent® version 2 reports (Frischknecht R. *et al*, 2007). For a given type of occupancy, the surface area is entered in the inventory in m^2/year.

Land use categories are defined according to CORINE Land Cover (Bossard *et al* 2000).

Table109: AGRIBALYSE® land-use categories.

culture	Category land
Shrub	heterogenous, agricultural
Sugar beet	arable
Durum wheat	arable
Soft wheat	arable
Cocoa	permanent crop, vine
Café	permanent crop, fruit
Carrot	arable
Clémentine	permanent crop, fruit
Rapeseed	arable
Faba bean	arable

Alfalfa	arable
Silage corn	arable
Grain corn	arable
Mango	permanent crop, fruit
Brewing barley	arable
Feed barley	arable
Skidding	pasture and meadow, extensive
Peach /nectarine	permanent crop, fruit
Peas	arable
Apple	permanent crop, fruit
Cider apple	permanent crop, fruit
Potatoes	arable
Potato starch	arable
Permanent meadow	pasture and meadow, extensive
Temporary meadow	arable
Wine grapes	permanent crop, vine
Thai rice	arable
Cut flower rose	heterogenous, agricultural
Tomato	heterogenous, agricultural
Sunflower	arable
Triticale	arable

Land occupancy is calculated by multiplying the area occupied by the time occupied (calculation see data sheet 11,**Table116**). In the case of permanent grassland, the duration considered is 1 year.

DIRECT TRANSFORMATION OF LAND USE

The PAS 2050-1:2012 model (BSI, 2012) was tested on French crops for AGRIBALYSE® version 3.0. It was found that data on land-use change were not sFUficiently accurate to provide robust analyses, correctly reflecting regional dynamics and drivers of land-use change (e.g. grassland reversal in some areas). Further work is required, drawing in particular on the results of the 4p1000 program, which will enable fine, spatially-distributed monitoring of land-use change.

11. Sheet n°11: Phosphorus (P)

General information

Table110: Models selected by emission item.

P emission station	Model selected
Emission per erosion	SALCA-P (Nemecek and Kägi, 2007 and Prasuhn, 2006)
Leaching emissions	
Runoff emissions	
Emissions from grazing and grasslands	
Emissions during manure storage	Not considered
Soilless cultivation	This report
Rice Thailand	This report

References:

FAO, 1992. CROPWAT - A computer program for irrigation planning and management. FAO Technical Irrigation and Drainage paper, num. 46, Rome, Italy.

Foster G. R., 2005. Revised Universal Soil Loss Equation - Version 2 (RUSLE2). USDA - Agricultural Research Service, Washington D.C., USA, 286 p.

Nemecek T. and Kägi T., 2007. Life Cycle Inventories of Swiss and European Agricultural Production Systems - Data v2.0 (2007). Ecoinvent® report No. 15a. Ed Swiss Center for Life Cycle Inventories, Zurich and Dübendorf, Switzerland. p360.

Prasuhn V., 2006. Erfassung der PO4-Austräge für die Ökobilanzierung. SALCA-Phosphor. Agroscope FAL Reckenholz, Zürich, Switzerland. p22.

Parameters for the animal sector: Emissions during manure storage

Due to the lack of documentation on the processes involved, emissions for this item could not be considered.

Parameters for the plant sector: Emissions from erosion

Table111: Simplified formulas and main input data required for the Prasuhn model, 2006 .

	SALCA-P models
Formulas	Erosion: PE = SE * PS * FR * FSR * t With: PE Phosphorus emitted by erosion into rivers (kg/ha*a) SE Quantity of soil eroded (kg/ha, see Sheet 5) PS Phosphorus content in the upper part of the soil EN Enrichment factor in eroded particles FSR Fraction of eroded soil that reaches the river

	t	Land occupation time (=number of days/365)

The quantity of soil eroded SE is calculated in the erosion model (see data sheet 5). For multi-annual or perennial crops, the erosion model provides a value for the first year and another for subsequent years.

In the SALCA-P model, the soil content measured is that of total phosphorus. French references generally refer to soluble phosphorus. According to expert information (V. Prasuhn, Agroscope), 1 to 10% of total phosphorus is soluble, but there is no scientifically established correlation between these two parameters. What's more, apart from apatite, much of the total phosphorus, initially non-soluble, will be dissolved in the medium term. From the point of view of the characterization model, the phosphorus contained in soil particles and available to plants (in the medium term) must be entered[16] . This phosphorus is more closely related to total phosphorus than to soluble phosphorus. For these reasons, the Swiss value for total phosphorus has been used (PS = 0.00095 kg P/kg soil).

For the FR factor, the value proposed by the SALCA-P orginal model was used (FR = 1.86, cf. Prasuhn, 2006). An average value of 0.2 was taken for the FSR factor, indicating an unknown distance to the nearest surface water (river).

PARAMETERS FOR THE PLANT CHAIN: EMISSIONS BY LEACHING AND RUNOFF

Table112: Simplified formulas and main input data required for the model; the original SALCA-P model includes other factors whose values for this simplified model have been set to 1 (cf Prasuhn, 2006).

	SALCA-P models
Formulas	**Leaching**: $P_L = P_{LM} * F_{CLB} * t$ with: P_L Phosphorus leached (kg/(ha*a)) P_{LM} Average quantity of phosphorus leached as a function of land-use category F_{CLB} Correction factor for fertilization with slurry and/or sludge t Occupancy time (=number of days/365)
	Runoff: $P_R = P_{RM} * F_C * F_p * t$ with: P_R Phosphorus lost through runoff to rivers (kg/ha*a) P_{RM} Average amount of phosphorus lost to runoff by land use category. F_C Correction factor depending on the form of phosphorus supplied (mineral, liquid/solid organic) F_P Slope" factor. FP = 0 if the slope is less than 3% and 1 if it is 3% or more. t Occupancy time (=number of days/365)

The average annual quantities leached and runoff are a function of seven crop groups. Each AGRIBALYSE® crop has been assigned to one of these groups (**Table114Table113** shows the quantities of phosphorus emitted (runoff and leachate) by type of crop and emission. These are Swiss values.

For mown grass (hay, silage, wraps), which was included in "grassland" inventories with mixed regimes (grazing and mowing), the average annual quantities leached and runoff were calculated on the basis of time spent in "grazing", "temporary

[16] See EDIP 2003, page 69 "For a compound to be regarded as contributing to aquatic eutrophication, it must thus contain nitrogen or phosphorus in a form which is biologically available".

grassland" and "permanent grassland". The total amount of P leached and runoff was then allocated to the different grasses on a mass basis.

Table113: Average annual phosphorus runoff and leaching by crop.

Leaching	Value (P_{LM})	Unit
market gardening	0,07	kg P/(ha*year)
grazed meadow	0,06	kg P/(ha*year)
permanent grassland	0,06	kg P/(ha*year)
temporary grassland	0,07	kg P/(ha*year)
arable land	0,07	kg P/(ha*year)
tropical[1)]	0,07	kg P/(ha*year)
orchard	0, 07	kg P/(ha*year)
vine	0,07	kg P/(ha*year)
Runoff	P_{RM}	
market gardening	0,175	kg P/(ha*year)
grazed meadow	0,15	kg P/(ha*year)
permanent grassland	0,15	kg P/(ha*year)
temporary grassland	0,25	kg P/(ha*year)
arable land	0,175	kg P/(ha*year)
tropical[1)]	0,175	kg P/(ha*year)
orchard	0, 175	kg P/(ha*year)
vine	0,175	kg P/(ha*year)

1) For the tropical category (which does not exist in the original SALCA-P model), the values of the "market gardening" category have been taken.

Table114: Assignment of AGRIBALYSE® crops to crop groups.

culture	Crop type
Peach/nectarine	orchard
Apple (fruit)	orchard
Cider apple (fruit)	orchard
Wine grapes	vine
Soil-grown tomatoes, outdoor	market gardening
Wine	vine
Café	tropical
Clémentine	tropical
Sugar beet	arable land
Durum wheat	arable land
Soft wheat	arable land
Carrot	arable land
Rapeseed	arable land
Faba bean	arable land
Alfalfa	arable land
Silage corn	arable land
Grain corn	arable land
Brewing barley	arable land
Feed barley	arable land
Potato (PDT)	arable land
Peas	arable land
Potato starch (PDTF)	arable land
Temporary meadow	temporary grassland
Permanent meadow	permanent grassland
Sunflower	arable land
Triticale	arable land

Grazed meadow	grazed meadow

To calculate the F_C correction factor applied to runoff, annual P_2O_5 inputs from fertilizers must be aggregated according to their type and form (solid/liquid). For crops with a duration of more than one year, the inputs must be divided by the duration of the crop.

The categories defined are "sludge", "compost", "solid manure", "liquid manure" and "mineral fertilizer" (**Table115**). To calculate the correction factor F_{CLB} which is applied to leaching, only liquid fertilizers need be taken into account (liquid form and various liquids). Phosphorus contents are taken from various French standards (seeAppendix FF

Table115: Fertilizer classification in relation to the SALCAP model

Initial name	Standard name	Category for F_C / F_{CLB}
Limed municipal sludge	Limed municipal sludge	sludge / various liquids
Liquid urban sludge s	Liquid urban sludge s	sludge / various liquids
Urban sludge paste s	Urban sludge paste s	compost / various solids
Dry urban sludge s	Dry urban sludge s	compost / various solids
Slurry/manure compost	Urban plant compost	compost / various solids
Urban compost (household waste)	Urban compost (household waste)	compost / various solids
Urban plant compost	Urban plant compost	compost / various solids
Sugar skimmings	Sugar skimmings	sludge / various liquids
Feather meal	Feather meal	compost / various solids
Free-stall cattle manure	Medium cattle manure	firm and solid
Cattle manure in piles	Medium cattle manure	firm and solid
Pig manure	Straw-based pig manure	firm and solid
Broiler manure	Broiler manure	firm and solid
Rabbit manure	Rabbit manure	firm and solid
Cattle slurry	Undiluted cattle slurry	liquid farm
Low-faeces cattle slurry	Diluted cattle slurry	liquid farm
Pig slurry	Mixed pig slurry	liquid farm
Sheep manure	Sheep manure	firm and solid
Vegethumus	Vegethumus	compost / various solids
Concentrated beet vinasse	Concentrated beet vinasse	sludge / various liquids
Distillation vinasses	Concentrated beet vinasse	sludge / various liquids
Poultry droppings	Dried laying hen droppings	firm and solid

Poultry manure	Laying hen manure	firm and solid
Poultry manure	Dried laying hen droppings	liquid farm

The formulas for the two factors FC and FCLB are as follows (in these formulas, the annual P2O5 inputs must be used)

$$F_C = 1 + \frac{0.7 \times \left(P_2O_{5\,Lisiers\ et\ Boues} \right) + 0.2 \times \left(P_2O_{5\,Engrais\ minéraux} \right) + 0.4 \times \left(P_2O_{5\,Fumiers\ et\ compostes} \right)}{80}$$

$$F_{CLB} = 1 + \frac{0.2 \times \left(P_2O_{5\,Lisiers\ et\ Boues} \right)}{80}$$

In line with the erosion model, the average slope has been set at 2%, which means that the "slope" factor (F_P) is equal to zero (and therefore there is no phosphorus runoff).

The length of occupancy, i.e. the duration of the crop, corresponds to the period between the harvest of the previous crop and that of the crop being surveyed (with one exception: for rice, a default duration of 120 was assumed). Given the diversity of rotations, the start of this period had to be calculated. This was done by weighting the harvest dates of previous crops according to their frequency in the rotations of the crop in question. The duration thus calculated was used for all models (ETM, P, land use).

Table116: Harvest dates used to calculate crop occupancy time.

Culture	Harvest date (dd.mm)
Sugar beet	15.10
Durum wheat	08.07
Soft wheat	20.07
Carrot	10.06
Rapeseed	15.07
Faba bean	22.07
But forage	15.09
Grain corn	15.10
Barley	08.07
Winter peas	08.07
Spring peas	22.07
Potatoes	22.09
Potato starch	08.09
Temporary prarie	22.09
Sunflower	11.09
Triticale	25.07

PARAMETERS FOR THE PLANT INDUSTRY: SOILLESS AND FERTIGATED SYSTEMS

For soilless and fertigated crops, phosphate emissions were calculated using expert information:

a) Soilless tomatoes: Emissions are calculated on the basis of discharged water, assuming a content of 0.06 g P-PO_4 per liter of water (CTIFL, 2013).

b) Fertirrigated tomatoes: Emissions are estimated at 5% of inputs

c) Soilless cut flower rose: Losses have been set at 1% of inputs.

d) Shrub: Losses in phase 1 were set at 5% of inputs and in phase 2 at 45%.

For fertigated systems, phosphate loss rates were considered to be similar to nitrate loss rates.

PLANT INDUSTRY SETTINGS: RICE THAILAND

Assumptions:

- ✓ Rice growing period = 120 days
- ✓ P / rainwater = 0.045 mg/l or 0.00045 g per ha per mm of rainfall
- ✓ P / irrigation water = 0.125 mg/l or 0.00125 g per ha per mm of irrigation

Phosphorus (P) is an input to rice production systems via mineral fertilization, irrigation and rainfall. The system's outputs are: crop exports, leaching and drainage, the latter two of which can lead to eutrophication. The mass balance of phosphorus can be expressed as follows:

$$0 = P_{en} - P_{sor} - P_{diff\ soil} \text{ (Equation 1)}$$

The various components of the P_{en} (input) and P_{sor} (output) parameters are presented in**Table117** . $P_{diff\ soil}$, considering an identical cropping system over several years, the assumption was made that soils have a stable phosphorus content over the long term, so this item was considered negligible. Similarly, soil organic matter dynamics were assumed to be constant, mineralization being equal to immobilization. As rice fields are flat and protected dykes, water rarely overflows (except under exceptional flood conditions). Thus, soil erosion by runoff is low and has been neglected as a possible source P loss.

Table117: Components of phosphorus mass balance in rice fields.

Feed (kg N ha-1)	Psorties (kg N ha-1)
+ P fertilization	- P exports by plants
+ P precipitation **+ P irrigation** **+ P immobilization (=mineralization of organic matter)**	- P leaching losses - P drainage losses - P losses through mineralization of organic matter (=immobilization)
∑ input	∑ outputs
Mass balance P = 0 = ∑ inputs - ∑ outputs - Pdiff soil	

Fertilization inputs were calculated on the basis of fertilizer composition and application rates.

P inputs from precipitation and irrigation water were calculated using their respective mean P contents, as well as precipitation and irrigation water quantities over the time period under consideration (cropping period).

Plant P exports were calculated on the basis of exported grain and straw yields, as well as their P content. In the event of straw being exported, burned or grazed, the phosphorus it contains is considered lost.

A water balance is required to determine P losses due to drainage and leaching (Pl). The same methodology was used as for nitrate (see nitrate data sheet). It is assumed that the proportions of P leached (Pl) or drained during the growing season are correlated to the proportion of water not used by plants: [1 - Ei].

$$Pl = Pt * [1 - Ei] \quad \text{(Equation 2)}$$

Water balance

See nitrate data sheet (Sheet n°9).

12. Sheet n°12: Dinitrogen monoxide (N_2O)

General information

Table118: Models selected by emission item.

Transmitter station	Model selected
Dejecta in the building and during storage	CORPEN 1999a-199b-2001-2003-2006: for calculating quantities of nitrogen excreted by animals
	For emission factors (and leached fraction): IPCC 2019, Level 2
Agricultural soils	IPCC 2019, Level 1
Soilless crops	IPCC 2019, Level 1
Grazing	IPCC 2019, Level 1
Rice Thailand	IPCC 2006b, Level 2 & Yan *et al*, 2003b
Tropical crops	IPCC 2019, Level 1

References:

CORPEN, 2006. Estimation des rejets d'azote, phosphore, potassium, calcium, cuivre, zinc par les élevages avicoles - Influence de la conduite alimentaire et du mode de logement des animaux sur la nature et la gestion des déjections. Ed CORPEN, Paris, France. p55.

CORPEN, 2003. Estimation des rejets d'azote, phosphore, potassium, cuivre et zinc des porcs - Influence de la conduite alimentaire et du mode de logement des animaux sur la nature et la gestion des déjections. Ed CORPEN, Paris, France. p41.

CORPEN, 2001. Estimation des flux d'azote, de phosphore et de potassium associés aux bovins allaitants et aux bovins en croissance ou à l'engrais, issus des troupeaux allaitants et laitiers, et à leur système fourrager. Ed CORPEN, Paris, France. p34.

CORPEN, 1999a. Estimation of nitrogen, phosphorus and potassium flows associated with dairy cows and their forage system - Influence of feed and production level. Ed CORPEN, Paris, France. p18.

CORPEN, 1999b. Estimation des rejets d'azote et de phosphore par les élevages cunicoles. p17.

Daum D. and Schenck M.K., 1996. Gaseous nitrogen losses from a soilless culture system in the greenhouse. Plant and soil 183, 69-78.

FAO, 2012. Global ecological zones for FAO forest reporting: 2010 Update, Rome: Food and Agriculture Organization of the United Nations.

http://www.fao.org/docrep/017/ap861e/ap861e00.pdf

IPCC, 2006b. Guidelines for national greenhouse gas inventories. Vol No 4: Agriculture, forestry and other land use (AFOLU). Ed Eggleston S., Buendia L., Miwa K., Ngara T. and Tanabe K., Kanagawa, Japan.

IPCC, 2019. Refinement to the 2006 IPCC guidelines for national greenhouse gas inventories, in, 2019

Yan X., Akimoto H. and Ohara T., 2003b. Estimation of nitrous oxide, nitric oxide and ammonia emissions from croplands in East, Southeast and South Asia. Global Change Biology, 9: 1080-1096.

Parameters for the animal sector: manure in buildings and in storage facilities

The quantities excreted were calculated using equations provided by CORPEN (1999a, 1999b, 2001, 2003, 2006). Emission factors depend on the storage system. The factors presented in**Table119** were used to calculate N_2O emissions.

Table119: Emission factors for N_2O emissions according to manure management system.

IPCC Management Systems 2019		EF3 N_2O in kg N2O-N per kg N excreted
Solid storage		0,01
Liquid/ice	covered pit	0,005
	uncovered pit with crust	0,005
	uncovered pit without crust	0
Liquids, slurry, stored in pre-pits under livestock buildings		0,002
Accumulated litter cattle and swine	without stirring (cattle)	0,01
	with stirring (pigs)	0,07
Poultry manure with litter		0,001
Poultry manure without litter		0,001

Parameters for the plant sector: Agricultural soils

Figure18 provides an overview of direct and indirect N_2O emissions for crop production. Only the N_2O emission factors have been included; the other flows (inputs, volatilization and leaching) have been calculated in the nitrate and ammonia/NO models on the basis of data collected for each crop.

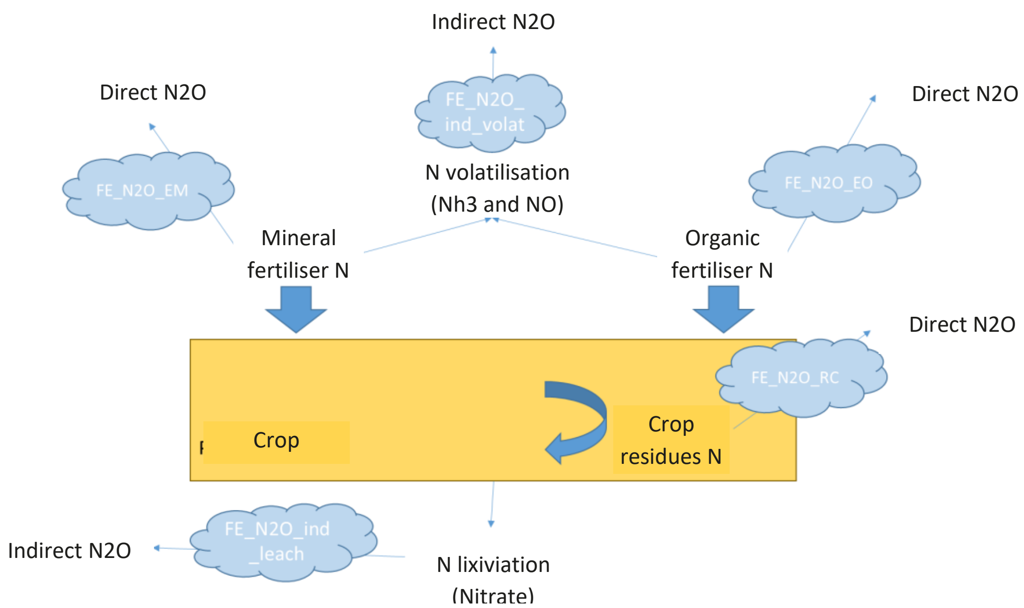

Figure18: N_2O emission model according to IPCC (2019) level 1.

The N_2O calculation model used by uses IPCC (2019) Level 1 only for the emission factors (FE1, FE4 and FE5, see equations 1 to 3 below).

Equation 1: Direct N_2O emissions from managed soils (level 1):

$$N - N_2O_{Direct} = N - N_2O_{N_{Inputs}} + N - N_2O_{SO} + N - N_2O_{PR}$$

Where:

$$N - N_2N_{Inputs} = [(F_{SN} + F_{ON} + F_{RR} + F_{MOS}) \times FE_1] + [(F_{SN} + F_{ON} + F_{RR} + F_{MOS})_{RI} \times FE_{1RI}]$$

$$N - N_2O_{SO} = \left(F_{SO,CP,Temp} \times FE_{2CP,Temp}\right) + \left(F_{SO,CP,Trop} \times FE_{2CP,Trop}\right) + \left(F_{SO,F,Temp,RN} \times FE_{2F,Temp,RN}\right) + \left(F_{SO,F,Temp,PN} \times FE_{2F,Temp,PN} + \left(F_{SO,F,Trop} \times FE_{2,Trop}\right)\right)$$

$$N - N_2O_{PR} = \left(F_{PPP,BVS} \times FE_{2PPP,BVS}\right) + \left(F_{PPP,MA} \times FE_{2PPP,MA}\right)$$

Where:

- Direct N-N2OD = annual direct N-N2O emissions from managed soils, kg N-N2O yr-1
- N-N2ON Inputs = annual direct N-N2O emissions attributable to N inputs on managed soils, kg N-N2O yr-1
- N-N2OSO = annual direct N-N2O emissions from managed organic soils, kg N-N2O yr-1
- N-N2OPR = annual direct N-N2O emissions from urine and faeces entering grazed land, kg N-N2O yr-1
- FSN = annual quantity of mineral fertilizer N applied to soil, kg N yr-1
- FON = annual quantity of animal manure, compost, sewage sludge and other organic N additions applied to soils (Note: If sewage sludge is included, cross-check with the Waste sector so as not to double-count N2O emissions due to N from sewage sludge), kg N yr-1
- FRR = annual quantity of N returned to the soil in crop residues (above and below ground), including nitrogen-fixing crops and forage/pasture renewal, kg N yr-1
- FMOS = annual amount of N mineralized in mineral soils associated with losses of soil C from soil organic matter due to changes in land use or management, kg N yr-1
- FSO = annual area of drained/managed organic soils, ha (Note: lower indices CP, F, Temp, Trop, RN and PN refer to cropland and grassland, forest land, temperate, tropical, nutrient-rich and nutrient-poor, respectively)
- FPPP = annual quantity of urine and faeces N deposited by animals grazing on pastures, rangelands and plots, kg N yr-1 (Note: the lower indices BVS and MA refer to cattle, poultry and swine, and sheep and other animals, respectively).
- EF1 = emission factor for N2O emissions due to N inputs, kg N-N2O (kg N inputs)-1
- FE1RI represents the emission factor for N2O emissions due to N inputs on flooded rice, kg N-N2O (kg N inputs)-1
- FE2 = emission factor for N2O emissions from drained/managed organic soils, kg N-N2O ha-1.yr-1 (Note: lower indices CP, F, Temp, Trop, RN and PN refer to cropland and grassland, forest land, temperate, tropical, nutrient-rich and nutrient-poor, respectively)
- FE3PPP = emission factor for N2O emissions due to N in urine and faeces deposited on pastures, rangelands and plots by grazing animals, kg N-N2O (kg N inputs)-1 ; (Note: lower indices BVS andMA refer to cattle, poultry and swine, and sheep and other animals, respectively)

Equation 2: N_2O emissions linked to atmospheric deposition of volatilized nitrogen from soil management (level 1):

$$N - N_2O_{(DAT)} = \left[(F_{SN} \times Frac_{GAZE}) + \left((F_{ON} + F_{PR}) \times Frac_{GAZM}\right)\right] \times FE_4$$

Where:

- $N\text{-}N_2O_{(DAT)}$ = annual amount of $N\text{-}N_2O$ produced by atmospheric deposition of volatilized N from managed soils, kg $N_2O\text{-}N\ yr^{-1}$
- F_{SN} = annual quantity of mineral fertilizer N applied to soil, kg N yr^{-1}
- $Frac_{GAZE}$ = fraction of mineral fertilizer N volatilized as NH_3 and NO, kg N volatilized (kg N applied)-1
- F_{ON} = annual quantity of managed animal manure, compost, sewage sludge and other organic N inputs applied to soils, kg N yr^{-1}
- F_{PR} = annual quantity of urine and faeces N deposited by animals grazing on pastures, rangelands and plots, kg N yr^{-1}
- $Frac_{GAZM}$ = fraction of organic N fertilizer materials applied (F_{ON}) and urine and faeces N deposited by grazing animals (FPPP) volatilized as NH_3 and NO, kg N volatilized (kg N applied or deposited)$^{-1}$
- EF_4 = emission factor for N_2O emissions due to atmospheric deposition of N on soils and aquatic surfaces, [kg $N\text{-}N_2O$ (kg $N\text{-}NH_3$ + volatilized N-NO$)^{(-1)}$]

Equation 3: N_2O emissions due to nitrogen leaching from managed soils, in regions where such runoff exists (level 1):

$$N - N_2O_{(L)} = (F_{SN} + F_{ON} + F_{PPP} + F_{RR} + F_{MOS}) \times Frac_{LIXI-(H)} \times FE_5$$

Where:

- $N\text{-}N_2O_{(L)}$ = annual quantity of $N\text{-}N_2O$ produced by leaching and runoff after N additions to managed soils in areas where leaching and runoff occur, kg $N\text{-}N_2O\ yr^{-1}$
- F_{SN} = annual quantity of mineral fertilizer N applied to soils in areas where leaching and run-off occur, kg N yr^{-1}
- F_{ON} = annual quantity of managed animal manure, compost, sewage sludge and other organic N additions applied to soils in areas where leaching and runoff occur, kg N yr^{-1}
- F_{PPP} = annual quantity of urine and faeces N deposited by animals grazing in areas where leaching and run-off occur, kg N yr^{-1}
- F_{RR} = annual amount of N returned to the soil in crop residues (above and below ground), including N-fixing crops, and due to forage/pasture renewal, in areas where leaching and run-off exist, kg N yr^{-1}
- F_{MOS} = annual amount of N mineralized in mineral soils, associated with losses of soil C from soil organic matter due to changes in land use or management in areas where leaching and runoff occur, kg N yr^{-1}
- $Frac_{LIXI-(H)}$ = fraction of all N mineralized/added to soils managed in areas where leaching and runoff occur, and lost through leaching and runoff, kg N (kg N additions)$^{-1}$
- EF_5 = emission factor for N_2O emissions due to N leaching and runoff, kg $N\text{-}N_2O$ (kg N leached and runoff$)^{(-1)}$

To calculate the leached (NO_3) and volatilized (NH_3) fractions, this model uses the quantities calculated in the "nitrate" and "ammonia" models. The quantity of nitrogen considered includes the quantity of organic and mineral manure, as well as crop residues, both above and below ground.

In line with the decision not to take into account carbon storage and destocking in soils, N_2O emissions due to nitrogen mineralization caused by organic matter losses linked to a CAS are not taken into account.

This approach was implemented in a similar way for all plant systems, annual crops, orchards, vineyards, nurseries and soilless crops.

The 2019 version of the N2O emission model proposes different emission factor values depending on crop location (wet or dry climate) and input type. A default factor is also proposed if the location/climate is unknown.

For the IPCC 2019 model, a humid climate zone is defined as follows: (1) in temperate and boreal zones, a zone where potential evapotranspiration > 1 and (2) in tropical zones, a zone where annual precipitation > 1000 mm. Crops grown in mainland France are therefore located in humid climates. Tropical crops in AGRIBALYSE® have been classified according to their country of origin, based on the classification proposed by the FAO (2012).

The emission factors used by AGRIBALYSE® are as follows:

Table120: Direct emission factors for N_2O (EF 1 in equation 1)

Location	Source of emission	Emission factor value (kg N_N_2O/kg N)
Not known (default)	Mineral fertilizers	0,01
Humid climate		0,016
Dry climate		0,005
Not known (default)	Organic fertilizers	0,01
Humid climate		0,006
Dry climate		0,005
Not known (default)	Crop residues	0,01
Humid climate		0,006
Dry climate		0,005

Table121: Indirect N_2O emission factors (EF 4 in equation 2 and EF 5 in equation 3)

Location	Source of emission	Emission factor value (kg N_N_2O/kg N)
Not known (default)	Volatilized N (NH_3, NO)	0,01
Humid climate		0,014
Dry climate		0,005
Not known (default)	N leached (NO_3)	0,011
Humid climate		0,011
Dry climate		0,011

Parameters for the plant sector: Grazing

For direct N_2O emissions due to grazing, Tier 1 of the IPCC (2019) method was applied without modification, using the factors $EF3_{PRPCPP}$ and $EF3_{PRPSO}$ depending on the grazing animal (the latter was set for grazed grass LCIs at one bovine,). The leached and volatilized fractions required to calculate indirect emissions were determined using nitrate and ammonia calculation models.

Table122: Direct N_2O emission factors for manure on grassland

Location	Source of emission	Emission factor value (kg N_N_2O/kg N)
Not known (default)	Cattle faeces and urine	0,004
Humid climate		0,006
Dry climate		0,002

PARAMETERS FOR THE PLANT CHAIN: CALCULATION OF N RETURNED TO THE SOIL DUE TO PASTURE RENEWAL (F_{RR})

The amount of N returned to the soil due to forage/pasture renewal (F_{RR}, see equation 3 above) was calculated by applying formula 11.6 of IPCC (2006b), page 11.14 and using the default values proposed in Table 11.2 of the IPCC (2006b) report. For permanent grassland, annual renewal has been set at 0 (see column 3 of**Table123**), which means that no N turnover is taken into account.

The**Table123** presents the quantities of nitrogen returned to the soil due to forage/pasture renewal for the AGRIBALYSE® LCIs.

Table123: Quantities of nitrogen returned to the soil due to forage/pasture renewal for AGRIBALYSE® LCIs.

LCI / crop	Crop name in Table 11.2 of IPCC (2006a)	% of surface area renewed each year	Returned nitrogen (kg N/(ha*yr))
Grazed grass, permanent meadow, without clover, Auvergne	perennial grass	0	0
Herbe conservé, enrubannage, prairie permanente, sans trèfle, Auvergne	perennial grass	0	0
Preserved grass, silage, permanent grassland, without clover, Auvergne	perennial grass	0	0
Preserved grass, hay, permanent meadow, no clover, Auvergne	perennial grass	0	0
Grazed grass, permanent meadow, no clover, North-West	perennial grass	0	0
Permanent grassland, clover-free, North-West, conserved grass, wrapping	perennial grass	0	0
Preserved grass, hay, permanent grassland, no clover, Northwestern	perennial grass	0	0
Grazed grass, temporary meadow, no clover, Northwestern	no n fixing drillings	0,25	10,79
Preserved grass, wrapping, temporary grassland, no clover, North-West	no n fixing drillings	0,25	14,12

Preserved grass, hay, temporary meadow, no clover, Northwestern	no n fixing drillings	0,25	15,61
Grazed grass, permanent meadow, with clover, Northwestern	perennial grass	0	0
Permanent grassland, with clover, North-West France	perennial grass	0	0
Preserved grass, hay, permanent meadow, with clover, Northwestern	perennial grass	0	0
Grazed grass, temporary meadow, with clover, Northwestern	grass clover mix	0,25	18,99
Retained grass, wrapping, temporary meadow, with clover, North-West	grass clover mix	0,25	26,84
Preserved grass, silage, temporary meadow, with clover, Northwestern	grass clover mix	0,25	25,23
Preserved grass, hay, temporary meadow, with clover, Northwestern	grass clover mix	0,25	29,31

PLANT INDUSTRY SETTINGS: RICE THAILAND

Assumptions: Rice growing period = 120 days

Due to flooded conditions, unfavorable to nitrification, N_2O and NO emissions have long been neglected in rice production. Yan et al (2003b) corrected the literature by measuring N_2O emissions in the field, including measurements on unfertilized plots, in order to determine fertilization-induced emissions. The model used is specific to rice, but not to Thailand or Southeast Asia. Their publication therefore focuses on estimating total emissions from a land-use perspective, and takes into account emissions from fallow land between rice cultivation, as well as background emissions. Due to the "product" LCA approach of AGRIBALYSE®, it was decided to focus on emissions during the cultivation period. Based on statistical analysis of 21 experiments, Yan *et al* (2003b) determined both an average fertilizer-induced emission factor (0.25% of all N fertilizer units applied) and an average reference emission of 0.26 kg $N\text{-}N_2O.ha^{-1}$ for an average season of 117 days. Equation 1 presents this model, which, however, does not take into account flooding conditions, intermittent with drying periods, during which more nitrification-denitrification occurs, probably leading increased N_2O emissions.

$$N\text{-}N_2O\ kg.ha^{-1} = [0.0025 * Nf] + [0.26 * D/117] \qquad \text{(Equation 1)}$$

Where:

- Nf: Total number of units of chemical fertilizer applied per hectare during the growing season.
- 0,0025: Average emission factor linked to fertilization (0.25%)
- D: Effective duration of cultivation period
- 0.26 N $kg.ha^{-1}$: Average baseline $N\text{-}N_2O$ emission over the cultivation period
- 44/14: Conversion factor from $N\text{-}N_2O$ to N_2O

PARAMETERS FOR THE PLANT SECTOR: TROPICAL CROPS

Nitrogen leaching is considered nil for clementine, mango and cocoa, whose plantations are located in "dry" zones, in line with the latest IPCC recommendations (see Nitrates chapter). Consequently, there are no associated indirect N_2O emissions.

For coffee, which grows in wetter conditions, indirect N_2O emissions due to leaching are calculated on the basis of the leached fraction (see Nitrates chapter).

13. Sheet no. 13: Phytosanitary active substances

GENERAL INFORMATION

Table124: Models selected by emission item.

Transmitter station	Model selected
All crops	OLCA-Pest recommendations[17]
Rice Thailand	Expertise S. Perret (CIRAD)
Soilless crops	This report
Plastic-covered floor	This report

References:

Thomas Nemecek, Assumpció Antón, Claudine Basset-Mens, Céline Gentil-Sergent, Christel Renaud-Gentié, et al. Operationalising emission and toxicity modelling of pesticides in LCA: the OLCA-Pest project contribution. International Journal of Life Cycle Assessment, Springer Verlag, 2022,10.1007/s11367-022-02048-7. hal-03660081

PARAMETERS FOR THE PLANT SECTOR: ALL CROPS

- **Updating plant protection product emission inventories**

The AGRIBALYSE® team, with technical support from Ecoinvent®, has updated and improved the modeling of pesticides in life cycle inventories. Until now, a default fraction of 100% of soil emissions was defined in the database, regardless of pesticide type, application method or crop type. This mainly due to a lack of scientific knowledge and capacity for better emission modelling.

In 2020, the results of a vast research project called OLCA-Pest[18] were published. A consensus between the main European teams working on pesticides in LCA for a new modeling approach at LCI and environmental impact assessment level was published. Different levels of modelling accuracy and detail have been provided, depending on data availability and the aim and scope of the study.

An approach based on "archetypes" is proposed for "background processes" and for database inventories in particular. These archetypes and emission fractions are based on the consensus Pest-LCI model, available online at[19] . AGRIBALYSE® considers this approach to be a significant improvement, and has implemented the recommendations of the OLCA-Pest project with technical support from Ecoinvent®. We would like to thank the Ecoinvent® team for their technical support, and the OLCA-PEST research team for their work (T.Nemeck, P.Fantke, C.Gentil, C.Basset-Mens and C.Renaud in particular).

A summary of the implementation method is described here, and the emission models have been applied from version AGRIBALYSE® 3.1 onwards. For the full method and details, please refer to the original OLCA-Pest reports and classification files.

- **Step 1: Classification of crop protection products**

To implement the OLCA-Pest approach, we extracted the list of pesticides (active ingredients) from the AGRIBALYSE® database, then assigned each ingredient a pesticide category as defined by the OLCA-Pest consortium (see table below).

Classification of crop protection products:

[17] https://www.sustainability.man.dtu.dk/english/research/qsa/research/research-projects/olca-pest

[18] https://www.sustainability.man.dtu.dk/english/research/qsa/research/research-projects/olca-pest
[19] https://pestlciweb.man.dtu.dk/documentation/PestLCI_Consensus_documentation.pdf

Pest-Class	Pesticide category
Hrb-pre	Herbicide, pre-emergence (applied on bare soil)
Hrb-post	Herbicide, post-emergence
Ins	Insecticide
Fun	Fungicide
PGR	Plant growth regulator
Ac/Mi	Acarcide or miticide
Nema	Nematicides (granulate)

Pesticide names are not harmonized, either in inventory databases, agricultural databases or other official chemical databases. Their classification as herbicide, fungicide, insecticide, etc. is not fully harmonized, and certain types of multiple application occur. Synonyms have been identified.

Thus, a classification has been assigned, in order of priority, on the basis of:

- Nomenclature in the Pesticide Properties Database (PPDB), the world's largest open-source database.
- Name in EU pesticide database
- CAS number: not always indicated in ICM databases.
- by manual search and online synonym search.

For active substances with "multiple applications", e.g. insecticides and acaricides, pre- and post-emergence herbicides, the specific use is impossible to identify at inventory level. Default choices have therefore been applied.

- **Step 2: Crop classification**

All agricultural inventories representing plant crops were extracted and classified according to PestLCI crop classes (see table below):

PestLCI Consensus archetype crop class	Examples
Pooideae	wheat, barley, oat, rye, upland rice, grass
Panicoideae	maize, sorghum
Paddy rice	paddy rice
Pulses	beans, lentils, peas, vetch, lupin, chickpea, cowpea
Roots, tubers and bulbs	potato (all varieties), yam, cassava, taro, onion
Oil-bearing crops	sunflower, rapeseed, sesame, soy bean, peanut
Vegetables leafy	cabbage, lettuce, onion, cauliflower, broccoli
Vegetables fruit	tomato, zucchini, passion fruit, lulo, maracuya
Fruit trees tropical	avocado, mango, guava, cherimoya

Fruit trees temperate	apple, pear, apricot, peach, cherry, nectarine
Citrus fruits	orange, lemon, lime, grapefruit
Grapes/vines	Grape
Berries	strawberry, cape gooseberry
Nuts	almond, chestnut, hazelnut, pistachio
Oil-bearing trees	oil palm, coconut, banana, plantain
Other permanent crops	coffee, cocoa, tea, cotton

Where direct classification was not obvious, attribution was based on:

1) archetype with a similar morphological appearance. The height and general shape or phenotype of the crop determine the typical application technique and drift function.
2) archetype with a similar cultivation system: e.g. twig cultivation, etc.
3) Annual/permanent crops and growth cycle: this mainly determines the bare soil between plants.

The most relevant factors influencing emission fractions are (for initial distribution):

- Soil cover at the time of pesticide application and therefore the proportion of pesticide reaching the soil and the crop, respectively.
- The application technique, which determines emission fractions in the air and on out-of-field surfaces.
- Drift reduction technology, which reduces emissions to off-field surfaces.
- Purely botanical criteria, on the other hand, are less important, unless they directly influence the above criteria.

- **Step 3: Emission fractions**

We have considered a "With bFUfer zone" scenario by default, in line with European regulations. However, this does not greatly affect the results.

Pest-LCI recommends modeling a fraction of pesticides in a new "crop compartment". This is highly relevant for modeling human exposure by ingestion, and human toxicity indicators. However, LCA software and databases are not yet designed to accept this "crop compartment". This is why we have modeled this fraction in a separate soil emission, mentioning in the metadata that it corresponds to the "crop compartment": "This fraction corresponds to the emission to the 'crop compartment'". When LCA formats evolve, we'll be able to redefine these emissions to a "crop compartment" in a simple way.

We believe that agricultural soils should be protected, and that farming practices should aim to reduce their impact on soil biodiversity. We therefore consider soil to be part of the ecosphere, and account for "pesticide emissions into the soil".

Extract from Appendix B of OLCA-PESTD4.5. Example for "Berries

Crop	Pest-class	air, low pop. density	soil, agricultural	soil, natural/forest	water, surface/river	Crop	Total
Berries	Hrb-post	10%	59%	0%	0%	31%	100%
Berries	Ins	10%	41%	0%	0%	48%	100%
Berries	Fun	10%	23%	0%	0%	66%	100%
Berries	PGR	10%	32%	0%	0%	57%	100%

Berries	Ac/Mi	10%	50%	0%	0%	39%	100%
Berries	Hrb-pre	10%	86%	0%	0%	4%	100%

- **Outlook**

We took a pragmatic approach to implementing the new large-scale modeling. Several improvements have been identified and could be implemented in the future.

- Pesticide names could be harmonized between and within databases to avoid synonyms. Substance naming remains a challenge. The CAS number could be used as a default identifier and should be provided for all substances.
- Metabolites are not modeled.
- A "culture compartment" should be created in LCA formats and software.
- It is very difficult to define a relevant emission fraction for "generic substances", so we should aim for a systematic definition of active molecules in all agricultural LCIs.

Parameters for the plant sector: Soilless crops and special practices

In the absence of precise information on the distribution and fate of active ingredients in systems where soils are protected (e.g. plastic-covered soils, greenhouses or tunnels) and for soilless crops, it has been assumed that 100% of flows end up in the soil.

Plant sector settings: Rice Thailand

It has been assumed that 100% plant protection products end up in the soil and water compartments, as they not supposed to concentrate in rice grains or remain in the plots after harvesting. In production areas, most of the pesticides used are in fact insecticides, which are applied by hand to the crop at various stages when the field is flooded most of the time. In these circumstances, it is arbitrarily decided to split emissions equally between soil and water (50% - 50%).

TheTable125 summarizes the different approaches adopted:

Table125: Breakdown of phytosanitary active substance emissions into the ecological compartments of air, water and agricultural soil.

Compartment			
Crops / cultivation practices	Air	Water	Agricultural soil
All crops (except excceptions below)			100%
Above ground			100%
Rice	50%	50%	
Plastic-covered floor			100%

14. Sheet no. 14: Fish farming emissions

General information

Table126: Models selected by emission item.

Transmitter station	Model selected
Nitrogen	Papatryphon *et al,* 2005
Phosphorus	Papatryphon *et al,* 2005
Suspended solids (SS)	Papatryphon *et al,* 2005

Fish farming emissions of N, P and TSS are dealt with separately here. This choice is justified by the fact that the emission mechanisms involved are very different from those of other animal productions.

General principle of the model:

The principle of the model adopted is that of an input/output balance requiring knowledge of the composition of the feed rations distributed to the animals, the composition of the animals, and the quantity of undigested nutrients.

References:

Papatryphon E., Petit J., van der Werf HMG., Kaushik S. and Kanyarushoki C., 2005. Nutrient-balance modeling as a tool for environmental management in aquaculture: The case of trout farming in France. Environmental Management 35 (2), 161-174.

Parameterization: nitrogen losses

Equation (1) below was considered:

$$N_{total\ rejected} = N_s + N_i \qquad \text{Eq (1)}$$

- $N_f = [(A_d - (A_d \times \%\ A_{(nc)})) \times (\%\ proteins / 6.25)] \times (100 - CUD)\ \%$
- $N_{nc} = A_d \times \%\ A_{nc} \times (\%\ proteins / 6.25)$
- $N_s = N_f + N_{nc}$
- $N_g = (A_d \times T_N) / IC$
- $N_i = N_c - N_f - N_g$
- $N\text{-}NH_4 = N_i \times 0.8$
- $NH_4 = N\text{-}NH_4 \times 1.26$
- $N_{dissolved} = N_i - N\text{-}NH_4$

With:

A_d: food distributed

% Anc: percentage of uneaten food, estimated at 5%.

% protein: percentage of crude protein in feed

CUD: Coefficient of Digestive Utilization, estimated at 90% (±5%)

N_c: nitrogen consumed

N_d: digested nitrogen

N_f: fecal nitrogen

N_i: dissolved nitrogen

T_N: nitrogen content of fish = 0.0256 to 0.0272 gN/g body mass

N_g: nitrogen content in body weight gain

$N\text{-}NH_4$: ammonia nitrogen

CI: consumer index

Parameterization: phosphorus losses

Equation (2) below was considered:

$$P_{total\ rejected} = P_s + P_i \qquad \text{Eq (2)}$$

- $P_f = [(A_d - (A_d \times \% A_{(nc)})) \times (\% P)] \times (100 - CUD) \%$
- $N_{nc} = A_d \times \% A_{nc} \times 90 \% \times (\% P / 90 \%)$
- $P_s = P_f + P_{nc}$
- $P_g = (A_d \times 0.0045) / IC$
- $P_i = P_c - P_f - P_g$

With:

A_d: food distributed

% Anc: percentage of uneaten food, estimated at 5%.

% P: percentage of phosphorus in feed

CUD: Coefficient of Digestive Utilization, estimated at 50% (±10%)

P_c: phosphorus consumed

P_d: digested phosphorus

P_f: fecal phosphorus

P_i: dissolved phosphorus

P_g: phosphorus content in body mass gain, based on P content of fish body (0.40 to 0.45 gP/100 g body mass)

CI: consumer index

Settings: MES

Equation (3) below was considered:

$$TSS_{total\ discharges} = TSS_f + TSS_{nc} \qquad \text{Eq (3)}$$

- $MES_f = \{[(A_d - (A_d \times \%A_{nc})] \times \sum [\% \text{ nutrient} \times (100 - CUD) \%]\}$
- $\sum [\% \text{ nutrient} \times (100 - CUD) \%] = (\% \text{ protein} \times (100 - CUD) \%) + (\% \text{ fat} \times (100 - CUD) \%) + (\% \text{ carbohydrate} \times (100 - CUD) \%) + (\% \text{ fiber} \times (100 - CUD) \%) + (\% \text{ ash} \times (100 - CUD) \%)$
- $TSS_{(nc)} = (A_d \times \%A_{(nc)}) \times \% \text{ dry matter})$

With:

A_d: food distributed

% Anc: percentage of uneaten food, estimated at 5%.

% protein: percentage of protein in the feed

% lipids: percentage of lipids in the food

% carbohydrates: percentage of carbohydrates in the food

% fiber: percentage of fiber in the food

% ash: percentage of ash in the feed

CUD: Coefficient of Digestive Utilization, estimated at 50% (±10%)

% dry matter: percentage of dry matter in feed

15. Sheet n°15: Extrapolation of LCI for seeds and seedlings

GENERAL INFORMATION

Seed LCIs were defined on the basis of exptrapolation from the main crop, with adjustment using GESTIM values (Gac et al, 2010). For seeds not documented in GESTIM, the Ecoinvent inventory was reused as is. Extrapolation was carried out as follows:

- by recalculating the quantity of seed produced on leaving the production site (taking losses into account)
- using GES'TIM references for yield, fuel consumption, irrigation and seed fertilization
- By adjusting machine operating time and the use of plant protection products based on the crop/seed energy ratio
- by adding the transport and energy requirements for seed manufacture indicated in GESTIM. Since some of the losses are recovered, these additional inputs have been allocated on a mass basis.

SETTIN

Calculating the quantity produced:

The quantity of seed produced is calculated according to the following formula:

$$Q_{SP} = (R_{SC} * (1 - t_R)) * (1 - t_P)$$

With:

- Q_{SP} = Quantity of seed produced, leaving the production site
- R_{SC} = Gross seed yield, field output
- t_R = Refusal rate
- t_P = Loss rate at production site

Data for these parameters were taken from GESTIM (**Table127**

Table127: Yields and loss/rejection rates according to GESTIM (Gac et al, 2010).

Culture	Yield R_{SC} (kg/ha)	Refusal rate t_R (%)	Valuation t_{VR} (%)	Loss rate t_P (%)	Recovery t_{VP} (%)
Sugar beet	2038	0,54	0	87	0
Durum wheat	3514	1,91	100	15	80
Soft wheat	4360	2,54	95	15	80
Rapeseed	1546	4,00	0	16	80
Alfalfa	2955	2,02	0	10	80
Corn	2790	0,59	0	12	80
Barley	4400	2,05	0	15	80
Protein peas	2955	0,33	0	10	80
Potatoes	24840	3,51	0	13	100
Potato starch	24840	3,51	0	13	100

Rye	4400	1,06	0	15	80
Grain sorghum	2170	3,27	0	12	80
Sunflower	937	1,70	0	10	80
Triticale	3509	2,47	0	15	80
Other (average)		3	0	15	0

If the extrapolation of the seed LCI was applied for a crop not listed in GESTIM (e.g. carrot), the field output was estimated by expert opinion. For loss and refusal rates, average values have been used (**Table127** , line "other").

__Calculation of the extrapolation factor to extrapolate the seed LCI from the LCI of the crop in question__:

Table128 shows the electricity and fuel consumption considered for field seed production.

Table128: Electricity and fuel consumption for seed production according to GESTIM (Gac et al, 2010).

Culture	Electricity	Fuel
	kwh/ha	l/ha
Sugar beet	1500	204
Durum wheat	9	99
Soft wheat	52	92
Rapeseed	0	90
Corn	1545	159
Barley	16	103
Protein peas	48	102
Potatoes	50	267
Potato starch	53	267
Rye		86
Sunflower	500	84
Triticale	14	89
Other	344,2	136,8

If extrapolation of the seed LCI was applied for a crop not listed in GESTIM (e.g. carrot), average consumptions were used (**Table128** , line "other").

The extrapolation factor was calculated using the following formula:

$$f_{Ex} = \max(\frac{C_{ElG}}{C_{ElA}}, \frac{C_{CaG}}{C_{CaA}}, 1) * \frac{R_{Sem}}{R_{Cult}}$$

With:

- f_{Ex} = extrapolation factor
- C_{ElG} = electricity consumption according to GESTIM
- C_{ElA} = electricity consumption according to AGRIBALYSE®.
- C_{CaG} = fuel consumption according to GESTIM
- C_{CaA} = fuel consumption according to AGRIBALYSE®.
- R_{Sem} = seed yield (kg/ha)
- R_{Cult} = crop yield (kg/ha)

Then, each input used to produce the AGRIBALYSE® crop was multiplied by this factor.

Addition of seed manufacturing processes:

Table129 summarizes the inputs required for seed production.

Table129: Distances, means of transport and energy consumption for seed production.

	Distances and means of transport (km)			Energy consumption	
Culture	Champ➔ station		Station➔ farm	Electricity	Natural gas
	Agricultural bucket	Truck	Truck	kWh/t	MJ/t
Sugar beet		1000	800		
Durum wheat	15		230	20	
Soft wheat	15		230	20	
Rapeseed	15		230	20	
Alfalfa	15		230	20	
Corn	15		230	40	681,12
Barley	15		230	20	
Protein peas	15		230	20	
Potatoes		15	305	37	
Potato starch		15	305	20	
Rye	15		230	20	
Grain sorghum	15		230	20	
Sunflower	15		230	20	
Triticale	15		230	20	
Other		15	305	20	

These inputs were multiplied with the quantity of certified seed (R_{SC} * (1 - t_R)), then an allocation to the quantity of seed produced (Q_{SP}) and to recovered losses was made using a mass allocation factor (f_{AIP}), calculated according to the following formula:

$$f_{AIP} = ((t_R * t_{VR}) + ((1 - t_R)* t_P * t_{VP})$$

$$f_{AIS} = 1 - f_{AIP}$$

- f_{AIP} = allocation factor for valued losses
- f_{AIS} = seed allocation factor
- t_{VR} = Refuse recovery rate
- t_{VP} = Loss recovery rate in the manufacturing plant

Finally, the quantities of energy consumed (fuel and electricity) have been adjusted by calculating the difference between "GESTIM seed energy" minus "AGRIBALYSE® crop energy" so that they are identical to those shown in**Table128**

Table130: Overview of LCI seeds used for purchased seeds.

Name of LCI seed	Type	Used for
Carrot seed, conventional, at farm gate	extrapolation	all conventional carrots
Carrot seed, organic, at farm gate	extrapolation	organic carrot
clover seed ip, at regional storehouse	LCI Ecoinvent®	alfalfa
Durum wheat seed, conventional, national average, at farm gate	extrapolation	durum wheat
Grain maize seed, conventional, national average, at farm gate	extrapolation	grain corn and forage corn
Grass seed IP, at regional storehouse	LCI Ecoinvent®	grasses, meadows, grass cover in vineyards, paturin grains
Rapeseed, seed, conventional, at farm gate	extrapolation	rapeseed
Soft wheat seed, conventional, breadmaking quality, 15% moisture, at farm gate	extrapolation	all conventional soft wheat
Spring barley seed, conventional, malting quality, national average, at farm gate	extrapolation	all barley (feed and malting)
Spring pea seed, conventional, at farm gate	extrapolation	spring peas
Starch potato seed, conventional, national average, at farm gate	extrapolation	potato starch
Sugar beet seed, conventional, at farm gate	extrapolation	beet root
Sunflower, seed, conventional, 9% moisture, national average, at farm gate	extrapolation	sunflower
Triticale seed, conventional, national average, at farm gate	extrapolation	conventional triticale
Ware potato seed, conventional, at farm gate	Extrapolation	potatoes for the fresh market
Winter pea seed, conventional, 15% moisture, at farm gate	Extrapolation	winter peas

16. Sheet n°16: Allocation of basic manure and organic fertilizers in crop succession

GENERAL INFORMATION

As described in chapter B.4.3, basal fertilization (P and K) and organic fertilization (nitrogen) are allocated at crop succession level. In the AGRIBALYSE® program, this allocation has been implemented by means of "corrective flows", which means that the inventories / LCIs include:

a) flows actually applied and entered in the data entry tool

b) correction of input flows (difference between actual and reallocated flows)

c) emission flows linked to flows actually applied

d) as well as the correction of emissions linked to the correction of input flows (N_2O, NH_3, NO, phosphorus and ETM emissions).

This approach makes it possible to clearly show the effect of allocation. In addition, it is required because the models used to calculate direct emissions require more detailed information (see explanations below).

SETTIN

Table131 shows the quantities of bottom-dressing manure and organic matter applied to crops after allocation of shared inputs at crop-succession level. These values were calculated using the method described in chapter B.3.3.

Table131: Quantities of basal fertilizer and organic nitrogen after allocation of shared inputs at crop succession level (Source: Arvalis).

Culture	Allocated quantity				
	K mineral	K	P mineral	P total	N_{org}
	(kg K_2O/ha)	(kg K_2O/ha)	(kg P_2O_5/ha)	(kg P_2O_5/ha)	(kg N/ha)
Sugar beet	126	193	29	40	44
Durum wheat	18	22	36	40	4
Soft wheat	33	58	39	58	18
Organic soft wheat after faba bean	0	0	0	15	56
Organic soft wheat after alfalfa	0	0	0	20	6
Rapeseed	25	41	34	44	17
Faba bean	25	61	46	66	8
Organic faba bean	0	0	0	30	6
Forage corn	65	258	33	79	114
Grain corn	55	96	52	78	37
Brewing barley	34	59	38	52	15

Feed barley	34	59	38	52	15
Pdt starch	161	259	25	37	43
Peas	41	63	26	33	9
Potato	161	259	25	37	43
Sunflower	23	34	25	32	11
Triticale	35	86	26	48	28
Organic triticale	0	0		45	44

Calculation of input flow correction

Four input streams need to be corrected, according to the following formula:

$$\Delta FC_{eng} = FO_{eng} - FR_{eng}$$

With:

- ΔFC_{eng} = Correction flow for fertilizer (see below)
- FO_{eng} = Moose flow of fertilizer eng (entered in the input interface)
- FR_{eng} = Allocated flux of fertilizer eng (according to**Table131**
- eng = mineral K, mineral P, organic P and organic N

With the help of**Table131** , the quantity of "organic P" fertilizers can be calculated as the difference between total P and mineral P; the quantities of organic and mineral K_2O fertilizers can also be calculated.

As we do not know in what form the mineral fertilizers were applied, the correction flows for mineral K and mineral P were included in the inventories as average fertilizers ("average mineral fertilizer, as K_2O, at regional storehouse/kg/FR" and "average mineral fertilizer, as P_2O_5, at regional storehouse/kg/FR").

Calculation of emission flow correction

Correcting the four input streams leads to changes (positive or negative) in the following emissions:

a) Bottom dressing (P/K)
➔ Phosphate emissions leached and run-off (bottom dressing)

b) Organic matter
➔ Ammonia emissions (NH_3)
➔ Nitrogen monoxide (NO) emissions
➔ Nitrous oxide (N_2O) emissions

c) Bottom dressing (P/K) and organic matter

➔ ETM emissions

The impact on nitrate leaching has not been taken into account. The correction of emission flows has been calculated on the basis of the specificities of the direct emission calculation models concerned.

a) Effects on phosphorus emissions

To estimate the impact of allocation on phosphorus emissions, we need to know the quantities of phosphorus supplied in: i) organic-liquid, ii) organic-solid and iii) mineral form. The quantity of organic phosphorus allocated according to**Table115** must be divided between the two forms (solid and liquid) according to the organic fertilizers actually applied. Where no organic fertilizer has been applied to the crop, the split between solid and liquid has been made on the basis of the composition of the average French organic fertilizer for phosphorus input (**Data on** the composition of trace metal elements taken from organic fertilizers in versions prior to Agribalyse 3.2 were deemed obsolete. Indeed, after analysis, several trace metal emission values came to our attention, in particular TMEs, which are independent of the trace elements required for animal feed. After comparing these values with several sources, it became clear that the concentrations of trace metal elements present in organic fertilizers in AGRIBALYSE® versions 3.1 and earlier needed updating. Following this observation, bibliographic work was carried out to identify robust, recent sources covering as many types of organic fertilizers as possible (in order to maintain homogeneity in the analysis and processing of the data collected). The TRACTION project led by IFIP, IDELE and ITAVI and financed by ADEME was selected. In this project, 47 categories of livestock effluent from various animal productions (ruminants, poultry, pigs, rabbits and fish) were subjected to an initial quantification of the levels and flows of 10 trace elements. As described in the TRACTION project report (Levasseur et al. 2021), 16 pig effluents were collected and analyzed. For the poultry, rabbit and fish sectors, 16 samples were also collected and analyzed. Fifteen types of manure were studied for the ruminant sectors, covering the majority of products from cattle (milk and meat), goat and sheep farms, from very compact manure with accumulated litter to slurry.

As part of the TRACTION project, the consistency of the analysis results was also verified by comparison with data from the early 2000s. However, the authors point out that the results need to be consolidated by further analysis campaigns. Future work will need to extend the number of samples and matrices that could not be included.

ETM concentration values have therefore been updated on the basis of the TRACTION study. The table below details the methodological choices made for each of the organic fertilizers in Means-InOut.

Libelle FR	Comments on the choice of input data
Pig slurry, mixed	The name in Means I-O is "Pig manure, mixed sows, piglets and pigs", but the TRACTION project proposes several types of pig manure, but not mixed as described above: Table 3, TRACTION project "The "breeder-fertilizer" category is the most frequently encountered in pig farming. These are the breeding herd and its offspring: piglets in post-weaning and pigs for pork. Farrow-to-finish farms can be partial (fattening a greater or lesser proportion of pigs on site). Post-weaner-finishers include - as the name suggests - only post-weaning piglets and pork butcher pigs, but not sows. This type of farming is less common than farrow-to-finish farming. The values taken for "Pig slurry, mixed sows, piglets and pigs" correspond to the average of the 5 categories of pig manure (lines 10 to 15 of appendix 3, TRACTION project).
Biological sludge from aerobic treatment	The name in Means I-O is "Biological sludge, from aerobic treatment (nitrification/denitrification)". As the animal source is not specified, the values adopted correspond to the "Biological sludge pig" present in the TRACTION project (line 27, appendix 3).
Hog manure solid fraction compost	The name in Means I-O "Compost de fraction solide de lisier de porc" has been considered as corresponding to the composted V-scraping refusal present in the TRACTION project entitled "Raclage composté porc charcutier" (line 22 of appendix 3) as well as to the "Refus composté de DC (non normé) porc" line 26 appendix 3. The values taken for "Compost of solid fraction of pig manure" correspond to the average of the 2 categories of pig fertilizers (line 22 and 26 of appendix 3, TRACTION project).
Straw-based pig manure compost	The name in Means I-O is "Straw-based pig manure compost". The values used correspond to "Accumulated composted fattening manure" in the TRACTION project (line 18, appendix 3).
Laying hen manure	No laying hen manure was analyzed in the TRACTION project. An average of "Standard broiler manure" (line 29, appendix 3) and "Future breeder manure" (line 35, appendix 3) was used as a proxy, pending more specific data on laying hens.
Rabbit slurry (scraping system)	The name in Means I-O is "Rabbit slurry (scraping system)". The values selected correspond to "Rabbit manure under cage" in the TRACTION project (line 43, appendix 3).
Poultry manure	No poultry manure was analyzed in the TRACTION project. The values for "Duck for roasting on slatted floors" present in the TRACTION project, which is a duck slurry (line 32, appendix 3), have been retained as a proxy pending more specific data on poultry slurry.

Duck slurry (for roasting or force-feeding)	The name in Means I-O is "Duck slurry". The values used correspond to "Duck for roasting on slatted floors", a slurry used in the TRACTION project (line 32, appendix 3).
Dried laying hen droppings	The values taken into account for "Dried droppings from laying hens" are based on "Dried droppings from laying hens in cages" line 36 appendix 3, TRACTION project.
Poultry manure compost	The name in Means I-O is "Poultry manure compost". The values used correspond to "Compost from standard broiler manure" in the TRACTION project (line 30, appendix 3).
Manure from ducks ready to force-feed	The name in Means I-O is "Manure from ducks ready to force-feed". The values used correspond to "Fattened ducks fattened on litter", which is a manure used in the TRACTION project (line 39, appendix 3).
Cattle slurry digestate	no digestates in TRACTION. The "Average bovine manure" values (average of "Dairy cow manure" (line 7, appendix 3), "Suckler cow manure" (line 8, appendix 3) presented in the TRACTION project) have been used as a proxy pending more specific digestate data, on the assumption that methanization does not modify TME concentrations "Methanization does not create TMEs, the TMEs present in the substrates are found in the digestate". FNE; 2021; METHANISATION: ANALYSE DE CONTROVERSES".
Hog manure compost on straw	The name in Means I-O is "Compost from pig slurry on straw". The values used correspond to "Raclage composté porc charcutier", which is a composted scrape from different farms at very different stages of composting in the TRACTION project (line 22, appendix 3).
Liquid digestate fraction from a slurry mix	no digestates in TRACTION: see analyses and assumptions in Tab1
Poultry manure (medium)	The values used for "average French poultry manure" are those of the average of "Standard broiler manure" (line 29, appendix 3, TRACTION project), "Future breeder manure" (line 35, appendix 3, TRACTION project) and "Standard turkey manure" (line 31, appendix 3, TRACTION project), since in France it is mainly broiler poultry that is reared, and therefore the source of farm effluent.
Broiler manure	The values used for "Broiler manure" are those of "Standard broiler manure" (line 29, appendix 3, TRACTION project).
Manure and slurry digestate	no digestates in TRACTION: the quantity of heavy metals (ETM) contained in inputs per mg/kg dry matter is not affected by their passage through the anaerobic digester. The data source here is an average of "manures and slurries" (preservation of ETM concentration values per kg dry matter) with adaptation of the % DM (preservation of the original value). The average of all manures and slurries from the TRACTION project was taken as the source (see Tab. 2).
Straw cattle manure compost	no cattle manure compost in TRACTION: calculation assumption based on factors linked to the transformation of pig manure into composted pig manure: see Tab3 assumption for cattle manure compost.
Medium cattle slurry	The values retained for "Average bovine manure" are those of the average of "Dairy cow manure" (line 7, appendix 3) and "Suckler cow manure" (line 8, appendix 3). In the TRACTION project, the values for veal calf manure were excluded because of their extreme values.
Veal manure	The values retained for "veal calf manure" are those of "veal calf manure" (line 9, appendix 3) present in the TRACTION project.

Feather and blood flour	no feather and blood meal in TRACTION: a literature review was carried out and the values retained are based on the studies Möller and Schultheiß, 2014 and Improve-P, Assessment of Alternative Phosphorus Fertilizers for Organic Farming: Meat and Bone Meal, 2015 (Cf Tab 4). For "feather and blood meal", the proxy "feather meal" has been retained.
Straw-based pig manure	The values used for "Straw-based pig manure" are the average of "Accumulated post-weaning manure" (line 16, appendix 3), "Accumulated fattening manure" (line 17, appendix 3), "Accumulated pregnant sow manure" (line 19, appendix 3), and "Scraped pregnant sow manure" (line 20, appendix 3).
Feather meal	no feather and blood meal in TRACTION: a literature review was carried out and the values retained are based on the studies Möller and Schultheiß, 2014 and Improve-P, Assessment of Alternative Phosphorus Fertilizers for Organic Farming: Meat and Bone Meal, 2015 (Cf Tab 4).
Meat flour	no feather and blood meal in TRACTION: a literature review was carried out and the values retained are based on the studies Möller and Schultheiß, 2014 and Improve-P, Assessment of Alternative Phosphorus Fertilizers for Organic Farming: Meat and Bone Meal, 2015 (Cf Tab 4).
Diluted cattle slurry	The values adopted for "Diluted bovine manure" correspond to the average of "Dairy cow manure" (line 7, appendix 3, TRACTION project) and "Suckler cow manure" (line 8, appendix 3, TRACTION project), which are diluted manures.
Cattle manure, accumulated litter	The values retained for "Cattle manure, accumulated litter" are those of "very compact manure, accumulated litter" (line 3, appendix 3, TRACTION project).
Cattle manure, cubicle slurry	The values used for "Cattle manure, soft cubicle" are those for "Soft manure - Cattle" (line 5, appendix 3, TRACTION project).
Medium cattle manure	The values retained for "Cattle manure (average France)" are those of "mixed manure - Cattle" (line 6, appendix 3, TRACTION project) which corresponds to "mixture of very compact and/or compact and/or soft manures" = an average manure reference. Table 29 TRACTION
Hog manure digestate	no digestates in TRACTION: the quantity of heavy metals (ETM) contained in the inputs per mg/kg dry matter is not affected by their passage through the anaerobic digester. The data source here is therefore "mixed pig manure" (ETM concentration values per kg dry matter retained) with adaptation of the % DM (original value retained).
Sheep manure	The values used for "Sheep manure" are those for "Sheep manure" (line 2, appendix 3, TRACTION project).
Sheep manure, accumulated litter	The values used for "Sheep manure" are those for "Sheep manure" (line 2, appendix 3, TRACTION project).
Undiluted cattle slurry	In the TRACTION project, there is no undiluted cattle slurry. The average of "slurry from dairy cows" (line 7 in appendix 3) and "slurry from suckler cows" (line 8 in appendix 3), which are diluted slurries, was used as a proxy for "undiluted cattle slurry", pending more specific data.

).

By distinguishing inputs in the three forms considered, the "F_{CLB}" and "$F_{(C)}$" factors (see phosphorus model, data sheet 11) were distinguished. The quantities of phosphorus leached and runoff after reallocation were then calculated. The final corrective flows added to the inventories result from the difference between the flows without allocation and the flows after allocation:

$$\Delta FCP_{R/L} = FOP_{R/L} - FRP_{R/L}$$

With:

- $\Delta FCP_{(R/L)}$ = Phosphorus correction flow runoff/leachate
- $FOP_{R/L}$ = Moose phosphorus runoff/leachate flux
- $FRP_{(R/L)}$ = Allocated phosphorus runoff/leachate flux

b) Effects on ammonia (NH_3) and nitric oxide (NO) emissions

To calculate NH_3 emissions, we need to know the type of manure applied (cattle slurry, pig manure, etc., see data sheets 1 and 10). To do this, an average organic manure has been calculated (**Table132**). The result is that each kilogram of organic nitrogen applied generates 147 g of N-NH_3 (= $NH_{3OrgMoy}$).

Table132: Composition of average French organic manure (Source: Arvalis, based on the SSP 2006 cropping practices survey) and calculation of average NH_3 emissions per kg of average organic manure.

Manure	Available as	In % (for N)	In % attributable	TAN	%EF NH_3	N-NH_3 (kg N/kg N)	In % (for P)	shape
Cattle manure	Medium cattle manure	64,47	68,84	0,19	0,79	1,05E-01	46	firm and solid
Dry droppings for laying hens	Dried laying hen droppings	4,16	4,45	0,10	0,69	3,22E-03	8	firm and solid
Broiler manure	Broiler manure	4,07	4,34	0,17	0,79	5,87E-03	12	firm and solid
Compost of animal origin	Straw cattle manure compost	3,34	3,57	0,05	0,71	1,27E-03	2	firm and solid
Vinasse	Concentrated beet vinasse	3,03	3,23	0,10	0,81	2,62E-03	0	various liquids
Sheep manure	Sheep manure	2,82	3,01	0,10	0,90	2,71E-03	2	firm and solid
Sludge from wastewater treatment plant	WWTP sludge	2,79	2,98	0,71	0,40	8,46E-03	5	various liquids
Plant-based compost	Urban plant compost	2,66	2,84	0,10	0,71	2,12E-03	1	solid compost
Other food industry sludge		2,55					3	
Pig slurry	Mixed pig slurry	2,34	2,50	0,71	0,40	7,15E-03	7	liquid farm
Cattle slurry	Undiluted cattle slurry	1,84	1,96	0,50	0,55	5,39E-03	2	liquid farm
Other industrial sludge		1,47					2	

Slurry from laying hens		1,27					3	
Other effluents		0,83					1	
Rabbit slurry	Rabbit manure	0,74	0,79	0,07	0,51	2,64E-04	2	liquid farm
Pig manure	Straw-based pig manure	0,70	0,75	0,32	0,81	1,93E-03	1	firm and solid
Duck manure	Manure from ducks ready to force-feed	0,29	0,31	0,30	0,71	6,71E-04	1	firm and solid
Compost household waste	Urban compost (household waste)	0,26	0,28	0,10	0,71	2,08E-04	0	solid compost
Pasty droppings for laying hens		0,18					1	
Sugar water	Sugar foam	0,10	0,11	0,10	0,81	8,92E-05	1	various liquids
Sheep slurry		0,06					0	
Calf slurry	Veal calf slurry	0,02	0,02	0,84	0,55	1,08E-04	0	liquid farm
Total		**100,0**				**0,147**	**100**	
Total attributable		**93,64**						

This average organic fertilizer can be used to directly calculate the NH_3 emission correction flow by multiplying this factor with the quantity of organic N reallocated:

$$\Delta NH_3 = NH_{3OrgMoy} * \Delta FC_{Norganic}$$

With:

- ΔNH_3 = NH_3 emission correction flux
- $\Delta FC_{Norganic}$ = Correction flow for organic N
- $NH_{3OrgMoy}$ = NH_3 emissions per kg average organic N

An identical approach was used for NO emissions; the average emission factor is equal to 0.026.

c) Effects on nitrous oxide (N_2O) emissions

The allocation of organic nitrogen also has consequences for direct and indirect nitrous oxide emissions:

The change in direct N2O emissions is calculated by applying the emission factor to the corrective flow of organic nitrogen.

The corrective flows for indirect N2O emissions due to the volatilization of NH3 and NO are calculated by applying the emission factors to the corrective flows of NH3 and NO

$$\Delta N_2O_{dir} = \Delta FC_{Norg} * FE1$$

$$\Delta N_2O_{indir} = (\Delta NH_3 + \Delta NO) * FE4$$

With:

- ΔN_2O_{dir} = corrective emission flow of direct N_2O
- $\Delta N2O_{indir}$ = corrective emission flow of indirect N_2O
- ΔFC_{Norg} = corrective organic nitrogen flow (input)
- ΔNH_3 = NH_3 corrective emission flux
- ΔNO = corrective emission flow of NO
- EF1 = emission factor 1 (for direct emissions, see N_2O model)
- EF4 = emission factor 4 (for indirect emissions, see N_2O model)

d) Effects on ETM emissions

The allocation of organic manure and organic nitrogen affects ETM flows at two levels:

- Increase (or decrease) of leached and runoff ETMs by modifying the outflow allocation factor ($Alloc_x$ see data sheet 4,**Figure15**
- Increase (or decrease) in soil ETM flows as a function of the amount of fertilizer reallocated

To calculate these effects, we first need to know the change in incoming ETM flows due to reallocated fertilizers:

$$\Delta IN_x = \Sigma \, \Delta FC_y * T_{y_x}$$

With:

- ΔIN_x = corrective ETM_x input flows (x) $=$ Cd, Cu, Zn, Pb, Ni, Cr, Hg
- T_{y_x} = ETM_x content (x= Cd, Cu, Zn, Pb, Ni, Cr, Hg) of the realigned fertilizer (y =ΔFC_{Norg},ΔFC_{PMin} andΔFC_{KMin})
- ΔFC_y = fertilizer flow y realigned (y =ΔFC_{Norg},ΔFC_{PMin} andΔFC_{KMin})

To calculate the ETM content of reallocated fertilizers, average fertilizers were used (for reallocated organic fertilizers, the amount of nitrogen was used). The outflow allocation factor can be calculated from the ETM flows due to reallocated fertilizers (ΔIN_x).

$$Alloc_x' = \frac{IN_x + \Delta IN_x}{(IN_x + \Delta IN_x) + Dep_x}$$

With:

- $Alloc_x'$ = outflow allocation factor for ETM_x after reallocation
- IN_x = initial ETM_x input flow
- ΔIN_x = corrective ETM_x input flow
- Dep_x = ETM_x deposition (atmospheric deposition)

These data can be used to calculate the effects on ETM emissions as follows:

$$\Delta LI_x = LI_x * (Alloc_x' - Alloc_x)$$

$$\Delta RU_x = RU_x * (Alloc_x' - Alloc_x)$$

$$\Delta SO_x = \Delta IN_x$$

With:

- ΔLI_x = corrective flux for leached ETM_x

- LI_x = Quantity of ETM_x leached before taking account of reallocated fertilizers
- $Alloc_x'$ = outflow allocation factor for ETM_x after allocation
- $Alloc_x$ = outflow allocation factor for ETM_x before taking into account allocated fertilizers
- ΔRU_x = corrective flux for ETM_x runoff/erosion
- RU_x = Quantity of ETM_x runoff/eroded before taking into account reallocated fertilizers
- ΔIN_x = corrective ETM_x input flow
- ΔSO_x = corrective flux ETM_x to soil

17. Sheet n°17: Weather data for calculating emissions Rice Thailand

Nitrate and phosphorus emission calculations for Thai rice require the implementation of a water balance. The meteorological data used to calculate water balances are presented in**Table133**

Table133: Effective rainfall and irrigation requirements in the rice cropping systems and production basins studied (wet and dry seed sowing) .

Growing system			Total precipitation			Actual evapotranspiration	Irrigation requirements
Region	**Season**	**Water regime**	**Period**	**Average total precipitation (mm)**	**Average effective precipitation (mm)**	**(mm)**	**(mm)**
North (Nam Mae Lao basin)	Wet	Pluvial	July - October	1126.9	620.47	480	-
	Wet	Irrigated					0.00
	Dryer	Irrigated	February - May	272.9	272.9	603.3	418.40
Northeast (Lam Sieo Yai basin)	Wet	Pluvial	July - October	707.7	628.5	646.07	-
	Wet	Irrigated					74.03
	Dryer	Irrigated	February - May	117.2	117.2	668.8	608.37

APPENDIX CC: CARBON STORAGE AND REMOVAL IN SOILS

- **Context**

Carbon storage consists in removing CO_2 from the atmosphere over a long period, thereby reducing the greenhouse effect (Pellerin et al. 2020). This is made possible by the growth of plants, which absorb CO_2 and can "store" part of it in the soil, depending on the type of farming practiced (agroforestry, increasing plant cover through crop associations, etc.), the choice of species grown in the rotation (intermediate crops, etc.) and their management. This subject is therefore linked to the impact on climate change. Indeed, the ecosystem service of carbon storage via the return of crop residues and roots offsets, at least in part, the greenhouse gas emissions linked to agricultural production and their impact on climate change. Storage can also become destocking, if the soil releases carbon. Until recently, the LCA methodological framework focused on negative impacts, without taking into account the positive externalities linked to the functioning of ecosystems in interaction with certain production systems.

Carbon storage varies according to land use (4 per 1000 study, INRAE). It is highest in forests or under grassland. It can be assessed using indicators based on models that calculate the quantity of carbon stored in the soil as a function of soil type, climatic context and cropping system. It can be reduced to a unit such as kg eq CO_2/kg product. INRAE's 4 for 1000 study quantified the carbon storage of certain levers (additional "stocking" practices): integration of temporary grassland into the rotation, intermediate cropping, etc. (Pellerin et al. 2020).

In AGRIBALYSE® 3.0, soil carbon dynamics associated with land use and land-use change (CAS[20]) were not taken into account. In the Organic LCA project, an estimate of direct SAC was made using the PAS 2050:2011 method (BSI 2011), in line with the recommendations of the Product Environmental Footprint. However, the calculated data were not implemented in the LCIs, as the results obtained were not relevant.

According to the IPCC (IPCC, 2019), carbon storage and removal are to be considered in the case of a change in land use (e.g. from grassland to arable land) and in the case of changes in practices (e.g. from unfertilized grassland to fertilized grassland).

Since AGRIBALYSE® 3.1, a temporary carbon patch has been applied to agricultural inventories in order to offer an initial approach to taking account of carbon storage/removal. This patch is applied to AGRIBALYSE® inventories only (excluding background data), pending the completion of more precise scientific modeling

- **Patch for trending carbon storage/removal**

INRAE's 4 for 1000 Study (Pellerin et al. 2020) provides a **basis for** a patch on: trend C storage through values from**Erreur ! Source du renvoi introuvable.**

Table134 - Extract from Abstract (Pellerin et al. 2020) table 3 (1st row values from meta-analysis, 2nd row simulation values)

[20] Direct CAS describes situations where the development of a crop changes the use of the land, which may previously have been occupied by forest or permanent grassland, for example. This results in a local change of land use category, with new environmental impacts. Indirect CAS (CASi) relates to a change in farming practices or in the purpose of production in an area already under cultivation (e.g. replacing a food crop with an energy crop), or to the disappearance of agricultural land which leads to a shift in food production to other land, indirectly inducing CAS in areas not previously under cultivation.

	Surfaces Mha	Stock agrégé France entière Horizon 0-30 cm MtC	Stockage ligne de base Valeur littérature Valeur simulations kgC/ha/an
Grandes cultures et prairies temporaires	18,4	950	-170 +47
Prairies permanentes	9,3	790	+110 +212
Vignes	0,8	27	0
Forêts	16,9	1370	+130 +420 (2)
Total (1)	**45,4**	**3137**	

The storage values in kgC/ha/year derived from the meta-analyses were used to construct the patch applied to the AGRIBALYSE® inventories.

A first step was to classify the inventories (illustrated onFigure19).

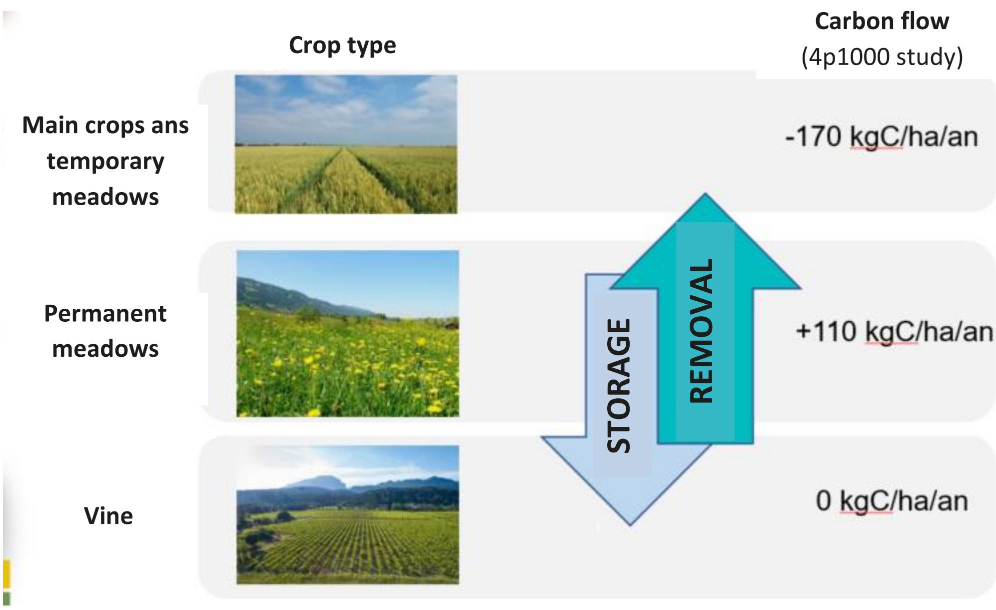

Figure19 Inventory classification and flow allocation

- **<u>CARBON PATCH FOR TREND STORAGE IN AGRIBALYSE® INVENTORIES</u>**

Based on this classification and the land use flows present in the AGRIBALYSE® inventories, a carbon patch was applied as follows:

- for arable crops and temporary meadows, a process called "Land use change, soil organic carbon changes for annual crops and temporary meadows {FR} U" is used.
- for permanent meadows, a process called "Land use change, soil organic carbon changes for permanent meadows{FR} U
- other vineyard and other inventories have been retained unchanged

In each of these processes, carbon storage and removal flows are called:

- If destocking: CO2 (carbon dioxide, land transformation) and N2O associated with SOC changes (IPCC)
- If storage: CO2 (Carbon dioxide to soil or biomass stock)

Thus, through AGRIBALYSE® inventories and patches applied in kg C/ha/year, carbon storage/removal can be taken into account in the assessment of climate change impact and reduced to a unit of the kg eq CO_2/kg product type.

- **Additional storage linked to agricultural practices**

The **additional storage** linked to an agricultural practice B is the difference between the carbon stock in a soil under practice B and that of the same soil under a reference practice A, starting from an initial state. Additional storage is therefore defined for 2 practices, a given site, and a time elapsed since the practices were differentiated.

Two hypotheses are worth recalling (from Pellerin et al. 2020):

- Hypothesis 1: consideration linked to the implementation of a practice
- Hypothesis 2: Inventory concerns a crop where carbon storage is in progress

These two hypotheses make the construction of the additional storage patch linked to agricultural practices complex, notably due to the application of this patch to already collected inventory data (frozen input data) and the temporality of these inventories (mainly concerning the period 2005-2009). Indeed, in order to validate the two previous hypotheses, it was necessary to identify whether the practice was newly implemented and whether the inventory fell within the 20-year time limit (from the start of the implementation of the practice).

The**Erreur ! Source du renvoi introuvable.** below summarizes the applicability of the additional storage patch linked to agricultural practices according to:

Table135 Summary of the applicability of the additional storage patch linked to agricultural practices, by practice:

Stocking practice	Status for integration into AGB 3.1
Inserting and extending intermediate crops	Integrated into AGB 3.1
Extending and inserting temporary meadows in crop rotations	Not integrated It is difficult to identify what proportion of systems have extended temporary grassland over this timeframe.
Mobilizing new organic resources	Not included AGRIBALYSE® inventories only slightly affected (2005-2009 timeframe): to be updated in future inventories
Substitute grazing for mowing	Not integrated Lack of historical data to justify a reference state different from practical application
Moderate increase in mineral nitrogen fertilization of permanent grassland	Not integrated Lack of data on the history and precise evolution of fertilization by plot (only IFT available).
Developing agroforestry in cultivated plots	Not integrated AGRIBALYSE® inventories not very concerned
Plant hedges around the edges of cultivated plots	Not integrated Lack of data in AGRIBALYSE® inventories (fixed input data)
Grassing vineyards	Not integrated Lack of data in inventories

- **CARBON PATCH FOR ADDITIONAL STORAGE IN AGRIBALYSE® INVENTORIES**

For field crops, the patch was applied with the value taken from Pellerin et al. 2020 (+ 127 kgC/ha/year for storage related to the practice "Insertion and lengthening of intermediate crops", Summary (Pellerin et al. 2020) table 2). A process called "Additionnal storage of soil organic carbon due to farming practice, Insertion and lengthening of intermediate crops {FR} U" has been added to the field crop inventories and is called the "Carbon dioxide to soil or biomass stock" flow.
Thus, through AGRIBALYSE® inventories and patches applied in kg C/ha/year, carbon storage/removal can be taken into account in the assessment of climate change impact and reduced to a unit of the kg eq CO_2/kg product type.

- **Limits and prospects for carbon patches**

This interim approach is not completely satisfactory, but is a first step towards taking account of soil carbon storage/removal. The integration of new, more recent inventories with more input data, as well as work on the methodology, are the prospects for this major project. Previously, work had already been carried out on carbon accounting. In the Organic LCA project (Nitschelm et al. 2020), the PAS 2050 method was applied. This method estimates direct CAS, and then attributes it to crops whose area has increased during the period under consideration. This approach proved irrelevant in the case of France. For example, over the past few decades, some grassland has been replaced by silage maize, but the area under silage maize has not increased. So the PAS 2050 method does not identify silage maize as the "culprit", but rather other annual crops whose surface area has increased, without these having developed on areas previously under grassland.

Another element to consider is the challenge of availability of input data to feed the models. To illustrate, additional storage due to the adoption of a practice depends on the environment (notably local climate, clay content and soil characteristics) and other co-variables that need to be taken into account in projections.

Over and above the choice of model, the SOCLE project report highlights the scientific limitations and hurdles to be overcome in order to assess the effect of Land Use Change in LCA (Bessou et al., 2018):

  - Effective determination of changes in land use;
  - The existence and availability of data, both to characterize carbon stocks and to represent the dynamics of changes in these stocks;
  - The notion of reference, which is a key choice for taking occupancy impacts into account and refers to value choices ;
  - The allocation, or temporal distribution, of the impacts of changes in use.

GIS REVALIM, through the co-supervision of a mission by ARVALIS and INRAE, wishes to

  - propose a methodological framework for taking soil C into account through the agricultural production inventories present in AGRIBALYSE® in order to provide a transparent, robust, sustainable and reproducible methodology, and
  - update AGRIBALYSE® life-cycle inventories by integrating soil C dynamics. This methodological framework will be applied to all agricultural inventories by 2024.

- **Glossary**

Carbon stock

Carbon stock is the total quantity of carbon contained in a given soil layer, per unit area. It is expressed in kg/m2 (kg C/ m2) or t/ha (t C/ha). It is generally calculated by multiplying the mass concentration by the mass of fine soil contained in the layer. The latter is the product of the layer's thickness, the mass proportion of fine soil [fine soil / (fine soil + coarse elements)] and soil's bulk density. Many C stock inventories refer to the 0-30 cm, or 0-100 cm layer (Hiederer and Köchy, 2011).

Carbon storage

Storage is the increase in carbon stock over time. Removal (or negative storage) is a decrease.

Additional storage linked to a practice

The additional storage linked to agricultural practice B is the difference between the carbon stock in a soil under practice B and that of the same soil under a reference practice, starting from a common initial state. Additional storage is defined for two practices at a given site, and depends on the time elapsed since the practices were differentiated.

- **Bibliographic resources consulted**

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Note from the scientific council for environmental labelling Experimentation affichage environnemental sur le secteur alimentaire, Groupe indicateurs - note n°5 , various subjects complementary to LCA_avril 2021

APPENDIX DD: ALLOCATION OF INPUTS TO ECOINVENT LCIS®

When describing technical itineraries, all the inputs used are entered. The correspondence between the names of the inputs used and the LCIs is managed within the MEANS-InOut software (Auberger et al., 2018; Auberger et al., 2024).

This correspondence between input and LCI is available here: https://doi.org/10.57745/VHTM7A

References:

- Auberger J, Malnoë C, Biard Y, Colomb V, Grassely D, Martin E, van der Werf H, Aubin J, 2018. MEANS, user-friendly software to generate LCIs of farming systems. 11th International Conference on Life Cycle assessment of food 2018 (LCA food), 17-19 october 2018, Bangkok, Thailand.
- Auberger J, Geneste C, Rostain G, Malnoë C, 2024. Mapping between MEANS-InOut input data and LCI from reference database. Plateforme nationale MEANS. Recherche Data Gouv, V1. https://doi.org/10.57745/VHTM7A

APPENDIX EE: COMPOSITION OF ORGANIC FERTILIZERS

The ETM content of organic fertilizers and data sources can be found in the Means platform dataverse "Fertiliser_Means_data_v0_1.tab"[21]

The ETM compositions of organic fertilizers were updated between versions 3.1 and 3.2. It should be noted that version AGRIBALYSE® 3.31.1 included a simplified evolutionary patch that allowed for a rough correction of the ETM compositions of organic fertilizers. The updating work carried out on this subject is described below.

Data on the composition of trace metal elements taken from organic fertilizers in versions prior to Agribalyse 3.2 were deemed obsolete. Indeed, after analysis, several trace metal emission values came to our attention, in particular TMEs, which are independent of the trace elements required for animal feed. After comparing these values with several sources, it became clear that the concentrations of trace metal elements present in organic fertilizers in AGRIBALYSE® versions 3.1 and earlier needed updating. Following this observation, bibliographic work was carried out to identify robust, recent sources covering as many types of organic fertilizers as possible (in order to maintain homogeneity in the analysis and processing of the data collected). The TRACTION project led by IFIP, IDELE and ITAVI and financed by ADEME was selected. In this project, 47 categories of livestock effluent from various animal productions (ruminants, poultry, pigs, rabbits and fish) were subjected to an initial quantification of the levels and flows of 10 trace elements. As described in the TRACTION project report (Levasseur et al. 2021), 16 pig effluents were collected and analyzed. For the poultry, rabbit and fish sectors, 16 samples were also collected and analyzed. Fifteen types of manure were studied for the ruminant sectors, covering the majority of products from cattle (milk and meat), goat and sheep farms, from very compact manure with accumulated litter to slurry.

As part of the TRACTION project, the consistency of the analysis results was also verified by comparison with data from the early 2000s. However, the authors point out that the results need to be consolidated by further analysis campaigns. Future work will need to extend the number of samples and matrices that could not be included.

ETM concentration values have therefore been updated on the basis of the TRACTION study. The table below details the methodological choices made for each of the organic fertilizers in Means-InOut.

Libelle FR	Comments on the choice of input data
Pig slurry, mixed	The name in Means I-O is "Pig manure, mixed sows, piglets and pigs", but the TRACTION project proposes several types of pig manure, but not mixed as described above: Table 3, TRACTION project "The "breeder-fertilizer" category is the most frequently encountered in pig farming. These are the breeding herd and its offspring: piglets in post-weaning and pigs for pork. Farrow-to-finish farms can be partial (fattening a greater or lesser proportion of pigs on site). Post-weaner-finishers include - as the name suggests - only post-weaning piglets and pork butcher pigs, but not sows. This type of farming is less common than farrow-to-finish farming. The values taken for "Pig slurry, mixed sows, piglets and pigs" correspond to the average of the 5 categories of pig manure (lines 10 to 15 of appendix 3, TRACTION project).
Biological sludge from aerobic treatment	The name in Means I-O is "Biological sludge, from aerobic treatment (nitrification/denitrification)". As the animal source is not specified, the values adopted correspond to the "Biological sludge pig" present in the TRACTION project (line 27, appendix 3).
Hog manure solid fraction compost	The name in Means I-O "Compost de fraction solide de lisier de porc" has been considered as corresponding to the composted V-scraping refusal present in the TRACTION project entitled "Raclage composté porc charcutier" (line 22 of appendix 3) as well as to the "Refus composté de DC (non normé) porc" line 26 appendix 3.

[21] Auberger, Julie; Malnoë, Caroline, 2024, "Fertilisers used in MEANS-InOut: compositions and characteristics useful for environmental assessment", https://doi.org/10.57745/LPRJIH, Recherche Data Gouv, V1,

	The values taken for "Compost of solid fraction of pig manure" correspond to the average of the 2 categories of pig fertilizers (line 22 and 26 of appendix 3, TRACTION project).
Straw-based pig manure compost	The name in Means I-O is "Straw-based pig manure compost". The values used correspond to "Accumulated composted fattening manure" in the TRACTION project (line 18, appendix 3).
Laying hen manure	No laying hen manure was analyzed in the TRACTION project. An average of "Standard broiler manure" (line 29, appendix 3) and "Future breeder manure" (line 35, appendix 3) was used as a proxy, pending more specific data on laying hens.
Rabbit slurry (scraping system)	The name in Means I-O is "Rabbit slurry (scraping system)". The values selected correspond to "Rabbit manure under cage" in the TRACTION project (line 43, appendix 3).
Poultry manure	No poultry manure was analyzed in the TRACTION project. The values for "Duck for roasting on slatted floors" present in the TRACTION project, which is a duck slurry (line 32, appendix 3), have been retained as a proxy pending more specific data on poultry slurry.
Duck slurry (for roasting or force-feeding)	The name in Means I-O is "Duck slurry". The values used correspond to "Duck for roasting on slatted floors", a slurry used in the TRACTION project (line 32, appendix 3).
Dried laying hen droppings	The values taken into account for "Dried droppings from laying hens" are based on "Dried droppings from laying hens in cages" line 36 appendix 3, TRACTION project.
Poultry manure compost	The name in Means I-O is "Poultry manure compost". The values used correspond to "Compost from standard broiler manure" in the TRACTION project (line 30, appendix 3).
Manure from ducks ready to force-feed	The name in Means I-O is "Manure from ducks ready to force-feed". The values used correspond to "Fattened ducks fattened on litter", which is a manure used in the TRACTION project (line 39, appendix 3).
Cattle slurry digestate	no digestates in TRACTION. The "Average bovine manure" values (average of "Dairy cow manure" (line 7, appendix 3), "Suckler cow manure" (line 8, appendix 3) presented in the TRACTION project) have been used as a proxy pending more specific digestate data, on the assumption that methanization does not modify TME concentrations "Methanization does not create TMEs, the TMEs present in the substrates are found in the digestate". FNE; 2021; METHANISATION: ANALYSE DE CONTROVERSES".
Hog manure compost on straw	The name in Means I-O is "Compost from pig slurry on straw". The values used correspond to "Raclage composté porc charcutier", which is a composted scrape from different farms at very different stages of composting in the TRACTION project (line 22, appendix 3).
Liquid digestate fraction from a slurry mix	no digestates in TRACTION: see analyses and assumptions in Tab1
Poultry manure (medium)	The values used for "average French poultry manure" are those of the average of "Standard broiler manure" (line 29, appendix 3, TRACTION project), "Future breeder manure" (line 35, appendix 3, TRACTION project) and "Standard turkey manure" (line 31, appendix 3, TRACTION project), since in France it is mainly broiler poultry that is reared, and therefore the source of farm effluent.
Broiler manure	The values used for "Broiler manure" are those of "Standard broiler manure" (line 29, appendix 3, TRACTION project).

Manure and slurry digestate	no digestates in TRACTION: the quantity of heavy metals (ETM) contained in inputs per mg/kg dry matter is not affected by their passage through the anaerobic digester. The data source here is an average of "manures and slurries" (preservation of ETM concentration values per kg dry matter) with adaptation of the % DM (preservation of the original value). The average of all manures and slurries from the TRACTION project was taken as the source (see Tab. 2).
Straw cattle manure compost	no cattle manure compost in TRACTION: calculation assumption based on factors linked to the transformation of pig manure into composted pig manure: see Tab3 assumption for cattle manure compost.
Medium cattle slurry	The values retained for "Average bovine manure" are those of the average of "Dairy cow manure" (line 7, appendix 3) and "Suckler cow manure" (line 8, appendix 3). In the TRACTION project, the values for veal calf manure were excluded because of their extreme values.
Veal manure	The values retained for "veal calf manure" are those of "veal calf manure" (line 9, appendix 3) present in the TRACTION project.
Feather and blood flour	no feather and blood meal in TRACTION: a literature review was carried out and the values retained are based on the studies Möller and Schultheiß, 2014 and Improve-P, Assessment of Alternative Phosphorus Fertilizers for Organic Farming: Meat and Bone Meal, 2015 (Cf Tab 4). For "feather and blood meal", the proxy "feather meal" has been retained.
Straw-based pig manure	The values used for "Straw-based pig manure" are the average of "Accumulated post-weaning manure" (line 16, appendix 3), "Accumulated fattening manure" (line 17, appendix 3), "Accumulated pregnant sow manure" (line 19, appendix 3), and "Scraped pregnant sow manure" (line 20, appendix 3).
Feather meal	no feather and blood meal in TRACTION: a literature review was carried out and the values retained are based on the studies Möller and Schultheiß, 2014 and Improve-P, Assessment of Alternative Phosphorus Fertilizers for Organic Farming: Meat and Bone Meal, 2015 (Cf Tab 4).
Meat flour	no feather and blood meal in TRACTION: a literature review was carried out and the values retained are based on the studies Möller and Schultheiß, 2014 and Improve-P, Assessment of Alternative Phosphorus Fertilizers for Organic Farming: Meat and Bone Meal, 2015 (Cf Tab 4).
Diluted cattle slurry	The values adopted for "Diluted bovine manure" correspond to the average of "Dairy cow manure" (line 7, appendix 3, TRACTION project) and "Suckler cow manure" (line 8, appendix 3, TRACTION project), which are diluted manures.
Cattle manure, accumulated litter	The values retained for "Cattle manure, accumulated litter" are those of "very compact manure, accumulated litter" (line 3, appendix 3, TRACTION project).
Cattle manure, cubicle slurry	The values used for "Cattle manure, soft cubicle" are those for "Soft manure - Cattle" (line 5, appendix 3, TRACTION project).
Medium cattle manure	The values retained for "Cattle manure (average France)" are those of "mixed manure - Cattle" (line 6, appendix 3, TRACTION project) which corresponds to "mixture of very compact and/or compact and/or soft manures" = an average manure reference. Table 29 TRACTION
Hog manure digestate	no digestates in TRACTION: the quantity of heavy metals (ETM) contained in the inputs per mg/kg dry matter is not affected by their passage through the anaerobic digester. The data source here is therefore "mixed pig manure" (ETM concentration values per kg dry matter retained) with adaptation of the % DM (original value retained).
Sheep manure	The values used for "Sheep manure" are those for "Sheep manure" (line 2, appendix 3, TRACTION project).

Sheep manure, accumulated litter	The values used for "Sheep manure" are those for "Sheep manure" (line 2, appendix 3, TRACTION project).
Undiluted cattle slurry	In the TRACTION project, there is no undiluted cattle slurry. The average of "slurry from dairy cows" (line 7 in appendix 3) and "slurry from suckler cows" (line 8 in appendix 3), which are diluted slurries, was used as a proxy for "undiluted cattle slurry", pending more specific data.

APPENDIX FF: CONSTRUCTION OF "AVERAGE FERTILIZER" LCIS

Table136 and**Table137** summarize the construction of average French N, P and K fertilizers based on UNIFA mineral fertilizer sales data for the period 2005 to 2009.

This was done in two stages: firstly, averages were calculated for each form of fertilizer used over the study period, and assigned to the corresponding LCI fertilizer in the World Food Database (WFLDB) (**Table136**). In the [2nd] stage, a balance sheet by nutrient (**Table137**) was used to arrive at an "average fertilizer" LCI for each nutrient N, P_2O_5 and K_2O.

Step 1:Table136 shows average annual French fertilizer consumption from 2005 to 2009. The 2nd column shows the LCI WFLDB corresponding to each fertilizer, defined according to several cases:

a) direct assignment: In this case, a WFLDB LCI corresponding to the fertilizer exists. For example, "Ammonnitrate" will be assigned to "Ammonium nitrate (AN), as N, at plant (WFLDB 3.5)/RER U" (Table137

b) combined" assignment: No WFLDB LCI corresponds directly to this type of fertilizer. However, information on fertilizer composition (source GESTIM) makes it possible to associate these fertilizers with a combination of several pre-existing WFLDB LCIs. For example, the fertilizer "Solution azotée" is produced by combining "Urea, as N, at regional storehouse" and "ammonium nitrate, as N, at regional storehouse, RER". 1 kg of nitrogen solution can be assimilated to the combination of 0.348 kg of urea and 0.457 kg of ammonium nitrate (the rest being water, see the "Splitting" column inTable137

c) distribution to other fertilizers: This approach is only used for "Organo-mineral" fertilizers. Inputs of N, P2O5 and K2O from these fertilizers are distributed to all other forms of fertilizer used, in proportion to their respective quantities (Table137

Step 2:Table137 shows the quantities of fertilizers applied, but this time sorted by nutrient. The 1st column contains the name of the fertilizer, the 2nd the assignment to LCI WFLDB. The 3rd and 4th columns show the tonnages and quantities of nutrients (identical to the corresponding columns inTable136). The 5th column adds nutrient quantities from organo-mineral fertilizer inputs. The 6th column is used to break down fertilizers requiring the combination of several WFLDB LCIs (see "combined" assignment). The 7th and 8th columns show the final distribution of nutrient inputs in relation to each WFLDB LCI. These data are used to construct the average fertilizer LCI.

For fertilizers, WFLDB LCIs have been used, and transport as defined by GESTIM added.

Calculating the impact of transport requires knowing both the distances and the mass of fertilizers transported. When mass was not directly available, as only fertilizer values were provided (e.g. N units), the following conversion factors were used:

Total mass = N x 1/28% + P2O5 x 1/18%+ K2O x 1/25%.

Table 139 and

Table140 summarizes the calculation of transport distances by fertilizer type for fertilizers used in France. The first part (in green) contains information on fertilizer origin and means of transport used, as well as the distances covered. The blue sub-table on the left summarizes distances by fertilizer type and "transport model" respectively. It is compared with the distances and means of transport used in the Ecoinvent® LCIs.

Table136: Average annual fertilizer deliveries in mainland France between 2005 and 2009 (Source: UNIFA).

The 3rd column shows the tonnage of fertilizers consumed, while columns 4 to 6 indicate the quantities of nutrients associated with these fertilizer inputs. Reading guide: Between 2005 and 2009, 1,551,887 t of DAP/MAP were spread on fields each year, equivalent to 276,495 tonnes of nitrogen (in kg N) and 716,727 tonnes of phosphorus (in kg P2O5). (in kg P2O5).

Fertilizers	Integration	Tonnage	t N	t P	t K
- AMMONITRATE	assignment to existing LCI WFLDB	15 686 424	4 844 129		
- NITROGEN SOLUTION	assignment to simulated LCI WFLDB (info GESTIM)	10 301 899	3 055 924		
- UREE	assignment to existing LCI WFLDB	3 002 222	1 380 913		
- OTHER SINGLES N	assignment to existing LCI WFLDB	1 437 386	445 655		
Total	Total	30 427 931	9 726 621		
- TSP	assignment to existing LCI WFLDB	922 301		419 621	
- OTHER SUPERPHOSPHATES	assignment to existing LCI WFLDB	310 560		60 018	
- OTHER SIMPLE P	allocation to simulated LCI WFLDB P (info GESTIM)	340 735		61 602	
- SIMPLE P	- SIMPLE P	1 573 596		541 241	
- POTASSIUM CHLORIDE	assignment to existing LCI WFLDB	2 291 553			1 374 932
- OTHER SINGLE K	assignment to existing LCI WFLDB	494 259			196 211
- SIMPLE K	- SIMPLE K	2 785 812			1 571 143
- SUPERPOTASSIUM	assignment to LCI WFLDB PK simulated (info GESTIM)	2 705 710		498 433	658 114
- PHOSPHO-POTASSIUM	assignment to LCI WFLDB PK simulated (info GESTIM)	377 562		51 184	65 095
- OTHER PKS	assignment to LCI WFLDB PK simulated (info GESTIM)	773 807		87 895	132 845

- BINAIRES PK	- BINAIRES PK	3 857 079		637 512	856 054
- DAP - MAP	assignment to existing LCI WFLDB	1 551 877	276 495	716 727	
- OTHER NP	assignment to existing LCI WFLDB	1 005 782	204 965	171 532	
- NK - NPK	assignment to LCI WFLDB NK simulated (info GESTIM)	6 717 677	996 357	677 445	1 075 104
- ORGANO-MINERALS	distribute according to N / P / K on LCI N P K	605 745	27 057	35 913	59 098
- COMPOUNDS NP, NK, NPK, OM	- COMPOUNDS NP, NK, NPK, OM	9 881 081	1 504 874	1 601 617	1 134 202

Table137: Construction of AGRIBALYSE® average fertilizer LCIs by N/P/K nutrient.

Reading guide ("nitrogen solution" line): Between 2005 and 2009, in France, 10,301,899 t of nitrogen solution were spread on fields each year, equivalent to an input of 3,055,924 tonnes of nitrogen (in kg N). To calculate the average fertilizer, we add to this input the portion derived from "organo-mineral" fertilizers (27,057 t N), distributed proportionally between all fertilizers, corresponding to an additional 7,379 t N for the nitrogen solution (column t N distributed). Since there is no "nitrogen solution" LCI in WFLDB, GESTIM assumes that each kg of nitrogen solution is equivalent to 0.348 kg of urea and 0.457 kg of ammonium nitrate (see "Splitting" column). Thus, the nitrogen solution contribution can be equated to 1,324,260 t of N in the form of urea and 1,739,043 t of N in the form of ammonium nitrate. The last column shows the contribution of the nitrogen solution to total N inputs on French fields: 118 g (included in the average fertilizer LCI as "urea") and 155 g (included in the average fertilizer LCI as "ammonium nitrate").

***Average mineral fertilizer, as N, at regional storehouse, FR**							
Component	LCI	t	t N	t N distributed	Splitting	t N	LCI
- AMMONITRATE	Ammonium nitrate, as N {RER}| ammonium nitrate production | Alloc Rec	15 686 424,00	4 844 129,00	4 855 826,83	1	4 855 826,83	0,432
- NITROGEN SOLUTION	Urea, as N {RER}| production | Alloc Rec	10 301 899,00	3 055 924,00	3 063 303,59	0,348	1 324 260,43	0,118
	Ammonium nitrate, as N {RER}| ammonium nitrate production | Alloc Rec				0,457	1 739 043,15	0,155
- UREE	Urea, as N {RER}| production | Alloc Rec	3 002 222,00	1 380 913,00	1 384 247,69	1	1 384 247,69	0,123

- OTHER SINGLES N	Ammonium sulfate, as N {RER}| ammonium sulfate production | Alloc Rec	1 437 386,00	445 655,00	446 731,19	1	446 731,19	0,040
- DAP - MAP	Nitrogen fertiliser, as N {RER}| diammonium phosphate production | Alloc Rec	1 551 877,00	276 495,00	277 162,69	1	277 162,69	0,025
- OTHER NP	Phosphate fertiliser, as P2O5 {RER}| ammonium nitrate phosphate production | Alloc Rec	1 005 782,00	204 965,00	205 459,96	1	205 459,96	0,018
- NK - NPK	Ammonium nitrate, as N {RER}| ammonium nitrate production | Alloc Rec	6 717 677,00	996 357,00	998 763,05	0,45	449 443,37	0,040
	Urea, as N {RER}| production | Alloc Rec				0,25	249 690,76	0,022
	Ammonium sulfate, as N {RER}| ammonium sulfate production | Alloc Rec				0,2	199 752,61	0,018
	Nitrogen fertiliser, as N {RER}| monoammonium phosphate production | Alloc Rec				0,1	99 876,30	0,009
- ORGANO-MINERALS	spread over the others	605 745,00	27 057,00				
Totals		40 309 012,00	11 231 495,00	11 231 495,00		11 231 495,00	1,000
***Average mineral fertilizer, as P2O5, at regional storehouse, FR**							
Component	LCI	t	t P	t P reparti	Splitting	t P	LCI
- TSP	Phosphate fertiliser, as P2O5 {RER}| triple superphosphate production | Alloc Rec	922 301,00	419 621,00	425 112,01	1	425 112,01	0,153
- OTHER SUPERPHOSPHATES	Phosphate fertiliser, as P2O5 {RER}| single superphosphate production | Alloc Rec	310 560,00	60 018,00	60 803,37	1	60 803,37	0,022
- OTHER SIMPLE P	Phosphate fertiliser, as P2O5 {RER}| single superphosphate production | Alloc Rec	340 735,00	61 602,00	62 408,10	1	62 408,10	0,022

- DAP - MAP	Phosphate fertiliser, as P2O5 {RER}| diammonium phosphate production | Alloc Rec	1 551 877,00	716 727,00	726 105,84	1	726 105,84	0,261
- OTHER NP	Phosphate fertiliser, as P2O5 {RER}| ammonium nitrate phosphate production | Alloc Rec	1 005 782,00	171 532,00	173 776,61	1	173 776,61	0,063
- NK - NPK	Nitrogen fertiliser, as N {RER}| monoammonium phosphate production | Alloc Rec	6 717 677,00	677 445,00	686 309,81	0,6	411 785,88	0,148
	Phosphate fertiliser, as P2O5 {RER}| ammonium nitrate phosphate production | Alloc Rec				0,3	205 892,94	0,074
	Phosphate fertiliser, as P2O5 {RER}| triple superphosphate production | Alloc Rec				0,1	68 630,98	0,025
- ORGANO-MINERALS	spread over the others	605 745,00	35 913,00				0,000
- SUPERPOTASSIUM	Phosphate fertiliser, as P2O5 {RER}| triple superphosphate production | Alloc Rec	2 705 710,00	498 433,00	504 955,32	1	504 955,32	0,182
- PHOSPHO-POTASSIUM	Phosphate fertiliser, as P2O5 {RER}| triple superphosphate production | Alloc Rec	377 562,00	51 184,00	51 853,78	1	51 853,78	0,019
- OTHER PKS	Phosphate fertiliser, as P2O5 {RER}| triple superphosphate production | Alloc Rec	773 807,00	87 895,00	89 045,16	1	89 045,16	0,032
Totals		15 311 756,00	2 780 370,00	2 780 370,00		2 780 370,00	1,000

***Average mineral fertilizer, as K2O, at regional storehouse, FR**							
Component	LCI	t	t K	t K reparti	Splitting	t P	LCI
- POTASSIUM CHLORIDE	Potassium sulfate, as K2O {RER}| potassium sulfate production | Alloc Rec	2 291 553,00	1 374 932,00	1 398 132,67	1	1 398 132,67	0,393

- OTHER SINGLE K	Potassium sulfate, as K2O {RER}| potassium sulfate production | Alloc Rec	494 259,00	196 211,00	199 521,87	1	199 521,87	0,056
- SUPERPOTASSIUM	Potassium chloride, as K2O {RER}| potassium chloride production | Alloc Rec	2 705 710,00	658 114,00	669 219,05	1	669 219,05	0,188
- PHOSPHO-POTASSIUM	Potassium chloride, as K2O {RER}| potassium chloride production | Alloc Rec	377 562,00	65 095,00	66 193,42	1	66 193,42	0,019
- OTHER PKS	Potassium chloride, as K2O {RER}| potassium chloride production | Alloc Rec	773 807,00	132 845,00	135 086,63	1	135 086,63	0,038
- NK - NPK	Potassium chloride, as K2O {RER}| potassium chloride production | Alloc Rec	6 717 677,00	1 075 104,00	1 093 245,36	0,8	874 596,29	0,246
	Potassium sulfate, as K2O {RER}| potassium sulfate production | Alloc Rec				0,2	218 649,07	0,061
- ORGANO-MINERALS	spread over the others	605 745,00	59 098,00				0,000
Totals		13 966 313,00	3 561 399,00	3 561 399,00		3 561 399,00	1,000

Table138: Example of 8-10-20 mineral fertilizer

Fertilizer composition 8-10-20	**Assignment**		**Content kg/t**	**Factor**	**INVENTORY**
N content	engrais moyen, average mineral fertilizer, as N, at regional storehouse, FR		80		80,00
P content	engrais moyen, average mineral fertilizer, as P2O5, at regional storehouse, FR		100	1,00	100,00
K content	engrais moyen, average mineral fertilizer, as K2O, at regional storehouse, FR		200	1,00	200,00
other components	Production is neglected, but for transport, quantity is taken into account		620		

Totals				1000		

Table 139: Recalculation of transport models for fertilizers, based on GESTIM (GAC *et al*, 2010).

Distances (km)	Origin									
Means of transport	F	EU 15	Russia	Ukraine	Africa N	Arabia	AmericaCent	Chile	Qatar	China /Austr
LKW	150	400	150	150	150	150	150	150	150	150
Boat			1500	5000	2500	3500	4000	6500	6000	1000
Type of fertilizer										
Ammonia	100%									
Urea	0%	30%	26%	0%	35%	0%	8%	0%	0%	1%
AN / CAN	52%	40%	8%	0%	0%	0%	0%	0%	0%	0%
Solution N	55%	16%	25%	2%	2%	0%	0%	0%	0%	0%
MAP/DAP	0%	16%	8%	8%	67%	0%	0%	0%	1%	0%
TSP	10%	26%	0%	0%	61%	0%	0%	0%	3%	0%
Potash	0%	97%	2%	0%	0%	0%	0%	0%	1%	0%

Transport model (tkm) GESTIM Original			
Type	Truck	Boat	

	Transport Lorry > 16,t aver. RER	transport, transoceanic freight ship; OCE	
MT NSimple	150	0	
MT Urea	225	1595	
MT AN/CAN	250	120	
MT Nliquid	190	525	
MT MAP/DAP	190	2255	
MT TSP	215	1705	
MT Potash	392,5	90	
MT Medium fertilizer	230,36	898,57	

Table140: Assignment of Transport Models (TMs) to LCIs.

LCI fertilizer used in AGRIBALYSE® inventories	Mod. Transport => seeTable 139
engrais moyen, average mineral fertilizer, as K, at regional storehouse, FR	MT Potash
engrais moyen, average mineral fertilizer, as N, at regional storehouse, FR	MT NSimple
engrais moyen, average mineral fertilizer, as P, at regional storehouse, FR	MT TSP
LCI Ecoinvent® Copper, primary, at refinery/RER U	MT Average
LCI Ecoinvent® ammonium nitrate, as N, at regional storehouse, RER	MT AN/CAN
LCI Ecoinvent® calcium nitrate, as N, at regional storehouse, RER	MT AN/CAN
LCI Ecoinvent® chemicals inorganic, at plant, GLO	MT Average
LCI Ecoinvent® diammonium phosphate, as N, at regional storehouse, RER	MT MAP/DAP
LCI Ecoinvent® Magnesium oxide, at plant, RER	MT Average
LCI Ecoinvent® Zinc, primary, at regional storage/RER U	MT Average
LCI Ecoinvent® Manganese oxide (Mn2O3), at plant, CN	MT Average
LCI Ecoinvent® Lime, from carbonation, at regional storehouse, CH	MT Average
LCI Ecoinvent® Limestone, milled, loose, at plant, CH	MT Average
LCI Ecoinvent® Magnesium sulphate, at plant, RER	MT MAP/DAP
LCI Ecoinvent® Monoammonium phosphate, as N, at regional storehouse	MT MAP DAP
LCI Ecoinvent® Potassium chloride, as K2O, at regional storehouse. RER	MT Potash
LCI Ecoinvent® Potassium nitrate, as K2O, at regional storehouse, RER	MT Potash

LCI Ecoinvent® Potassium sulphate, as K2O, at regional storehouse, RER			MT Potash
LCI Ecoinvent® Single superphosphate, as P2O5, at regional storehouse, RER			MT TSP
LCI Ecoinvent® Triple superphosphate, as P2O5, at regional storehouse, RER			MT TSP
LCI Ecoinvent® Urea ammonium nitrate, as N, at regional storehouse, RER			MT Urea
LCI Ecoinvent® Urea, as N, at regional storehouse			MT Urea
LCI Ammonium sulphate, as N, at regional storehouse, RER			MT NSimple

APPENDIX GG: MACHINE CONSTRUCTION

All the elements presented below can be consulted on the dataverse dataset of the Means platform .[22]

LCIs for agricultural machinery are modelled from several sources:

- **LCI of tractors modeled from literature sources.**

For tractors, 3 LCIs have been fully modeled on the basis of bibliographic data . These LCIs represent tractors fitted with a pollution control system to limit emissions during diesel combustion. The 3 tractors are as follows:

- a 7200h tractor, 155 HP, 6 cylinders, 4WD
- a 1000h tractor, 155 HP, 6 cylinders, 4WD
- a 12000h tractor, 155 HP, 6 cylinders, 4WD

These 3 tractors are described in detail in the associated publication .

- **LCI adapted from Ecoinvent:**

The other machines were modeled by adapting Ecoinvent data.

The**Table141** shows the grouping of machines entered, together with the data required to parameterize Ecoinvent® LCIs (see B.2.1).

Of the 191 machines defined in AGRIBALYSE®, 186 can be assimilated to one of the five existing "agricultural machine" LCIs in Ecoinvent® 2.0 - self-propelled machine, trailer, trailed machine (with wheels), mounted machine, tanker. A new LCI "electrically-powered machine" has been created to group together the 5 machines not previously assimilated. These six groups (5+1) were then divided according to their service life, to take account of variable consumption for machine maintenance (wheels, engine oils and filters). In the end, we obtain 11 groups of machines, with an average lifetime and weight (see line in light blue). These groups correspond to the 11 "AGRIBALYSE® machine" LCIs (designated by the 1st column), built from Ecoinvent® inventories, and parameterized according to the weight and lifespan of French machines. In these machine LCIs created for AGRIBALYSE® 1 with inventories from Ecoinvent® 2.0, the processes included in these inventories have been updated with the latest Ecoinvent® version available for AGRIBALYSE® .

The unit processes of these 11 machines are presented in**Table142**

Table141: Equipment grouped into 11 AGRIBALYSE® machines.

[22] Auberger, Julie; Malnoë, Caroline, 2024, "Agricultural operations used in MEANS-InOut: characteristics useful for environmental assessment with LCA", https://doi.org/10.57745/TS0NTA, Recherche Data Gouv, V1

Grouping of machines; and summary of values used for LCI "production machine XY".	Machine name in InOut	Power (kW); working width (m), capacity (m^3)	Service life (h)	Machine weight (kg)
Self-propelled machine, < 5000 h (based on "Harvester)	Self-propelled vine harvester		3000	5000
	Self-propelled 6-row beet harvester-loader	265 kW, 6 rows	2500	15100
	Self-propelled carrot processor Aquitaine	102.9 kW, 3000 l tank, 24 m boom	3600	7335
	600 hp forage harvester with attached bucket	600 hp	4000	9000
	Self-propelled forage harvester	8 rows, 480 hp	4000	9000
	Self-propelled grape harvester		3000	5800
	Combine harvester, 200 HP, 5.5m	200 kW, 5.5 m	4000	10000
	Tiller with water pump 1600l/mn	4kW	700	30
Value used			3000	8000
Self-propelled machine, 5 - 10,000 h (based on "Harvester")	3-row self-propelled harvester	147 kW (200 hp)	6000	14000
	Self-propelled sprayer 18 HP	13 kW	7200	150
	Self-propelled harvester		6400	9500
	Self-propelled carrot harvester	147 kW (200 hp)	6000	14000
Value used			7200	5400
Self-propelled machine, > 10,000 h (based on "Harvester")	Self-propelled with powder tanker	220 kW (300 hp)	18000	9100
	Self-propelled platform	14.7 kW	12000	2250
Value used			15000	6000
Trailer <20 t (based on "Trailer")	Trailer (clementine harvest)		10000	500
	4-box trailer		6000	760
	Trailer, 12-14t	12-14 t, 2 axles	6000	5139

	Trailer, 16-18t	16-18 t, 2 axles	6000	6590
	Trailer, 8t	8 t, 2 axles	6000	4'084
Value used			6000	3500
Trailer, >20 t (based on "Trailer")	21-ton bucket	21 tons	15000	8100
	2-axle tipper - 15 t		6000	5883
Value used			10000	7000
Pressure tanker 5000l, (based on "Slurry tanker")	Slurry tanker / 5000l pressure tanker	5000 l	5000	1690
Value used			5000	1700
Trailed machine, < 2'500h (based on "agricultural machinery, general")	Potato harvester	2 rows, classic, 75 cm	1800	5500
	Wrapper 17 bales / h	17 bales / h	1000	2000
	Manure spreader, 5t	5t	2400	3848
	Fertilizer spreader/distributor, centrifugal, 1500l	24 m, 1500 l	800	550
	4-row planter 75 cm	4 rows	1500	2000
	Scion planter		1000	500
	4-row nursery planter	4 rows	2250	1060
	Nursery planter/repicker		2250	300
	Powder orchard	600-litre drag	240	260
	Round baler		1800	1773

	Cider apple harvester		1875	1200
	Kaset Phattana rice combine harvester	120 kW, 3 m	2000	4000
	Disc seed drill for direct seeding, 4m	4 m	1200	5300
	Classic seed drill, 4m	4 m	1200	1000
	Seed drill with shoe	3 m	900	680
	Seed drill with shoe (3 m)	3 m	900	680
	Precision seed drill, dist. Pneumatic - 6 rgs	6 rows (3m)	1200	1000
Value used			1500	2000
Trailed machine, 2'500 -5'000h (based on "agricultural machinery, general")	Windrower 9m	9 m	3000	3200
	1 row trailed carrot harvester	1 row	4800	5500
	2000 l towed sprayer, double horizontal turbines	2000 l	4000	650
	Slurry spreader 1500-2000l	1 axle, 1500-2000 l	5000	1000
	Manure spreader, 8-10t	2 axles, 8-10 t	5000	3500
	Soil disinfection spreader	13 coulters, 4.75 m, 2 tanks 1000 l	4500	3500
	4-row potato planter 75 cm	4 rows, 75 cm	3000	1000
	Jacto Arbus 2000 sprayer (mango)		2000	820
	Trailed sprayer, 2500l	24 m, 2500 l	3000	2600
	3-bed seeder	5,5 m	3600	2250
	Pneumatic seeder		900	550

Value used			4000	2500
Trailed machine, >5000h (based on "agricultural machinery, general")	Trailed windrower1.83 m	1,83 m	6000	3370
	3-row trailed carrot harvester	3 rows	6000	9000
	3-board spreader, 6-8 tonnes	6-8 tons	9000	3120
	Trailed sprayer, 3000l	24 / 28 m, 3000 l	6000	2500
	Trailed carrot harvester		6000	9000
Value used			7800	6200
mounted machine (based on "Agricultural machinery, tillage")	Windrower for pruning wood	2,5 m	200	250
	Nursery stock harvester		7200	1500
	Atomizer		2300	900
	Weeder		2300	900
	2-row weeder	2,5 m	2400	450
	Weeder 3.6 m	3,6 m	1800	550
	4 m camera hoe	4 m, teeth	3000	1600
	Triple weeder	5,5 m	4800	770
	Vineyard weeder	2,5 m	1500	550
	Grinder	4,5 m	2300	2100
	Hammer mill	2,5 m	200	645
	Vine shoot crusher		2300	530

	Pruning wood chipper (clementines)		1000	500
	Husk shredder	4 rows	3000	1000
	Grinder for carrot tops	4,8 m	2400	2600
	Moulder	4 rows	3000	1000
	Diablolo mounder	2 mounds	2400	300
	Layer for tunnel tarpaulin		450	450
	Reversible 1-body plough		3000	1350
	1-share plough		3000	400
	5-body mounted plough	5 bodies, range	3000	1000
	8-body plough	3,2 m	4800	3150
	Kubota disc plough	3-4 discs	1500	200
	Quadrisoc mounted plough	4 plowshares	480	1039
	Furrow plough		2500	163
	Vineyard plough 1 share	1 soc	900	150
	6-share ploughs	6 base	4800	1760
	Chisel 2.5m	2,5 m	2300	709
	Chisel 4.5m	4,5 m	1570	1029
	Mounted compressor		2300	900
	Portable compressor for pruning shears	600 l tank	3750	500

	Cover-crop (mango)		2500	1000
	Cover-crop, 36 discs, 5.5m		2300	3000
	Cover-crop, 4m	5,5 m	2100	3000
	Heavy cultivator + roller	3 m	2400	1300
	Rotary cultivator (triturating), 2m	2 m	2300	330
	Triple cultivator	5,5 m	3600	3900
	Trimmer		2300	800
	2.5 m disc harrow	2,5 m	800	780
	Independent disc harrow, 4m	4 m	1500	2100
	5.5 m semi-mounted stubble cultivator	5,5 m	3600	3900
	Cultivator, mounted, 5.5m	5.5	1500	2100
	Decompactor 4 m	4 m	4800	1000
	7-tooth compactor	7 teeth	2400	1000
	Decompactor, 5 bodies/teeth	3	3000	900
	Router		2300	1000
	Wire unwinder		2250	80
	Hail net unwinder		2250	600
	Thermal weeder		1500	550
	Removal disc		300	200

	Trimmer		1800	200
	Leaf stripper		1800	500
	Vine leaf stripper		2300	100
	3-point lift		6000	460
	Pile driver		3000	335
	Post driver		2300	700
	Stone burier	2,1 m	1500	860
	Rewinder		2250	400
	1-row forage harvester	1 row	3000	480
	Chemical shredder		2300	450
	Mechanical pruner		2300	450
	Spreader 500 l	500 l	1800	126
	500 L fertilizer spreader	1,45 m	800	126
	1000kg mounted spreader	1000 kg	2300	150
	Spreader, mounted, 2500L	1500 l	800	463
	Fertilizer spreader/distributor, centrifugal, 500l	500 l	2300	193
	Windrower 3 m	3 m	3000	370
	Mower 7 m	7 m	1500	3200
	Mounted mower conditioner, 3m	3 m	1500	1075

	Rotary mower, 3m	3 m	2300	643
	Tying machine		1800	150
	Front fork		1000	150
	Tiller 4 m	4 m	1800	1270
	Front bucket		900	320
	Claws		2300	600
	Grinder		2300	900
	Orchard rototiller	3,6 m	700	530
	Gyroceps sunflower		2300	200
	Reciprocating harrow, 3 m	3 m	2300	1686
	Animated harrow with roller	2,05 m	900	625
	Weeder for mechanical weeding, 12m	12 m	610	1020
	Rotary harrow	4 m	1800	1380
	Rotary harrow + roller	2 m	750	780
	Rotary harrow with roller 3 m	3 m	1800	960
	Rotary harrow, 4m	4 m	2010	1686
	Rotary harrow, with 2.5 m roller	2,5 m	800	840
	Rotary hoe		300	500
	Incorporator for soil disinfection		1800	300

	Interceptive blade		1500	40
	Trimmer for fruit hedges		500	750
	Ouitil for soil disinfection Normandie	10 cutters	2400	800
	Pirouette, 5.5	5.5 m	2300	552
	Triple plasticiser	3 boards from 1.65 to 1.90 m	2400	1000
	Forage plateau		6000	3150
	Trimmer		2300	900
	2000 l sprayer with spray jet	2000 l	4000	800
	3400 l sprayer, 24 m	24 m	3000	2300
	Mitsubishi TU 26 knapsack sprayer	2 kW	2300	12
	Sprayer with recovery panels		2300	450
	Lance sprayer		1000	200
	Sprayer 1200 l tank, 18 m boom	18 m	3000	650
	1000L mounted sprayer, 24 m boom	24 m	4800	990
	400 l mounted sprayer	400 l	3000	200
	600 L, 4-row mounted sprayer	4 rows	3000	500
	800 l mounted sprayer with 12 m boom	12 m	4800	950
	Mounted sprayer, 800l	15 m, 800 l	2300	477
	Greenhouse sprayer for trellised crops	400-litre tank, vertical boom	2400	500

	Sprayer 18 m, 1200 l	18 m, 1200 l	3000	1000
	Ramp		2300	150
	Rigoleuse		4800	400
	Trimmer		2300	900
	Rotavator	2 m	1800	405
	Rotavator		4800	685
	Rotavator 3 m	3 m	2400	1000
	Rotobèche	2 m	1800	830
	Rotofanner	3 m	1500	300
	Grooved roller, 3m	3 m, 3-point hitch	3000	1130
	Roller, 9m	9 m	1410	4500
	Weeder, potato ridger		2300	450
	Shaker		375	800
	Wrap-around lifter		2400	550
	Under soleuse 2 m	2 m	375	450
	Subsoiler, 6 teeth, 3 m	6 teeth, 3 m	2400	770
	Subsoiler		2300	900
	Subsoiler		2500	300
	auger		3000	290

	Cider orchard mower 3.4 m	3,4 m	700	650
	Thermal pole saw for cider orchard pruning	0.95 kW	500	6.3
	Vibrocultivator 6.3 m	6,3 m	1800	910
	Vibrocultivator, 3m	3 m	2300	538
	Vibrocultivator, 5m	5m, carried	1300	750
Value used			2300	900
Machine with electric motor	Electric rail-mounted forklift truck	0.37 kW	2500	300
	Conveyor	0.18 kW	1500	41
	Honda UMK 435T portable brushcutter	2kW	250	12
	Potters	4.12 kW	1500	1200
	Soil reservoir	4 kW	2250	1500
Value used			2300	900

Table142: Unit processes for the 11 groups of agricultural machinery adapted from Ecoinvent used in the AGRIBALYSE® LCIs. The unit processes were calculated by parameterizing the Ecoinvent® base LCIs with the average service life and average weight (see previous table).

Harvester machine with engine, LT <5'000h, production/FR. FU = kg per service life, based on "Harvester, CH".			
Products			
Harvester machine with engine, LT <5,000h production/FR/I U	1	kg	
Materials/fuels			
Electricity, medium voltage {FR}| market for | Cut-off	1,5	kWh	
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,92	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,84	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,84	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,33244	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	4,2432	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,19947	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	2,5459	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,068497	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,87427	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,13889	kWh	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,7	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,07	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,03	kg	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,045	kg	
Copper {GLO}| market for | Cut-off	0,02	kg	
Zinc {GLO}| market for | Cut-off	0,01	kg	
Lead {GLO}| market for | Cut-off	0,01	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,005	kg	
Flat glass, uncoated {RER}| production | Cut-off	0,01	kg	
Synthetic rubber {RER}| production | Cut-off	0,07	kg	
Polypropylene, granulate {RER}| production | Cut-off	0,03	kg	
Lubricating oil {RER}| production | Cut-off	0,002	kg	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,14	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,014	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,006	kg	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,009	kg	
Copper {GLO}| market for | Cut-off	0,004	kg	
Zinc {GLO}| market for | Cut-off	0,002	kg	
Lead {GLO}| market for | Cut-off	0,002	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,001	kg	
Flat glass, uncoated {RER}| production | Cut-off	0,002	kg	
Synthetic rubber {RER}| production | Cut-off	0,014	kg	

Polypropylene, granulate {RER}| production | Cut-off	0,006	kg	
Synthetic rubber {RER}| production | Cut-off	0,12	kg	
Paper, woodfree, coated {RER}| paper production, woodfree, coated, at integrated mill | Cut-off	0,0024	kg	
Polypropylene, granulate {RER}| production | Cut-off	0,0012	kg	
Lead {GLO}| market for | Cut-off	0,012	kg	
Lubricating oil {RER}| production | Cut-off	0,025608	kg	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,04	tkm	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,4	tkm	
Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,0048	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,002176	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,0013056	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00044834	kg	
Carbon dioxide, fossil	0,000035	kg	
Carbon dioxide, fossil	0,000007	kg	
Heat, waste	8,012	MJ	
Waste to treatment			
Waste glass sheet {CH}| treatment of, collection for final disposal | Cut-off	0,01	kg	
Waste glass sheet {CH}| treatment of, collection for final disposal | Cut-off	0,002	kg	
Waste graphical paper {CH}| treatment of, municipal incineration | Cut-off	0,0024	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,035	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,007	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,0012	kg	
Waste mineral oil {CH}| treatment of, hazardous waste incineration | Cut-off	0,002	kg	
Waste mineral oil {CH}| treatment of, hazardous waste incineration | Cut-off	0,025608	kg	
Harvester machine with engine, LT >10'000h, production/FR. FU = kg per service life, based on "Harvester, CH			
Products			
Harvester machine with engine, LT >10,000h production/FR/I U	1	kg	
Materials/fuels			
Electricity, medium voltage {FR}| market for | Cut-off	1,5	kWh	
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,92	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,84	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,84	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,45711	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	5,8344	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	1,4461	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	18,458	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,34248	kWh	

Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	4,3713	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,13889	kWh	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,7	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,07	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,03	kg	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,045	kg	
Copper {GLO}| market for | Cut-off	0,02	kg	
Zinc {GLO}| market for | Cut-off	0,01	kg	
Lead {GLO}| market for | Cut-off	0,01	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,005	kg	
Flat glass, uncoated {RER}| production | Cut-off	0,01	kg	
Synthetic rubber {RER}| production | Cut-off	0,07	kg	
Polypropylene, granulate {RER}| production | Cut-off	0,03	kg	
Lubricating oil {RER}| production | Cut-off	0,002	kg	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,1925	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,01925	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,00825	kg	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,012375	kg	
Copper {GLO}| market for | Cut-off	0,0055	kg	
Zinc {GLO}| market for | Cut-off	0,00275	kg	
Lead {GLO}| market for | Cut-off	0,00275	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,001375	kg	
Flat glass, uncoated {RER}| production | Cut-off	0,00275	kg	
Synthetic rubber {RER}| production | Cut-off	0,01925	kg	
Polypropylene, granulate {RER}| production | Cut-off	0,00825	kg	
Synthetic rubber {RER}| production | Cut-off	0,87	kg	
Paper, woodfree, coated {RER}| paper production, woodfree, coated, at integrated mill | Cut-off	0,012	kg	
Polypropylene, granulate {RER}| production | Cut-off	0,006	kg	
Lead {GLO}| market for | Cut-off	0,06	kg	
Lubricating oil {RER}| production | Cut-off	0,12804	kg	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,04	tkm	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,4	tkm	
Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,0048	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,002992	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,0094656	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,0022417	kg	
Carbon dioxide, fossil	0,000035	kg	
Carbon dioxide, fossil	0,000009625	kg	
Heat, waste	8,012	MJ	
Waste to treatment			
Waste glass sheet {CH}| treatment of, collection for final disposal | Cut-off	0,01	kg	
Waste glass sheet {CH}| treatment of, collection for final disposal | Cut-off	0,00275	kg	
Waste graphical paper {CH}| treatment of, municipal incineration | Cut-off	0,012	kg	

Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,035	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,009625	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,006	kg	
Waste mineral oil {CH}| treatment of, hazardous waste incineration | Cut-off	0,002	kg	
Waste mineral oil {CH}| treatment of, hazardous waste incineration | Cut-off	0,12804	kg	
Harvester machine with engine, LT 5'000 to 10'000h, production/FR. FU = kg per lifetime, based on "Harvester, CH".			
Products			
Harvester machine with engine, LT 5,000 to 10,000h production/FR/I U	1	kg	
Materials/fuels			
Electricity, medium voltage {FR}| market for | Cut-off	1,5	kWh	
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,92	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,84	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,84	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,41556	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	5,304	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,55269	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	7,0543	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,14613	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	1,8651	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,13889	kWh	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,7	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,07	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,03	kg	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,045	kg	
Copper {GLO}| market for | Cut-off	0,02	kg	
Zinc {GLO}| market for | Cut-off	0,01	kg	
Lead {GLO}| market for | Cut-off	0,01	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,005	kg	
Flat glass, uncoated {RER}| production | Cut-off	0,01	kg	
Synthetic rubber {RER}| production | Cut-off	0,07	kg	
Polypropylene, granulate {RER}| production | Cut-off	0,03	kg	
Lubricating oil {RER}| production | Cut-off	0,002	kg	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,175	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,0175	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,0075	kg	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,01125	kg	
Copper {GLO}| market for | Cut-off	0,005	kg	
Zinc {GLO}| market for | Cut-off	0,0025	kg	
Lead {GLO}| market for | Cut-off	0,0025	kg	

Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,00125	kg	
Flat glass, uncoated {RER}| production | Cut-off	0,0025	kg	
Synthetic rubber {RER}| production | Cut-off	0,0175	kg	
Polypropylene, granulate {RER}| production | Cut-off	0,0075	kg	
Synthetic rubber {RER}| production | Cut-off	0,3325	kg	
Paper, woodfree, coated {RER}| paper production, woodfree, coated, at integrated mill | Cut-off	0,00512	kg	
Polypropylene, granulate {RER}| production | Cut-off	0,00256	kg	
Lead {GLO}| market for | Cut-off	0,0256	kg	
Lubricating oil {RER}| production | Cut-off	0,05463	kg	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,04	tkm	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,4	tkm	
Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,0048	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00272	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,0036176	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00095647	kg	
Carbon dioxide, fossil	0,000035	kg	
Carbon dioxide, fossil	0,00000875	kg	
Heat, waste	8,012	MJ	
Waste to treatment			
Waste glass sheet {CH}| treatment of, collection for final disposal | Cut-off	0,01	kg	
Waste glass sheet {CH}| treatment of, collection for final disposal | Cut-off	0,0025	kg	
Waste graphical paper {CH}| treatment of, municipal incineration | Cut-off	0,00512	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,035	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,00875	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,00256	kg	
Waste mineral oil {CH}| treatment of, hazardous waste incineration | Cut-off	0,002	kg	
Waste mineral oil {CH}| treatment of, hazardous waste incineration | Cut-off	0,05463	kg	
General machinery, with tires, LT <2'500h, production/FR. FU = kg per service life, based on "Agricultural machinery, general, CH".			
Products			
General machinery, with tires, LT <2,500h production/FR/I U	1	kg	
Materials/fuels			
Electricity, medium voltage {FR}| market for | Cut-off	1,27	kWh	Production.
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,1	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,718	MJ	Production.
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,7	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,337	kWh	Repair.
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	4,35	MJ	Repair.
Electricity, medium voltage {FR}| market for | Cut-off	0,141	kWh	Waste management.

Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,85	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,06	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,05	kg	
Brass {CH}| production | Cut-off	0,005	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,005	kg	
Synthetic rubber {RER}| production | Cut-off	0,03	kg	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,17	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,012	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,01	kg	
Brass {CH}| production | Cut-off	0,001	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,001	kg	
Synthetic rubber {RER}| production | Cut-off	0,006	kg	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,04	tkm	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,4	tkm	
Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00408	kg	Production
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00222	kg	Repair
Carbon dioxide, fossil	0,000035	kg	
Carbon dioxide, fossil	0,000007	kg	
Heat, waste	7,024	MJ	
Waste to treatment			
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,005	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,001	kg	
General machinery, with tires, LT >5'000h, production/FR. FU = kg per service life, based on "Agricultural machinery, general, CH".			
Products			
General machinery, with tires, LT >5,000h production/FR/I U	1	kg	
Materials/fuels			
Electricity, medium voltage {FR}| market for | Cut-off	1,27	kWh	Production.
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,1	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,718	MJ	Production.
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,7	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,464	kWh	Repair.
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	5,99	MJ	Repair.
Electricity, medium voltage {FR}| market for | Cut-off	0,141	kWh	Waste management.
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,85	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,06	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,05	kg	
Brass {CH}| production | Cut-off	0,005	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,005	kg	

Synthetic rubber {RER}| production | Cut-off	0,03	kg	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,23375	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,0165	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,01375	kg	
Brass {CH}| production | Cut-off	0,001375	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,001375	kg	
Synthetic rubber {RER}| production | Cut-off	0,00825	kg	
Synthetic rubber {RER}| production | Cut-off	0,0583	kg	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,04	tkm	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,4	tkm	
Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00408	kg	Production
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00305	kg	Repair
Carbon dioxide, fossil	0,000035	kg	
Carbon dioxide, fossil	0,000009625	kg	
Heat, waste	7,024	MJ	
Waste to treatment			
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,005	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,001375	kg	
General machinery, with tires, LT 2'500-5'000h, production/FR. FU = kg per lifetime, based on "Agricultural machinery, general, CH".			
Products			
General machinery, with tires, LT 2,500-5,000h production/FR/I U	1	kg	
Materials/fuels			
Electricity, medium voltage {FR}| market for | Cut-off	1,27	kWh	Production.
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,1	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,718	MJ	Production.
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,7	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,421	kWh	Repair.
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	5,44	MJ	Repair.
Electricity, medium voltage {FR}| market for | Cut-off	0,141	kWh	Waste management.
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,85	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,06	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,05	kg	
Brass {CH}| production | Cut-off	0,005	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,005	kg	
Synthetic rubber {RER}| production | Cut-off	0,03	kg	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,2125	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,015	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,0125	kg	
Brass {CH}| production | Cut-off	0,00125	kg	

Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,00125	kg	
Synthetic rubber {RER}| production | Cut-off	0,0075	kg	
Synthetic rubber {RER}| production | Cut-off	0,0165	kg	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,04	tkm	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,4	tkm	
Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00408	kg	Production
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00277	kg	Repair
Carbon dioxide, fossil	0,000035	kg	
Carbon dioxide, fossil	0,00000875	kg	
Heat, waste	7,024	MJ	
Waste to treatment			
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,005	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,00125	kg	
General machinery, without tires, LT 8000h, production/FR. FU = kg per lifetime, based on "Agricultural machinery, tillage, CH".			
Products			
General machinery, without tires, LT 8,000h production/FR/I U	1	kg	
Materials/fuels			
Electricity, medium voltage {FR}| market for | Cut-off	1,25	kWh	
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,1	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,7	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,7	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,33244	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	4,2432	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,13889	kWh	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,84	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,05	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,1	kg	
Brass {CH}| production | Cut-off	0,005	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,0025	kg	
Synthetic rubber {RER}| production | Cut-off	0,0025	kg	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,168	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,01	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,02	kg	
Brass {CH}| production | Cut-off	0,001	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,0005	kg	
Synthetic rubber {RER}| production | Cut-off	0,0005	kg	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,04	tkm	

Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,4	tkm	
Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,004	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,002176	kg	
Carbon dioxide, fossil	0,00001	kg	
Carbon dioxide, fossil	0,000002	kg	
Heat, waste	7,706	MJ	
Waste to treatment			
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,0025	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,0005	kg	
Trailer, < 20 t, production/FR. FU = kg per lifetime, based on "Trailer, CH".			
Products			
Trailer, < 20 t, production/FR/I U	1	kg	
Materials/fuels			
Electricity, medium voltage {FR}| market for | Cut-off	1,25	kWh	
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,1	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,7	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,7	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,33244	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	4,2432	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,55269	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	7,0543	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,13889	kWh	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,7	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,03	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,02	kg	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,19	kg	
Brass {CH}| production | Cut-off	0,005	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,005	kg	
Synthetic rubber {RER}| production | Cut-off	0,05	kg	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,14	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,006	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,004	kg	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,038	kg	
Brass {CH}| production | Cut-off	0,001	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,001	kg	
Synthetic rubber {RER}| production | Cut-off	0,01	kg	
Synthetic rubber {RER}| production | Cut-off	0,3325	kg	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,04	tkm	

Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,4	tkm	
Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,004	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,002176	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,0036176	kg	
Carbon dioxide, fossil	0,00003	kg	
Carbon dioxide, fossil	0,000006	kg	
Heat, waste	5,814	MJ	
Waste to treatment			
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,005	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,001	kg	
Trailer, > 20 t, production/FR. FU = kg per lifetime, based on "Trailer, CH".			
Products			
Trailer, > 20 t, production/FR/I U	1	kg	
Materials/fuels			
Electricity, medium voltage {FR}| market for | Cut-off	1,25	kWh	
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,1	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,7	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,7	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,33244	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	4,2432	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,97379	kWh	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	12,429	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,13889	kWh	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,7	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,03	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,02	kg	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,19	kg	
Brass {CH}| production | Cut-off	0,005	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,005	kg	
Synthetic rubber {RER}| production | Cut-off	0,05	kg	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,14	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,006	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,004	kg	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,038	kg	
Brass {CH}| production | Cut-off	0,001	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,001	kg	
Synthetic rubber {RER}| production | Cut-off	0,01	kg	
Synthetic rubber {RER}| production | Cut-off	0,58583	kg	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,04	tkm	

Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,4	tkm	
Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,004	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,002176	kg	
NMVOC, non-methane volatile organic compounds, unspecified origin	0,0063739	kg	
Carbon dioxide, fossil	0,00003	kg	
Carbon dioxide, fossil	0,000006	kg	
Heat, waste	5,814	MJ	
Waste to treatment			
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,005	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,001	kg	
Slurry tanker, 5'000 lt, production/FR. FU = kg per lifetime, based on "Slurry tanker, CH".			
Products			
Slurry tanker, 5'000 lt, production/FR/I U	1	kg	
Materials/fuels			
Electricity, medium voltage {FR}| market for | Cut-off	1,28	kWh	Production.
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,1	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	0,731	MJ	Production.
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,7	MJ	
Electricity, medium voltage {FR}| market for | Cut-off	0,341	kWh	Repair.
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	4,43	MJ	Repair.
Electricity, medium voltage {FR}| market for | Cut-off	0,142	kWh	Waste management.
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,82	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,05	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,05	kg	
Brass {CH}| production | Cut-off	0,005	kg	
Zinc {GLO}| market for | Cut-off	0,02	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,005	kg	
Synthetic rubber {RER}| production | Cut-off	0,05	kg	
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,164	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,01	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,01	kg	
Brass {CH}| production | Cut-off	0,001	kg	
Zinc {GLO}| market for | Cut-off	0,004	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,001	kg	
Synthetic rubber {RER}| production | Cut-off	0,01	kg	
Synthetic rubber {RER}| production | Cut-off	0,0475	kg	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,04	tkm	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,4	tkm	

Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00414	kg	Production
NMVOC, non-methane volatile organic compounds, unspecified origin	0,00225	kg	Repair
Carbon dioxide, fossil	0,00003	kg	
Carbon dioxide, fossil	0,000006	kg	
Heat, waste	6,254	MJ	
Waste to treatment			
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,005	kg	
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,001	kg	
Agricultural machinery with electronic motor, production/GLO. FU = kg per lifetime			
Products			
Agricultural machinery with electronic motor, production/GLO/I U	1	kg	
Materials/fuels			
Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off	0,756	kg	
Steel, low-alloyed, hot rolled {RER}| production | Cut-off	0,084	kg	
Steel, chromium steel 18/8, hot rolled {RER}| production | Cut-off	0,036	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Cut-off	0,006	kg	
Electricity, medium voltage {FR}| market for | Cut-off	7,97445	kWh	
Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at industrial furnace >100kW | Cut-off	4,92	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, light fuel oil, at industrial furnace 1MW | Cut-off	8,19487	MJ	
Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, at hard coal industrial furnace 1-10MW | Cut-off	0,84	MJ	
Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | Cut-off	0,44	tkm	
Transport, freight train {FR}| processing | Cut-off	0,1	tkm	
Aluminium, wrought alloy {GLO}| market for | Cut-off	0,054	kg	
Copper {GLO}| market for | Cut-off	0,024	kg	
Zinc {GLO}| market for | Cut-off	0,012	kg	
Lead {GLO}| market for | Cut-off	0,012	kg	
Electric motor, vehicle {RER}| production | Cut-off	0,06	kg	
Lubricating oil {RER}| production | Cut-off	0,153267	kg	
Emissions to air			
NMVOC, non-methane volatile organic compounds, unspecified origin	0,0086	kg	
Heat, waste	9,574	MJ	
Carbon dioxide, fossil	0,00653333	kg	
Waste to treatment			
Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off	0,162	kg	
Waste mineral oil {CH}| treatment of, hazardous waste incineration | Cut-off	0,153267	kg	

APPENDIX HH: BUILDING AGRICULTURAL PROCESSES

Table143 shows the grouping of agricultural processes available in InOut, together with the data required for setting up the Ecoinvent® LCI (see B.2.1). The first column contains the name in French, the second the name of the AGRIBALYSE® LCI, the 3rd and 6th columns contain the process flow and actual fuel consumption respectively. The 4th and 5(th) columns are due to the fact that an AGRIBALYSE® LCI may encompass several processes with different fuel consumptions. For example, column 4th shows the fuel consumption of the AGRIBALYSE® LCI for the "general" process (e.g. the LCI for "crushing, with shredder or chipper": 13.47 l/h), to which a correction factor is added (column 5th) to correspond to the specific process (e.g. potato haulm crushing, actual consumption 13 l/h, i.e. a correction factor of 0.47). If we add columns 4 and 5 and multiply by the flow rate, we obtain the data in column 6 (see also B.3.3.4): If an AGRIBALYSE® LCI requires an agricultural process for which column 5 of this table contains a value, an additional input ("Fuel consumption correction") is added to the unit process.

On French farms, a certain number of agricultural machines are stored in sheds (e.g. tractors, sprayers, seed drills, etc.), while others may be kept outdoors (e.g. tillage tools, etc.).

Machinery storage buildings are included in agricultural processes. Agricultural machines such as tractors, self-propelled machines, seed drills and trailers are considered as being stored in sheds, using the "shed" input taken from the Ecoinvent® database. The quantity of input is calculated on the basis of the shed's depreciation time (50 years), lifespan and surface area occupied by the machines.

Machines stored outdoors take up ground surface area, as they are stored on farm land. The surface occupied is therefore indicated in the ecosphere inputs with the "Occupation, heterogenous, agricultural" flow.

Table143: Process and LCI assignment, throughput, fuel consumption and fuel type for agricultural processes used to construct AGRIBALYSE® LCIs.

Process - name filled in	Inventory name.	Work rate h/ha	Fuel consumption l/hour	Fuel correction l per hour	Fuel consumption per hectare	Fuel type
Wood pole routing	Harvesting, with trailer (clementine)/hr/FR	3	3,52		10,56	diesel
Soil refinement	Harrowing, 3m harrow/hr/FR	3	14		42	diesel
Windrowing (9m windrower, 140 hp drive)	Swath, with 9m swather/hr/FR	0,18	13,75		2,48	diesel
Pruning wood swathing	Swath, with swather (orchard)/hr/FR	1,5	6,2		9,3	diesel
Apple tree pruning swath	Swath, with swather (orchard)/hr/FR	1,88	6,2		11,66	diesel
Carrot swathing Aquitaine	Swath, with 1.8m swather (carrot)/hr/FR	4	14,08		56,32	diesel
Application of fruit growth regulator, sprayer	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	1	3,1		3,1	diesel
Nursery weedkiller application	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	4	3,1	-0,45	10,6	diesel
Application of herbicides/fungicides/insecticides	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	0,5	3,1	7,67	5,39	diesel
Application of mineral fertilizers	Fertilizing, with spreader/broadcaster, 500 l (orchard)/hr/FR	0,5	4,2	6,44	5,32	diesel
Peach orchard powder application	Plant protection, spraying, with dusting machine (orchard)/hr/FR	0,1	6,00		0,6	diesel
Application of phytosanitary products for carrots Mont St Michel	Fertilizing or plant protection, with sprayer, 2500 l/hr/FR	0,5	13	-9	2	diesel
Nursery treatment application	Plant protection, spraying, with atomiser 800 l/hr/FR	1	6,16		6,16	diesel

Treatment application, 2500l trailed sprayer	Fertilizing or plant protection, with sprayer, 2500 l/hr/FR	0,08	13		1,04	diesel
Fertilizing the cider orchard	Fertilizing, with spreader/broadcaster, 500 l (orchard)/hr/FR	0,6	4,2		2,52	diesel
Manure application (terrage)	Fertilizing, solid manure (charging and spreading) with 8-10t spreader/hr/FR	1,33	8,70		11,57	diesel
Autumn carrot digging Mont St Michel	Harvesting, 1 row puller/hr/FR	12,5	8,8		110	diesel
Harvesting organic carrots Normandy	Harvesting, 1 row puller/hr/FR	25	8,8		220	diesel
Vine removal for narrow vines	Grubbing of vine-stocks, with puller/hr/FR	20	22		440	diesel
Vine removal for wide vines	Grubbing of vine-stocks, with puller/hr/FR	10	22		220	diesel
Tree removal	Rooting up trees, with tractopelle/hr/FR	8	20		160	diesel
Aquitaine carrot harvesting with trailed tool	Harvesting, 3 row puller/hr/FR	2,5	14,08		35,2	diesel
Uprooting vine nursery plants	Grubbing/Sorting of maiden tree, with puller/hr/FR	9,7	13.9	-1.68	118.6	diesel
Scion harvesting	Grubbing/Sorting of maiden tree, with puller/hr/FR	37,5	13,86		519,75	diesel
Grubbing apple scions	Grubbing/Sorting of maiden tree, with puller/hr/FR	25	13,86		346,5	diesel
Tomato harvesting, cold shelter	Rooting up, with font fork/hr/FR	10	4,62		46,2	diesel
Orchard uprooting	Rooting up trees, with tractopelle/hr/FR	8	20,00		160	diesel
Aquitaine carrot harvesting with self-propelled harvester	Harvesting and tailing, with complete harvester (carrot)/hr/FR	2,5	17,6		44	diesel
Nursery scion harvester	Grubbing/Sorting of maiden tree, with puller/hr/FR	37,5	13,86		519,75	diesel
Harvesting assistance	Harvesting assistence, with trailer (orchard)/hr/FR	3	3,08		9,24	diesel

Apple harvesting assistance	Harvesting assistence, with trailer (orchard)/hr/FR	3,5	3,08		10,78	diesel
Covering carrot Aquitaine	Maintenance, covering with plastic, with lifter/hr/FR	0,67	13,13		8,8	diesel
Carrot baling Mont St Michel	Maintenance, covering with and withdrawing of plastic, with lifter/hr/FR	2	3,65		7,3	diesel
Hoeing	Hoeing, with 4-6m hoe (standard)/hr/FR	0,33	15		4,95	diesel
Carrot hoeing Aquitaine	Hoeing, with 3 boards hoe/hr/FR	0,67	7,91		5,3	diesel
Organic carrot hoeing Normandy	Hoeing, with 2 row hoe/hr/FR	1	6,17	2,63	8,8	diesel
Carrot hoeing Normandy	Hoeing, with 2 row hoe/hr/FR	1,33	6,17		8,21	diesel
Vine hoeing	Hoeing, with 2 row hoe/hr/FR	1,5	4.4	2.34	10.1	diesel
Cold shelter bleaching	Bleaching of greenhouse, with tractor and atomizer/hr/FR	2	6,15		12,3	diesel
Greenhouse bleaching	Bleaching of greenhouse, with tractor and atomizer/hr/FR	10	0,45		4,5	diesel
Greenhouse wall whitening	Bleaching of greenhouse, with tractor and atomizer/hr/FR	1	6,15		6,15	diesel
Pruning wood shredding	Crushing wood, with hammer mill/hr/FR	2	9,20		18,4	diesel
Shredding apple tree prunings	Crushing wood, with hammer mill/hr/FR	2,5	9,20		23	diesel
potato haulm shredder, haulm shredder	Crushing, with shredder or chipper/hr/FR	1	13,47	-0,47	13	diesel
Shredding carrot tops	Crushing, with shredder or chipper/hr/FR	0,5	13,47	-0,26	6,61	diesel
Shredding prunings	Crushing wood, with shredder/hr/FR	2	8		16	diesel
Straw chopper, shredder	Crushing, with shredder or chipper/hr/FR	0,67	13,47		9,02	diesel

Shredding vine shoots	Crushing, with shredder or chipper/hr/FR	1	13.5	-1.32	12.2	diesel
Shredding vine shoots with high-clearance tractor	Crushing, with shredder or chipper/hr/FR	1	13.5	-1.32	12.2	diesel
Shredding wide vine shoots	Crushing, with shredder or chipper/hr/FR	0,6	13.5	-4.92	5.1	diesel
North tunnel plastic lining	Earthing up, with bedder/hr/FR	2,5	7,7		19,25	diesel
Plastic lining south tunnel	Earthing up, with bedder/hr/FR	3,75	7,7		28,88	diesel
Potato ridging, ridging machine	Earthing up, with 2 row hoe/hr/FR	0,6	21		12,6	diesel
Straight vine training	Earthing-up (buttage) of vine, with disc harrow/hr/FR	2,8	10		28	diesel
Loading compost	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	0,5	4,88		2,44	diesel
Loading and unloading scions	Maintenance, rooting up maiden tree, with elevator (special crops)/hr/FR	50	3,52		176	diesel
Loading and unloading scions from the truck	Maintenance, rooting up maiden tree, with elevator (special crops)/hr/FR	50	3,52		176	diesel
Loading manure	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	0,5	4,88		2,44	diesel
Organic matter loading	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	0,5	4,88		2,44	diesel
Organic carrot straw loading	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	2	4,88		9,76	diesel
Loading and spreading manure, with crane and trailer (5t) manure spreader	Fertilizing, solid manure (charging and spreading) with 8-10t spreader/hr/FR	1,33	8,70		11,57	diesel
Liming carrot Aquitaine	Fertilizing, with self-propelled tanker/hr/FR	0,1	20		2	diesel

Coffee harvester	Harvesting, with complete harvester (coffee)/hr/GLO	1	6		6	diesel
Convoying (distancing)	Transporting, with conveyor/p/FR	1	0,45		0,45	diesel
Conveying (potting)	Transporting, with conveyor/p/FR	1	0,45		0,45	diesel
Cover-crop, cover-crop 4m	Soil maintenance, with cover crop 4m/hr/FR	0,5	20		10	diesel
Cover-crop (disking), cover-crop 3m	Soil maintenance, with cover crop 4m/hr/FR	0,5	20		10	diesel
2.5m chisel cultivator	Soil decompactation, with 4.5m chisel/hr/FR	0,8	25		20	diesel
Chisel cultivator 4.5m	Soil decompactation, with 4.5m chisel/hr/FR	0,83	25		20,75	diesel
Carrot grower Normandy	Soil decompactation, with chisel and roller/hr/FR	0,6	11,1		6,66	diesel
Cultivating	Harrowing, with vibrating tine cultivator (standard equipment) 5m/hr/FR	1	15	5,56	20,56	diesel
Carrot unloading Aquitaine	Maintenance, withdrawing of plastic, with lifter/hr/FR	0,67	13,13		8,8	diesel
Greenhouse bleaching	Bleaching of greenhouse, with tractor and atomizer/hr/FR	6	0,45		2,7	diesel
Narrow vine debut	Ploughing-back (debuttage) of vine, with inter-vine plough/hr/FR	2,8	15		42	diesel
Stubble ploughing peach nursery	Maintenance, with rolling off device (special crops)/hr/FR	1,33	0,4	6,56	9,26	petrol
Stubble ploughing peach/apple nursery	Maintenance, with rolling off device (special crops)/hr/FR	1,33	0,4	6,56	9,26	petrol
Stubble ploughing in apple nursery	Stubble ploughing, with stuble share 2.5m (orchard)/hr/FR	1,33	7,04		9,36	diesel
Stubble cultivation, 4m disc harrow	Stubble ploughing, with stuble share 5.5m/hr/FR	0,43	16		6,88	diesel

Stubble ploughing, mounted stubble cultivator	Stubble ploughing, with stuble share 5.5m/hr/FR	0,31	16		4,96	diesel
Plastic removal of North tunnel cover	Baring plastic (greenhouse)/hr/FR	2	6,15		12,3	diesel
Plastic removal of South tunnel cover	Baring plastic (greenhouse)/hr/FR	3	6,15		18,45	diesel
Decompacting carrots Aquitaine	Soil decompactation, with heavy tractor/hr/FR	0,29	8,90		2,58	diesel
Decompacting cider orchards	Soil decompactation, with decompactation machine (orchard)/hr/FR	1	12,32		12,32	diesel
Decompacting, 5-body decompactor	Soil decompactation/hr/FR	0,77	17,69		13,62	diesel
Deep ploughing	Preparing ground, with trenching plough/hr/FR	15	9.5		142.5	diesel
Trimming	Distributing straw, with rotary tedder/hr/FR	8	4,63		37,04	diesel
Unrolling the hail protection net	Maintenance, with rolling off device, heavy tractor (special crops)/hr/FR	5,5	2,64		14,52	diesel
Unwinding and winding drop by drop	Maintenance, with rolling off device, heavy tractor (special crops)/hr/FR	8	2,64		21,12	diesel
Unwinding ridge wire	Maintenance, with rolling off device, heavy tractor (special crops)/hr/FR	1	2,64		2,64	diesel
Unwinding wire trellising	Maintenance, with rolling off device (special crops)/hr/FR	12	0,4		4,8	petrol
Chemical weeding	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	2	3,1		6,2	diesel
Chemical weed control carrot Aquitaine	Plant protection, chemical weeding, with self-propelled machine/hr/FR	0,1	12		1,2	diesel
Chemical weed control carrot Normandy	Plant protection, spraying, with sprayer, 1200 l/hr/FR	0,5	12,22	-4,22	4	diesel

Chemical orchard weeding	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	2	3,1		6,2	diesel
Chemical weeding in apple orchards	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	2,5	3,1	3,06	15,4	diesel
Mango mechanical weeding	Plant protection, weeding, with rotary beater/hr/FR	1,1	4.6	0.36	5.5	diesel
Manual mechanical weeding	Plant protection, weeding, with portable swinging scythe/hr/FR	5	0,4		2	petrol
Mechanical weeding in open orchards	Plant protection, weeding, with vibrating tine/hr/FR	2,5	7,68		19,2	diesel
Mechanical weeding of peach orchard rows	Plant protection, weeding, with cutter/hr/FR	1,5	7,7		11,55	diesel
Mechanical weeding of apple orchards on the row	Plant protection, weeding, with cutter/hr/FR	1,88	7,7		14,48	diesel
Mechanical weeding, mowing with 2m rotary mower	Plant protection, weeding, with rotary beater/hr/FR	0,5	4,62		2,31	diesel
Thermal weeding of organic carrots	Plant protection, weeding, with thermic weeder/hr/FR	2	6,6		13,2	diesel
Weeding cider orchards	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	0,8	3,1		2,48	diesel
Weeding narrow vines	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	1	3.1	0.81	3.9	diesel
Soil disinfection carrot Aquitaine	Soil maintenance (disinfection), with spreader and heavy tractor/hr/FR	0,29	13,5		3,92	diesel
Soil disinfection carrot Normandie	Soil maintenance (desinfection) with incorporateur (carrot)/FR	1	15,80		15,8	diesel
Soil disinfection Mont St Michel	Soil maintenance (desinfection) with incorporateur (carrot)/FR	1	15,80	0,7	16,5	diesel
Distribution of straw before spreading	Harvesting assistence, with trailer (carrot)/hr/FR	8	3,08		24,64	diesel

Wooden pole distribution	Maintenance, setting pillar, with elevator (special crops)/hr/FR	3	3,08		9,24	diesel
Disbudding in nurseries	Maintenance, cutting buds (special crops)/hr/FR	9	0,8		7,2	petrol
Disbudding Large vines	Disbudding, with trunk cleaner/hr/FR	2,4	9		21.6	diesel
Scion topping before digging	Maintenance, pruning or cutting, with header / bunch limber/hr/FR	5,33	5,27		28,09	diesel
Topping up straight vines with a high-clearance tractor	Tipping, with vine shoot tipping machine/hr/FR	1	15	-3.24	11.8	diesel
Carrot leaf removal Normandy	Harvest related workleaf stripping, with leaf stripper/hr/FR	2	14,1		28,2	diesel
Leaf-thinning on straight vines	Leaf thinning, with leaf stripper/hr/FR	3	5		15	diesel
Removing plants from the greenhouse	Rooting up plant/hr/FR	2	4,60		9,2	diesel
Organic carrot straw removal	Distributing straw, with rotary tedder/hr/FR	12	4,63	1,97	79,2	diesel
Wrapping with wrapper 17 bales/hour	Harvesting, with balling machine/t/FR	1	2,09		2,09	diesel
Silage (600 hp forage harvester with attached bucket)	Harvesting silage grass, with hay chopper and blower/hr/FR	0,29	84,00	8,4	26,8	diesel
Tomato plant care	Maintenance, with electric carriage (greenhouse)/hr/FR	2	950		1900	electricity
De-budding and weeding wide vines	Disbudding, with trunk cleaner/hr/FR	1,8	9	-0.9	14.6	diesel
Mechanical pruning of straight vines	Disbudding, with trunk cleaner/hr/FR	2,5	9	0.9	24.8	diesel
Liquid nitrogen spreading, sprayer, trailed 2500l	Fertilizing or plant protection, with sprayer, 2500 l/hr/FR	0,08	13		1,04	diesel

Lime spreading	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	0,66	4,88		3,22	diesel
Spreading compost	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	1,25	4,88		6,1	diesel
Straw spreading	Distributing straw, with rotary tedder/hr/FR	3	4,63		13,89	diesel
Slurry spreading, slurry tanker/pressure tanker	Fertilizing, slurry, with tanker/hr/FR	1	5		5	diesel
Slurry spreading, pendillary slurry spreader 1500-2000l	Fertilizing, slurry, with tanker/hr/FR	1	5		5	diesel
Spreading carrot fertilizer Aquitaine	Fertilizing, solid manure (spreading only), with 8-10t spreader/hr/FR	0,25	8,70	-6,7	0,5	diesel
Spreading organic carrot fertilizer Normandy	Fertilizing, with spreader, 2500 l/hr/FR	0,33	13	-6,33	2,2	diesel
Spreading carrot fertilizer Mont St Michel	Fertilizing, with spreader, 2500 l/hr/FR	0,17	13	-6,53	1,1	diesel
Spreading carrot fertilizer Normandy	Fertilizing, with spreader, 2500 l/hr/FR	0,25	13	-7,8	1,3	diesel
Spreading fertilizer under cover	Fertilizing, with spreader/broadcaster, 500 l (orchard)/hr/FR	1,5	4,2		6,3	diesel
Fertilizer spreading, 2500l mounted spreader	Fertilizing, with spreader, 2500 l/hr/FR	0,12	13		1,56	diesel
Manure spreading	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	1,25	4,88		6,1	diesel
Spreading organic matter	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	1,25	4,88		6,1	diesel
Spreading organic carrot straw	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	8	4,88		39,04	diesel
Vine nursery spreading	Fertilizing, solid manure (charging and spreading) with 8-10t spreader/hr/FR	2,4	8.7	-0.63	19.4	diesel

Vigne etroite spreading	Fertilizing, solid manure (charging and spreading) with 8-10t spreader/hr/FR	0,75	8.7	1.17	7.4	diesel
Wide vine spreading	Fertilizing, solid manure (charging and spreading) with 8-10t spreader/hr/FR	0,3	8.7	0.27	2.7	diesel
Manure spreading, manure spreader	Fertilizing, solid manure (charging and spreading) with 8-10t spreader/hr/FR	1,33	8,70		11,57	diesel
Gasoline	Plant protection, spraying, with knapsack sprayer/hr/FR	0,33	2.67		0.9	fuel
Organic carrot straw spread	Distributing straw, with rotary tedder/hr/FR	2	4,63	2,19	13,64	diesel
Rootstock topping	Maintenance, pruning or cutting, with chopper blower/hr/FR	5,33	7,04		37,52	diesel
Rootstock topping with pruning shears	Maintenance, cutting buds (special crops)/hr/FR	16	0,8		12,8	petrol
Windrow tedding with 3 m windrower tedder	Haying, with tedder/hr/FR	0,5	2		1	diesel
Mowing (7m mower, 300 hp drive)	Mowing, with rotary mower 7m/hr/FR	0,19	22,26		4,23	diesel
Mowing, mower conditioner	Mowing, with rotary mower 3m/hr/FR	0,5	5,7	-3,1	1,3	diesel
Mowing, 3m rotary mower	Mowing, with rotary mower 3m/hr/FR	0,5	5,7		2,85	diesel
Medium mango spray fertilization	Fertilizing or plant protection, with sprayer, 2500 l	0,42	5		2.1	diesel
Foliar spray fertilization, atomizer	Fertilizing, with spreader/broadcaster, 500 l (orchard)/hr/FR	1	4,2		4,2	diesel
Fertilization, 1500l centrifugal spreader	Fertilizing, with spreader, 2500 l/hr/FR	0,12	13		1,56	diesel
Fertilization, 500l centrifugal spreader	Fertilizing, with spreader, 2500 l/hr/FR	0,12	13		1,56	diesel
Tying up plants	Maintenance, tying of plants, with binding machine (special crops)/hr/FR	5	1,00		5	diesel

Soil supply	Transporting of growing media, with trailer/p/FR	1	0,45		0,45	diesel
Milling, milling cutter with lump breaker roller	Hoeing, with rotary hoe 3m/hr/FR	1,3	11.2		14.6	diesel
Carrot milling Mont St Michel	Soil maintenance, with rotary cultivator/hr/FR	2,5	41,2		103	diesel
Scratching the nursery soil	Hoeing, with 2 row hoe/hr/FR	4	6,17	-1,77	17,6	diesel
Scratching narrow vines	Soil preparation (vine), with harrow/hr/FR	1,4	9.5		13.3	diesel
Scratching wide vines	Soil preparation (vine), with harrow/hr/FR	1	9.5		9.5	diesel
Harrowing, 4m rotary harrow	Harrowing, with rotary harrow (standard equipment)/hr/FR	0,7	14,3		10,01	diesel
Harrowing, rotary harrow with packer roller	Harrowing, with rotary harrow (standard equipment)/hr/FR	0,7	14,3		10,01	diesel
Hersage carrot after disinfection	Harrowing, with rotary harrow (standard equipment)/hr/FR	0,33	14,3	5,4	6,5	diesel
Organic carrot harvester Normandy	Harrowing, with rotary harrow (standard equipment)/hr/FR	1	14,3	-1,1	13,2	diesel
Carrot weevil Mont St Michel	Harrowing, with rotary harrow (standard equipment)/hr/FR	1,33	14,3	2,17	21,91	diesel
Peach tree nursery	Harrowing, with rotary harrow and packer (orchard)/hr/FR	2	13,85		27,7	diesel
Harvesting peach/apple nursery	Harrowing, with rotary harrow and packer (orchard)/hr/FR	2	13,85		27,7	diesel
Apple nursery	Harrowing, with rotary harrow and packer (orchard)/hr/FR	2	13,85		27,7	diesel
Harvesting under cover	Harrowing, with rotary harrow and packer (orchard)/hr/FR	5	13,85	-6,15	38,5	diesel

Hersage cider orchard	Harrowing, with small tractor (orchard)/hr/FR	1	9,20	4,88	14,08	diesel
Harrow 12m	Harrowing, with harrow 12m/hr/FR	0,11	10,8		1,19	diesel
Platform time	Maintenance, with platform self-propelled (special crops)/hr/FR	1	1,17		1,17	electricity
Tractor and compressor time	Maintenance, with compressor (special crops)/hr/FR	1	3,10		3,1	diesel
Installing trellis anchors	Maintenance, pillar installation, with post hole digger (special crops)/hr/FR	2,5	5,28		13,2	diesel
Intercep vigne etroite	Hoeing, with 2 row hoe/hr/FR	2,1	4.4	9.54	29.3	diesel
Interceps wide vine	Hoeing, with 2 row hoe/hr/FR	1,2	4.4	9.54	16.7	diesel
Ploughing	Ploughing (vine), with frame plough/hr/FR	1,5	8	10.8	28.2	diesel
Ploughing, 5 furrow plough	Ploughing, with 5 or 6 soc plough/hr/FR	1,33	18,75		24,9	diesel
Ploughing before planting orchard	Ploughing, in orchard/hr/FR	1	16,15	-2,07	14,08	diesel
Ploughing with plough frame - vineyard vinep	Ploughing (vine), with frame plough/hr/FR	1,45	8		11.6	diesel
Carrot ploughing Aquitaine	Ploughing, with 8 soc plough/hr/FR	0,5	24,60		12,3	diesel
Organic carrot ploughing Normandy	Ploughing, with 5 or 6 soc plough/hr/FR	1	18,75	2,35	21,1	diesel
Carrot ploughing Mont St Michel	Ploughing, with 5 or 6 soc plough/hr/FR	0,67	18,75	4,39	15,5	diesel
Carrot ploughing Normandy	Ploughing, with 4 soc plough/hr/FR	1	15,80		15,8	diesel
Ploughing peach nursery	Ploughing, in orchard/hr/FR	2	16,15		32,3	diesel
Ploughing peach/apple nursery	Ploughing, in orchard/hr/FR	2	16,15		32,3	diesel
Ploughing apple nursery	Ploughing, in orchard/hr/FR	2	16,15		32,3	diesel

Deep ploughing orchard	Ploughing, with 1 soc plough/hr/FR	3	24,67		74,01	diesel
Wide vine ploughing	Ploughing (vine), with frame plough/hr/FR	1,4	8	1.35	13.1	diesel
Ploughing, quadrisoc plough	Ploughing, with 5 or 6 soc plough/hr/FR	1,4	18,75		26,25	diesel
Land preparation - Dry	Soil preparation, with disc harrow/hr/FR	3	4,24		12,72	petrol
Land preparation - Humid	Soil preparation, with disc harrow/hr/FR	2,5	4,24		10,6	petrol
Land preparation post seeding	Soil preparation, with rotary tiller/hr/FR	2,5	4,24		10,6	petrol
Land preparation pre seeding	Soil preparation, with rotary tiller/hr/FR	2,5	4,24		10,6	petrol
Handling potato plants	Maintenance, with forklift truck/hr/FR	0,86	20,77		17,86	diesel
Impoundment (3.5h)	Flooding of paddy fields, with motor cultivator/hr/FR	3,5	0,64		2,24	petrol
Impoundment of lockers (11h)	Flooding of paddy fields, with motor cultivator/hr/FR	11	0,64		7,04	petrol
Impoundment of lockers (7h)	Flooding of paddy fields, with motor cultivator/hr/FR	7	0,64		4,48	petrol
Scion gauging and gauge output	Sowing or planting, maiden tree, with ditcher/hr/FR	20	7,04		140,8	diesel
Harvesting, cereal combine 200 hp	Harvesting, with combine harvester/hr/FR	0,67	25,60		17,15	diesel
Setting up organic carrot beds in Normandy	Earthing up, with 2 row hoe/hr/FR	1,5	21,00	-3,4	26,4	diesel
Mont St Michel carrot ridge assembly	Earthing up, with how (carrot)/hr/FR	1,33	6,15	4,82	14,59	diesel
Setting up carrot beds in Normandy	Earthing up, with how (carrot)/hr/FR	2	6,15		12,3	diesel
Opening and closing trenches for drip irrigation	Tillage, irrigation preparation/hr/FR	3	7,70		23,1	diesel
Trellising (sinking of posts)	Indentation of pots, with tractopelle/hr/FR	2,66	20,00		53,2	diesel

Planting + ridging potatoes, planter + 4-row ridging machine	Sowing or planting and earthing up, potato, with 4-row-planter and 2 row how/hr/FR	0,9	20,00		18	diesel
Planting trellis poles in the nursery	Maintenance, setting pillar for tying in (special crops)/hr/FR	2,66	3,53		9,39	diesel
Planting apple trellis posts	Maintenance, setting pillar for tying in (special crops)/hr/FR	4	3,53	1,75	21,12	diesel
Marcotte apple tree plantation	Sowing or planting, trees (orchard)/hr/FR	20	5,61		112,2	diesel
Peach tree rootstock core planting	Sowing or planting, trees (orchard)/hr/FR	16	5,61		89,76	diesel
Staking narrow vines before trellising	Maintenance, setting pillar for tying in (special crops)/hr/FR	8	3.5	0.87	34.9	diesel
Planting wide vine stakes before trellising	Maintenance, setting pillar for tying in (special crops)/hr/FR	3	3.5	0.87	13.1	diesel
Potato planting, 4-row planter	Sowing or planting, potato, with 4-row-planter/hr/FR	1	17,20		17,2	diesel
Rootstock planting nursery	Sowing or planting, trees (orchard)/hr/FR	14	5,61	5,61	157,08	diesel
Cider orchard planting	Sowing or planting, trees (orchard)/hr/FR	1,25	5,61	1,43	8,8	diesel
Double-row plastic coating for nursery vines	Maintenance, soil covering with plastic (grafted vine plants)/hr/FR	3	8		24	diesel
Ploughing	Ploughing, with 5 or 6 soc plough/hr/FR	0,87	18,75	-5,56	11,48	diesel
Installing stakes in nurseries	Maintenance, rooting up maiden tree, with elevator (special crops)/hr/FR	8	3,52		28,16	diesel
Installation and removal of trellis wire in nurseries	Maintenance, with rolling off device, heavy tractor (special crops)/hr/FR	12	2,64		31,68	diesel
Pushing pruning wood	Pushing wood, with small tractor/hr/FR	5	1,1		5,5	diesel

Preparing the Aquitaine carrot boards	Soil decompactation, with cultivator/hr/FR	1	26,40		26,4	diesel
Seedbed preparation	Harrowing, with small tractor (orchard)/hr/FR	1	9,20		9,2	diesel
Apple seedbed preparation	Harrowing, with small tractor (orchard)/hr/FR	1,25	9,20		11,5	diesel
Soil preparation for orchard planting	Tillage, ploughing, tree nursery/hr/FR	0,83	7,70		6,39	diesel
Soil preparation for apple orchard planting	Tillage, ploughing, tree nursery/hr/FR	1,04	7,70		8,01	diesel
Soil preparation for drip trench	Maintenance, preparation soil for irrigation channel, with rotary hoe (special crops)/hr/FR	3	7,93		23,79	diesel
Hay baling (4 t ms/ha) with round baler	Baling, with round baler (straw)/ha/FR	1	11,7		11,7	diesel
Large vine pruning	Preliminary pruning, with pruning machine/hr/FR	1,5	22		33	diesel
Straight vine pruner	Preliminary pruning, with pruning machine/hr/FR	2	22		44	diesel
Crop protection: greenhouse sprayer	Plant protection, spraying, with self-propelled atomiser/hr/FR	2,5	4,60		11,5	diesel
Plant protection, with the 1200l sprayer	Plant protection, spraying, with sprayer, 1200 l/hr/FR	0,11	12,22		1,34	diesel
Crop protection, with the 2500l sprayer	Fertilizing or plant protection, with sprayer, 2500 l/hr/FR	0,08	13,00		1,04	diesel
Crop protection, 800 l mounted sprayer, tree nursery	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	1	6,15		6,15	diesel
Pseudo-tillage, chisel with 13 teeth	Soil decompactation, with 4.5m chisel/hr/FR	0,63	25,00		15,75	diesel
Mounted sprayer 400L vineyard and nursery treatment equipment	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	1	8.8	5.58	14.4	diesel
Pulverization for uprooting	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	2	8.8	5.58	28.8	diesel

Straight vine spraying	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	1	8.8	3.78	12.6	diesel
Wide vine spraying	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	0,5	8.8	5.13	7	diesel
Forage harvesting, self-propelled forage harvester	Harvesting silage grass, with hay chopper and blower/hr/FR	0,5	84,00		42	diesel
Carrot harvest Créances	Harvesting, 1 row puller/hr/FR	11	8,80		96,8	diesel
Winter carrot harvest in Aquitaine with self-propelled harvester	Harvesting, with complete harvester (carrot)/hr/FR	4	17,60		70,4	diesel
Aquitaine winter carrot harvest with trailed harvester	Harvesting, 3 row puller/hr/FR	4	14,08		56,32	diesel
Winter carrot harvest Mont St Michel	Harvesting, 1 row puller/hr/FR	14	8,80		123,2	diesel
Carrot harvest Val de Saire autumn	Harvesting, 1 row puller/hr/FR	15	8,80		132	diesel
Carrot harvest Val de Saire winter	Harvesting, 1 row puller/hr/FR	17,5	8,80		154	diesel
Beet harvesting with a split job: 1 tractor with leaf stripper, 6-row harvester and loading, tractor equipped with leaf stripper and 6-row harvester-loader beet.	Harvesting, with tractor an 6 row rooting up (beets)/hr/FR	1,3	25,00		32,5	diesel
Beet harvesting, 6-row self-propelled loader harvester + (1 or 2 trailers)	Harvesting, with complete harvester (6 row) and trailers (beets)/hr/FR	1	40,00		40	diesel
Beet harvesting, 6-row integral self-propelled machine	Harvesting, with complete harvester (beets)/hr/FR	1	40,00		40	diesel
Clementine harvest	Harvesting, with trailer (clementine)/hr/FR	9	3,52		31,68	diesel
Potato harvest, potato harvester	Harvesting, with complete harvester (potatoes)/hr/FR	2	16		32	diesel

Mechanical harvesting of cider apples	Harvesting, with harvester (fruits)/hr/FR	3	14,08		42,24	diesel
Rice harvest	Harvesting, with combine harvester/hr/FR	0,83	25,6		21,25	diesel
Carrot recovery and transport Receivables	Harvesting assistence, with trailer (carrot)/hr/FR	11	3,08		33,88	diesel
Autumn carrot recovery and transport Mont St Michel	Harvesting assistence, with trailer (carrot)/hr/FR	12,5	3,08		38,5	diesel
Winter carrot recovery and transport Mont St Michel	Harvesting assistence, with trailer (carrot)/hr/FR	14	3,08		43,12	diesel
Carrot recovery and transport Val de Saire autumn	Harvesting assistence, with trailer (carrot)/hr/FR	15	3,08		46,2	diesel
Carrot recovery and transport Val de Saire winter	Harvesting assistence, with trailer (carrot)/hr/FR	17,5	3,08		53,9	diesel
Core recovery and transport Aquitaine	Harvesting assistence, with trailer (21 t)/hr/FR	2,5	7,05		17,63	diesel
Recovery and transport of winter carrots Aquitaine	Harvesting assistence, with trailer (21 t)/hr/FR	4	7,05		28,2	diesel
Potting	Repotting, with potting machine/hr/FR	1	0,45		0,45	electricity
Ploughing apple orchard	Soil decompactation, with 4.5m chisel/hr/FR	0,63	25		15,75	diesel
Carrot turning Mont St Michel	Preparation of soil, with plough (before carrot harvest)/hr/FR	3	15,8	-5,23	31,71	diesel
Carrot turning Aquitaine	Preparation of soil, with plough (before carrot harvest)/hr/FR	1	15,80		15,8	diesel
Removal of trellis wires before uprooting apple orchard	Maintenance, with rolling off device (special crops)/hr/FR	6	0,4		2,4	petrol
Trimming vine nursery with tractor	Tipping, with vine shoot tipping machine/hr/FR	3,6	15		54	diesel
Narrow vine trimming	Tipping, with vine shoot tipping machine/hr/FR	1,4	15		21	diesel
Wide vine trimming	Tipping, with vine shoot tipping machine/hr/FR	1	15	-3.24	11.8	diesel

Rotavator carrot Normandy	Hoeing, with rotary hoe 3m/hr/FR	0,4	13,25		5,3	diesel
Rotavator under cover	Hoeing, with rotary hoe (greenhouse)/hr/FR	7	7,70		53,9	diesel
Rotobèche under cover	Hoeing, with rotobêche/hr/FR	7	7,70		53,9	diesel
Roller, splined roller 3m	Rolling, with roller 3m/hr/FR	0,59	4,20		2,48	diesel
Rolling, 9m roller	Rolling, with roller 9m/hr/FR	0,2	15,00		3	diesel
Soil rolling before sowing straight vines	Rolling, with roller 9m/hr/FR	1	10	-4.5	5.5	diesel
Shaking trees before harvesting	Shaking, with shaker (orchard)/hr/FR	1	8,80		8,8	diesel
Seeding, conventional 4 m seeder	Sowing or planting, with classic seeder and harrow/hr/FR	1,3	12		15.6	diesel
Carrot sowing Aquitaine	Sowing or planting, with 3 row seeder (carrot)/hr/FR	1	7,90		7,9	diesel
Sowing organic carrots Normandy	Sowing or planting, with pneumatic seeder (carrot)/hr/FR	1,5	6,16	2,64	13,2	diesel
Carrot sowing Normandy	Sowing or planting, with pneumatic seeder (carrot)/hr/FR	2,5	6,16		15,4	diesel
Combi seeding, drill, mechanical	Sowing or planting, with classic seeder and harrow/hr/FR	0,83	16,83		13,97	diesel
Combi seeding, drill, single-seeder	Sowing or planting, with pneumatic seeder and harrow/hr/FR	0,83	16,83		13,97	diesel
Direct seeding, disc seeder, 4m	Sowing or planting, direct seeding/hr/FR	0,42	14,29		6	diesel
Orchard sowing	Sowing or planting, grass (orchard)/hr/FR	1	6,16		6,16	diesel
Sowing grass in apple orchard	Sowing or planting, grass (orchard)/hr/FR	1,25	6,16		7,7	diesel

Single-seed, single-seed drill, pneumatic	Sowing or planting, with pneumatic seeder, 6 rows/hr/FR	0,67	13,47		9,02	diesel
Scions out of the nursery	Maintenance, rooting up maiden tree, with elevator (special crops)/hr/FR	20	3,52		70,4	diesel
Scions out of the nursery	Maintenance, rooting up maiden tree, with elevator (special crops)/hr/FR	20	3,52		70,4	diesel
Subsoiling - decompacting	Soil decompactation, with subsoil plow 2m/hr/FR	2	13	1.8	29.6	diesel
Carrot subsoil Mont St Michel	Soil decompactation/hr/FR	0,67	17,69	5,44	15,5	diesel
Carrot subsoil Normandy	Soil decompactation, with subsoil plow 2m/hr/FR	1	13,00	5,5	18,5	diesel
Under soil under plastic cover	Soil decompactation, with subsoil plow 2m/hr/FR	3	13,00		39	diesel
Underflooring, subsoiler	Soil decompactation, with subsoil plow 2m/hr/FR	2	13		26	diesel
Subsoleuse-mangue	Soil decompactation, with subsoil plow 2m/hr/FR	1,5	13	6.3	29	diesel
Pruning cider orchard	Maintenance, pruning or cutting, with chain saw/hr/FR	15	0,48		7,2	petrol
Cider orchard pruning (trimming)	Maintenance, pruning, with angle mower/hr/FR	6	8,8		52,8	diesel
Silo settlement	Silage plat, settling for silage with 2 tractors/hr/FR	0,61	11,53		7,03	diesel
Tillage / Rolling	Rolling, with roller 9m/hr/FR	0,33	15		4,95	diesel
Mowing weeds in orchards	Plant protection, weeding, with rotary beater/hr/FR	0,75	4,62		3,47	diesel
Mowing weeds in apple orchards	Plant protection, weeding, with rotary beater/hr/FR	0,94	4,62		4,34	diesel
Inter-row mowing cider orchard	Plant protection, weeding, with mower/hr/FR	0,9	4,7		4,23	diesel
Mowing between rows of narrow vines	Plant protection, weeding, with mower/hr/FR	2	4.7	4.77	18.9	diesel

Manual herbicide treatment	Plant protection, spraying, with knapsack sprayer/hr/TH	3	11,7		35,1	diesel
Manual insecticide treatment	Plant protection, spraying, with knapsack sprayer/hr/TH	3	0,5		1,5	diesel
Phytosanitary treatment against California citrus louse (fruit fly), lance sprayer	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	3	3,1		9,3	diesel
Phytosanitary treatment against citrus pests (leafminer, ceratitis), sprayer	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	1	3,1		3,1	diesel
Average phytosanitary treatment for mango	Fertilizing or plant protection, with sprayer, 2500 l/hr/FR	0,42	13	-7.2	2.4	diesel
Phytosanitary treatment under cover	Plant protection, spraying, with atomiser (greenhouse)/hr/FR	4	1,76		7,04	diesel
Phytosanitary treatment peach orchard	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	0,5	8,80		4,4	diesel
Phytosanitary treatment apple orchard	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	0,75	8,80	-2,64	4,62	diesel
Cider orchard treatment	Plant protection, spraying, with trailed atomizer, 2000l/hr/FR	0,67	8,80		5,9	diesel
Carrot phytosanitary treatments Aquitaine	Plant protection, chemical weeding, with self-propelled machine/hr/FR	0,1	12,00		1,2	diesel
Phytosanitary treatments carrot Normandy	Plant protection, spraying, with sprayer, 1200 l/hr/FR	0,5	12,22	-4,22	4	diesel
Transport of tomato harvest crates	Harvesting assistence, with trailer (carrot)/hr/FR	8	3,08		24,64	diesel
Grain transport 140 hp, tipper, 2 axles - 15 t	Transporting to farm, with 2 axle trailer (15 t)/hr/FR	0,67	13,34		8,94	diesel
Grain transport 160 hp, tipper, 2 axles - 15 t	Transporting to farm, with 2 axle trailer (15 t)/hr/FR	0,67	13,34	2	10,28	diesel

Transport forage 110 hp, tipper, 2 axles - 15 t	Transporting to farm, with trailer (<15t) heavy tractor/hr/FR	0,59	12,10		7,14	diesel
Forage transport 90 hp, forage platform, 2 axles - 10-12t	Transporting, with forage flatbed/hr/FR	0,4	9,90		3,96	diesel
Corn forage transport 110 hp, tipper, 2 axles - 15 t	Transporting to farm, with trailer (<15t) heavy tractor/hr/FR	1,25	12,1		15,13	diesel
Corn grain transport 100 hp, tipper, 2 axles - 12-14t	Transporting to farm, with trailer (<15t) heavy tractor/hr/FR	1	12,1	-1,2	10,9	diesel
Potato transport 135 hp, tipper, 2 axles - 16-18t	Transporting to farm, with trailer (<15t) heavy tractor/hr/FR	2,5	12,1	2,9	37,5	diesel
Working the soil before sowing straight vines	Harrowing, 3m harrow/hr/FR	2	10		20	diesel
Inter-row tillage (all rows),	Hoeing, with 4-6m hoe (standard)/hr/FR	0,33	15		4,95	diesel
Soil cultivation to change plastic cover for north tunnel	Hoeing, with rotary hoe/hr/FR	1	7,7		7,7	diesel
Soil cultivation to change plastic cover for south tunnel	Hoeing, with rotary hoe/hr/FR	1,5	7,7		11,55	diesel
Shallow work on wide vines	Hoeing, with rotary hoe 3m/hr/FR	1,3	13.3	0.23	17.6	diesel
Harvest grape harvest narrow vine	Harvesting (vine), with trailer/hr/FR	2,14	30		64.2	diesel
Harvest grape harvest large vine	Harvesting (vine), with trailer/hr/FR	1,6	30		48	diesel
Vibrocultivator, 3m	Harrowing, with vibrating tine cultivator (standard equipment) 5m/hr/FR	0,34	15		5,1	diesel
Vibrocultivator, 5m	Harrowing, with vibrating tine cultivator (standard equipment) 5m/hr/FR	0,34	15		5,1	diesel
Organic carrot vibrocultivator	Harrowing, with vibrating tine cultivator 6m/hr/FR	1	15		15	diesel

APPENDIX II: PROCESS DESIGN FOR ANIMAL FEED

For more details on animal feed in AGRIBALYSE®, we recommend reading the ECO-ALIM report (Wilfart et al. 2017) as a supplement.

1. Methodological choices

List of raw materials and processes

The AGRIBALYSE® "Feed ingredients" LCIs are derived from the ECO-ALIM project (IFIP 2016). These LCIs provide reference values for the "ingredients" (e.g. corn, wheat etc.) used by livestock farming in France. These ingredients are then combined in the form of compound feeds (e.g. bovine feed), corresponding to the needs of different types of breeding and physiological stages.

Transport models

Several transport models were considered.

Raw materials

All PM must be transported to the compound feed manufacturing plant. All PM production processes are "field exit" or "factory exit" processes.

For PM produced in mainland France, it was assumed that the location of the food manufacturing plant was unknown. Consequently, the same transport modes and distances were considered for all PM, whether or not their production area was known. Average transport distances and modes were determined based on the work of Nguyen et al (2012).

For PM from abroad, the distances and modes of transport between the place of production and the French territory defined in GESTIM (Gac et al, 2010) were considered. The distances and modes of transport within mainland France were then added, according to the methodology described above.

TheTable144 presents the distances and modes of transport, and the processes selected.

Table144: Models for transporting raw materials from the place of production to the food processing plant.

MP origin	Mode of transport	Transport distance (km)	Process considered	Original BDD
Metropole	Road	110	Transport, lorry >32t, EURO3/RER U	Ecoinvent®
Metropole	Rail	390	Transport, freight, rail/RER U	Ecoinvent®
Foreign	Road	According to GESTIM	Transport, lorry >32t, EURO3/RER U	Ecoinvent®
Foreign	Rail	According to GESTIM	Transport, freight, rail/RER U	Ecoinvent®
Foreign	Maritime	According to GESTIM	Transport, transoceanic freight ship/OCE U	Ecoinvent®

Compound feeds

Compound feeds have to be transported from the feed manufacturing plant to the production facility where they will be consumed by the animals. The assumption described in GESTIM was adopted: road transport by truck over a distance of 130 km. The process used is "Transport, lorry >32t, EURO3/RER U" (Ecoinvent®).

On-farm production

Some compound feeds are manufactured directly on the farm, partly from PM produced on the farm. The following assumptions have been made:

No transport for PM produced on the farm

Distances and modes of transport identical to those considered for transport between the place of production and the feed mill for PM not produced on the farm.

2. Compound feeds

Manufacturing process

The energy required to produce compound feeds has been taken into account. The data are taken from the Tecaliman report (1995-1997 and 2009). The**Table145** presents the data considered.

These energy requirements were considered for both farm-produced and factory-produced feeds.

Table145: Energy requirements for the production of one tonne of compound feed.

Type of energy	Quantity (kWh)	Process considered	Original BDD
Electricity	41	Electricity, medium voltage, production FR, at grid/FR U	Ecoinvent®
Heat	20,5	Heat, natural gas, at industrial furnace >100kW/RER U	Ecoinvent®

Construction of compound feeds produced on the farm

Many compound feeds are manufactured partly or wholly on the farm. For feeds manufactured 100% on the farm, the construction is identical to that of commercial feeds. Only the transport assumptions have been modified (see above).

For feeds produced partly on the farm and partly in the factory, the approach was as follows: i) construction of a feed using the "factory production" transport model; ii) construction of a feed using the "on-farm production" transport model; and iii) construction of the final feed inventory using a certain percentage of each of the previously constituted feeds.

Formulation of compound feeds

Table146 toTable149 present the formulation of the compound feeds created as part of AGRIBALYSE®.

Table146: AGRIBALYSE® compound feed processes for the pork sector. Feed formulation.

SimaPro process	Raw materials	% composition	Comment
Sow,rapeseed meal based feed,gestating feed,conv prod, at farm gate	Soft wheat	31,3	
	Barley	30	
	Grain corn	3,3	
	Soft wheat bran	15	
	Soft wheat remoulding	3,6	
	Protein peas	5	
	Rapeseed meal	3,2	
	Unhulled sunflower meal	2,2	
	Dehydrated beet pulp	3	
	Calcium carbonate	2,13	
	Dicalcium phosphate	0,16	
	Salt (NaCl)	0,4	

	L-Lysine HCl	0,15	
	L-Threonine	0,04	
Sow,rapeseed meal based feed,lactating feed,conv prod, at farm gate	Soft wheat	41	
	Barley	15	
	Grain corn	2,3	
	Soft wheat remoulding	10,2	
	Protein peas	12,2	
	Soybean meal	3	
	Rapeseed meal	12	
	Rapeseed	0,9	
	Calcium carbonate	1,49	
	Dicalcium phosphate	0,65	
	Salt (NaCl)	0,4	
	L-Lysine HCl	0,26	
	DL Methionine	0,02	
	L-Threonine	0,07	
Weaned piglet,rapeseed meal based feed,WP 1st phase feed,conv prod, at farm gate	Soft wheat	41,9	
	Grain corn	20	
	Soybean meal	15,3	
	Potato protein concentrate	3	
	Soy protein concentrate	3	
	Sweet whey powder	10	
	Palm oil	2,6	
	Calcium carbonate	1,01	
	Dicalcium phosphate	1,33	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,56	
	DL Methionine	0,22	

	L-Threonine	0,22	
	L-Tryptophan	0,06	
Weaned piglet,rapeseed meal based feed,WP 2nd phase feed,conv prod, at farm gate	Soft wheat	60	
	Soft wheat remoulding	2,8	
	Protein peas	13,8	
	Soybean meal	6,5	
	Rapeseed meal	12	
	Rapeseed	1,5	
	Calcium carbonate	1,04	
	Dicalcium phosphate	0,7	
	Salt (NaCl)	0,4	
	L-Lysine HCl	0,47	
	DL Methionine	0,09	
	L-Threonine	0,16	
	L-Tryptophan	0,03	
Pig,rapeseed meal based feed,growing feed,conv prod, at farm gate	Soft wheat	69,1	
	Soft wheat remoulding	1,3	
	Protein peas	7,1	
	Rapeseed meal	15	
	Unhulled sunflower meal	4,3	
	Rapeseed	0,6	
	Calcium carbonate	1,25	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,41	
	DL Methionine	0,02	
	L-Threonine	0,11	
	L-Tryptophan	0,01	
	Soft wheat	71,7	

Pig,rapeseed meal based feed,finishing feed,conv prod, at farm gate	Barley	8	
	Protein peas	1,9	
	Rapeseed meal	11	
	Unhulled sunflower meal	5	
	Calcium carbonate	1,07	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,42	
	DL Methionine	0,01	
	L-Threonine	0,1	
Sow,soybeal meal based feed,gestating feed,conv prod, at farm gate	Soft wheat	21,2	
	Barley	30	
	Grain corn	10	
	Soft wheat bran	15	
	Soft wheat remoulding	9,2	
	Soybean meal	4,7	
	Dehydrated beet pulp	6,5	
	Calcium carbonate	2,07	
	Dicalcium phosphate	0,24	
	Salt (NaCl)	0,4	
	L-Lysine HCl	0,13	
	L-Threonine	0,04	
Sow,soybeal meal based feed,lactating feed,conv prod, at farm gate	Soft wheat	29,7	
	Barley	18,1	
	Grain corn	17,9	
	Wet grain corn	15	
	Soybean meal	15,7	
	Calcium carbonate	1,51	
	Dicalcium phosphate	0,86	

	Salt (NaCl)	0,4	
	L-Lysine HCl	0,24	
	DL Methionine	0,02	
	L-Threonine	0,06	
Weaned piglet,soybeal meal based feed,WP 1st phase feed,conv prod, at farm gate	Soft wheat	41,9	
	Grain corn	20	
	Soybean meal	15,3	
	Potato protein concentrate	3	
	Soy protein concentrate	3	
	Sweet whey powder	10	
	Palm oil	2,6	
	Calcium carbonate	1,01	
	Dicalcium phosphate	1,33	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,56	
	DL Methionine	0,22	
	L-Threonine	0,22	
	L-Tryptophan	0,06	
Weaned piglet,soybeal meal based feed,WP 2nd phase feed,conv prod, at farm gate	Soft wheat	61,2	
	Barley	10	
	Soft wheat remoulding	4,7	
	Soybean meal	20,5	
	Calcium carbonate	1,03	
	Dicalcium phosphate	1,03	
	Salt (NaCl)	0,4	
	L-Lysine HCl	0,41	
	DL Methionine	0,09	
	L-Threonine	0,13	

	Soft wheat	71,4	
Pig,soybeal meal based feed,growing feed,conv prod, at farm gate	Soft wheat bran	8	
	Soft wheat remoulding	2	
	Soybean meal	9,3	
	Rapeseed meal	5	
	Unhulled sunflower meal	1,7	
	Calcium carbonate	1,26	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,39	
	DL Methionine	0,03	
	L-Threonine	0,11	
Pig,soybeal meal based feed,finishing feed,conv prod, at farm gate	Soft wheat	61	
	Barley	13,4	
	Soft wheat bran	7,4	
	Protein peas	4,2	
	Soybean meal	3,6	
	Rapeseed meal	5	
	Unhulled sunflower meal	3	
	Calcium carbonate	1,09	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,37	
	DL Methionine	0,03	
	L-Threonine	0,11	
Sow,on-farm feed supply,gestating feed,conv prod, at farm gate	Soft wheat	45,64	local mp-100% FAF
	Barley	36,36	local mp-100% FAF
	Rapeseed meal	8,4	100% FAF
	Unhulled sunflower meal	6	100% FAF

	Calcium carbonate	2,17	100% FAF
	Dicalcium phosphate	0,362	100% FAF
	Salt (NaCl)	0,4	100% FAF
	L-Lysine HCl	0,152	100% FAF
	L-Threonine	0,005	100% FAF
Sow,on-farm feed supply,lactating feed,conv prod, at farm gate	Soft wheat	60	local mp-100% FAF
	Barley	14,7	local mp-100% FAF
	Soybean meal	7	100% FAF
	Rapeseed meal	10	100% FAF
	Unhulled sunflower meal	4,66	100% FAF
	Calcium carbonate	1,416	100% FAF
	Dicalcium phosphate	0,858	100% FAF
	Salt (NaCl)	0,4	100% FAF
	L-Lysine HCl	0,326	100% FAF
	L-Threonine	0,07	100% FAF
Weaned piglet,on-farm feed supply,WP 1st phase feed,conv prod, at farm gate	Soft wheat	41,9	
	Grain corn	20	
	Soybean meal	15	
	Potato protein concentrate	3	
	Soy protein concentrate	3	
	Sweet whey powder	10	
	Palm oil	2,6	
	Calcium carbonate	1,01	
	Dicalcium phosphate	1,33	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,56	
	DL Methionine	0,22	
	L-Threonine	0,22	

	L-Tryptophan	0,06	
Weaned piglet,on-farm feed supply,WP 2nd phase feed,conv prod, at farm gate	Soft wheat	59,12	local mp-100% FAF
	Barley	15	local mp-100% FAF
	Soybean meal	18	100% FAF
	Rapeseed meal	3,44	100% FAF
	Palm oil	0,16	100% FAF
	Calcium carbonate	1,3	100% FAF
	Dicalcium phosphate	0,988	100% FAF
	Salt (NaCl)	0,4	100% FAF
	L-Lysine HCl	0,434	100% FAF
	DL Methionine	0,084	100% FAF
	L-Threonine	0,135	100% FAF
	L-Tryptophan	0,01	100% FAF
Pig,on-farm feed supply,growing feed,conv prod, at farm gate	Soft wheat	41,86	local mp-100% FAF
	Barley	10	local mp-100% FAF
	Wet grain corn	25	local mp-100% FAF
	Soybean meal	14	100% FAF
	Rapeseed meal	6,3	100% FAF
	Calcium carbonate	1,384	100% FAF
	Dicalcium phosphate	0,234	100% FAF
	Salt (NaCl)	0,4	100% FAF
	L-Lysine HCl	0,332	100% FAF
	DL Methionine	0,027	100% FAF
	L-Threonine	0,089	100% FAF
	L-Tryptophan	0,004	100% FAF
Pig,on-farm feed supply,finishing feed,conv prod, at farm gate	Soft wheat	44,86	local mp-100% FAF
	Barley	10	local mp-100% FAF
	Wet grain corn	25	local mp-100% FAF
	Soybean meal	6	100% FAF

	Rapeseed meal	12	100% FAF
	Calcium carbonate	1,15	100% FAF
	Dicalcium phosphate	0,1	100% FAF
	Salt (NaCl)	0,4	100% FAF
	L-Lysine HCl	0,356	100% FAF
	DL Methionine	0,004	100% FAF
	L-Threonine	0,082	100% FAF
	L-Tryptophan	0,006	100% FAF
Sow,excess slurry treatment,gestating feed,conv prod, at farm gate	Soft wheat	33,4	
	Barley	24,56	
	Grain corn	6,64	
	Soft wheat bran	11	
	Soft wheat remoulding	4,74	
	Protein peas	4,72	
	Rapeseed meal	1,05	
	Semi-shelled sunflower meal	1,1	
	Unhulled sunflower meal	5,9	
	Dehydrated beet pulp	3	
	Cane molasses	0,8	
	Calcium carbonate	2,146	
	Dicalcium phosphate	0,238	
	Salt (NaCl)	0,4	
	L-Lysine HCl	0,164	
	L-Threonine	0,042	
Sow,excess slurry treatment,lactating feed,conv prod, at farm gate	Soft wheat	43,56	
	Barley	18	
	Grain corn	4,34	
	Soft wheat bran	5	

	Soft wheat remoulding	4,96	
	Protein peas	3	
	Soybean meal	8,92	
	Rapeseed meal	8,16	
	Rapeseed	0,76	
	Cane molasses	0,12	
	Calcium carbonate	1,542	
	Dicalcium phosphate	0,74	
	Salt (NaCl)	0,4	
	L-Lysine HCl	0,278	
	DL Methionine	0,017	
	L-Threonine	0,07	
Weaned piglet,excess slurry treatment,WP 1st phase feed,conv prod, at farm gate	Soft wheat	41,9	
	Grain corn	20	
	Soybean meal	15,3	
	Potato protein concentrate	3	
	Soy protein concentrate	3	
	Sweet whey powder	10	
	Palm oil	2,6	
	Calcium carbonate	1,01	
	Dicalcium phosphate	1,33	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,56	
	DL Methionine	0,22	
	L-Threonine	0,22	
	L-Tryptophan	0,06	
Weaned piglet,excess slurry treatment,WP	Soft wheat	62,4	
	Barley	10	

2nd phase feed,conv prod, at farm gate	Soft wheat remoulding	1,98	
	Soybean meal	17,32	
	Rapeseed meal	4,38	
	Rapeseed	0,36	
	Calcium carbonate	1,044	
	Dicalcium phosphate	0,94	
	Salt (NaCl)	0,4	
	L-Lysine HCl	0,444	
	DL Methionine	0,077	
	L-Threonine	0,136	
	L-Tryptophan	0,007	
Pig,excess slurry treatment,growing feed,conv prod, at farm gate	Soft wheat	70,44	
	Barley	0,4	
	Grain corn	0,74	
	Soft wheat bran	2	
	Soft wheat remoulding	3,34	
	Protein peas	1,16	
	Soybean meal	3,64	
	Rapeseed meal	14,32	
	Unhulled sunflower meal	1	
	Rapeseed	0,14	
	Cane molasses	0,18	
	Calcium carbonate	1,218	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,414	
	DL Methionine	0,018	
	L-Threonine	0,11	
	Soft wheat	57,18	

Pig,excess slurry treatment,finishing feed,conv prod, at farm gate	Barley	19,84	
	Grain corn	0,06	
	Soft wheat bran	2	
	Soft wheat remoulding	2,76	
	Protein peas	1,82	
	Soybean meal	2,18	
	Rapeseed meal	10,98	
	Unhulled sunflower meal	0,3	
	Cane molasses	1	
	Calcium carbonate	0,982	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,382	
	DL Methionine	0,018	
	L-Threonine	0,098	
Sow,French average,gestating feed,conv prod, at farm gate	Soft wheat	25,06	for locally produced FAF mp-75% purchase and 25% FAF
	Barley	28,52	for locally produced FAF mp-75% purchase and 25% FAF
	Grain corn	4,98	75% purchase and 25% FAF
	Wet grain corn	10	for locally produced FAF mp-75% purchase and 25% FAF
	Soft wheat bran	7,94	75% purchase and 25% FAF
	Soft wheat remoulding	3,56	75% purchase and 25% FAF
	Protein peas	3,56	75% purchase and 25% FAF
	Soybean meal	1,7	75% purchase and 25% FAF
	Rapeseed meal	2,04	75% purchase and 25% FAF
	Unhulled sunflower meal	5,22	75% purchase and 25% FAF
	Dehydrated beet pulp	3,3	75% purchase and 25% FAF
	Cane molasses	0,6	75% purchase and 25% FAF

	Calcium carbonate	2,096	75% purchase and 25% FAF
	Dicalcium phosphate	0,34	75% purchase and 25% FAF
	Salt (NaCl)	0,4	75% purchase and 25% FAF
	L-Lysine HCl	0,144	75% purchase and 25% FAF
	L-Threonine	0,032	75% purchase and 25% FAF
Sow,French average,lactating feed,conv prod, at farm gate	Soft wheat	32,78	for locally produced FAF mp-75% purchase and 25% FAF
	Barley	18,46	for locally produced FAF mp-75% purchase and 25% FAF
	Grain corn	3,26	75% purchase and 25% FAF
	Wet grain corn	13	for locally produced FAF mp-75% purchase and 25% FAF
	Soft wheat bran	3,46	75% purchase and 25% FAF
	Soft wheat remoulding	3,72	75% purchase and 25% FAF
	Protein peas	2,26	75% purchase and 25% FAF
	Soybean meal	11,18	75% purchase and 25% FAF
	Rapeseed meal	7,38	75% purchase and 25% FAF
	Rapeseed	0,58	75% purchase and 25% FAF
	Dehydrated beet pulp	0,8	75% purchase and 25% FAF
	Cane molasses	0,09	75% purchase and 25% FAF
	Calcium carbonate	1,504	75% purchase and 25% FAF
	Dicalcium phosphate	0,862	75% purchase and 25% FAF
	Salt (NaCl)	0,4	75% purchase and 25% FAF
	L-Lysine HCl	0,264	75% purchase and 25% FAF
	DL Methionine	0,0156	75% purchase and 25% FAF
	L-Threonine	0,0628	75% purchase and 25% FAF
	L-Tryptophan	0,0032	75% purchase and 25% FAF
Weaned piglet,French average,WP 1st phase feed,conv prod, at farm gate	Soft wheat	41,9	
	Grain corn	20	
	Soybean meal	15,3	

	Potato protein concentrate	3	
	Soy protein concentrate	3	
	Sweet whey powder	10	
	Palm oil	2,6	
	Calcium carbonate	1,01	
	Dicalcium phosphate	1,33	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,56	
	DL Methionine	0,22	
	L-Threonine	0,22	
	L-Tryptophan	0,06	
Weaned piglet,French average,WP 2nd phase feed,conv prod, at farm gate	Soft wheat	62,4	
	Barley	10	
	Soft wheat remoulding	1,98	
	Soybean meal	17,32	
	Rapeseed meal	4,38	
	Rapeseed	0,36	
	Calcium carbonate	1,044	
	Dicalcium phosphate	0,94	
	Salt (NaCl)	0,4	
	L-Lysine HCl	0,444	
	DL Methionine	0,077	
	L-Threonine	0,136	
	L-Tryptophan	0,007	
Pig,French average,growing feed,conv prod, at farm gate	Soft wheat	54,54	local mp for the FAF part-70% purchase and 30 FAF
	Barley	0,18	local mp for the FAF part-70% purchase and 30 FAF
	Grain corn	0,52	70% purchase and 30 FAF

	Wet grain corn	15	local mp for the FAF part-70% purchase and 30 FAF
	Soft wheat bran	1,46	70% purchase and 30 FAF
	Soft wheat remoulding	4,8	70% purchase and 30 FAF
	Protein peas	0,82	70% purchase and 30 FAF
	Soybean meal	6,38	70% purchase and 30 FAF
	Rapeseed meal	12,5	70% purchase and 30 FAF
	Unhulled sunflower meal	0,7	70% purchase and 30 FAF
	Rapeseed	0,24	70% purchase and 30 FAF
	Cane molasses	0,126	70% purchase and 30 FAF
	Calcium carbonate	1,294	70% purchase and 30 FAF
	Dicalcium phosphate	0,036	70% purchase and 30 FAF
	Salt (NaCl)	0,3	70% purchase and 30 FAF
	L-Lysine HCl	0,388	70% purchase and 30 FAF
	DL Methionine	0,018	70% purchase and 30 FAF
	L-Threonine	0,102	70% purchase and 30 FAF
	L-Tryptophan	0,004	70% purchase and 30 FAF
Pig,French average,finishing feed,conv prod, at farm gate	Soft wheat	41,64	local mp for the FAF part-70% purchase and 30 FAF
	Barley	14,46	local mp for the FAF part-70% purchase and 30 FAF
	Grain corn	0,04	70% purchase and 30 FAF
	Wet grain corn	15	local mp for the FAF part-70% purchase and 30 FAF
	Soft wheat bran	1,62	70% purchase and 30 FAF
	Soft wheat remoulding	3,64	70% purchase and 30 FAF
	Protein peas	1,28	70% purchase and 30 FAF
	Soybean meal	3,72	70% purchase and 30 FAF
	Rapeseed meal	10,58	70% purchase and 30 FAF
	Unhulled sunflower meal	0,48	70% purchase and 30 FAF

	Cane molasses	0,7	70% purchase and 30 FAF
	Calcium carbonate	1,078	70% purchase and 30 FAF
	Salt (NaCl)	0,3	70% purchase and 30 FAF
	L-Lysine HCl	0,368	70% purchase and 30 FAF
	DL Methionine	0,0122	70% purchase and 30 FAF
	L-Threonine	0,092	70% purchase and 30 FAF
	L-Tryptophan	0,0066	70% purchase and 30 FAF
Sow,pig with run syst,gestating feed,Label Rouge prod, at farm gate	Soft wheat	33,4	for locally produced FAF mp-75% purchase and 25% FAF
	Barley	24,56	for locally produced FAF mp-75% purchase and 25% FAF
	Grain corn	6,64	for locally produced FAF mp-75% purchase and 25% FAF
	Soft wheat bran	11	75% purchase and 25% FAF
	Soft wheat remoulding	4,74	75% purchase and 25% FAF
	Protein peas	4,72	for locally produced FAF mp-75% purchase and 25% FAF
	Rapeseed meal	1,05	75% purchase and 25% FAF
	Semi-shelled sunflower meal	1,1	75% purchase and 25% FAF
	Unhulled sunflower meal	5,9	75% purchase and 25% FAF
	Dehydrated beet pulp	3	75% purchase and 25% FAF
	Cane molasses	0,8	75% purchase and 25% FAF
	Calcium carbonate	2,146	75% purchase and 25% FAF
	Dicalcium phosphate	0,238	75% purchase and 25% FAF
	Salt (NaCl)	0,4	75% purchase and 25% FAF
	L-Lysine HCl	0,164	75% purchase and 25% FAF
	DL Methionine	0,042	75% purchase and 25% FAF
Sow,pig with run syst,lactating feed,Label Rouge prod, at farm gate	Soft wheat	43,56	for locally produced FAF mp-75% purchase and 25% FAF
	Barley	18	for locally produced FAF mp-75% purchase and 25% FAF

	Grain corn	4,34	for locally produced FAF mp-75% purchase and 25% FAF
	Soft wheat bran	5	75% purchase and 25% FAF
	Soft wheat remoulding	4,96	75% purchase and 25% FAF
	Protein peas	3	for locally produced FAF mp-75% purchase and 25% FAF
	Soybean meal	8,92	75% purchase and 25% FAF
	Rapeseed meal	8,16	75% purchase and 25% FAF
	Rapeseed	0,76	75% purchase and 25% FAF
	Cane molasses	0,12	75% purchase and 25% FAF
	Calcium carbonate	1,542	75% purchase and 25% FAF
	Dicalcium phosphate	0,74	75% purchase and 25% FAF
	Salt (NaCl)	0,4	75% purchase and 25% FAF
	L-Lysine HCl	0,278	75% purchase and 25% FAF
	DL Methionine	0,017	75% purchase and 25% FAF
	L-Threonine	0,07	75% purchase and 25% FAF
Weaned piglet,pig with run syst,WP 1st phase feed,Label Rouge prod, at farm gate	Soft wheat	41,9	
	Grain corn	20	
	Soybean meal	15,3	
	Potato protein concentrate	3	
	Soy protein concentrate	3	
	Sweet whey powder	10	
	Palm oil	2,6	
	Calcium carbonate	1,01	
	Dicalcium phosphate	1,33	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,56	
	DL Methionine	0,22	
	L-Threonine	0,22	

	L-Tryptophan	0,06	
Weaned piglet,pig with run syst,WP 2nd phase feed,Label Rouge prod, at farm gate	Soft wheat	62,4	
	Barley	10	
	Soft wheat remoulding	1,98	
	Soybean meal	17	
	Rapeseed meal	4,38	
	Rapeseed	0,36	
	Calcium carbonate	1,044	
	Dicalcium phosphate	0,94	
	Salt (NaCl)	0,4	
	L-Lysine HCl	0,444	
	DL Methionine	0,077	
	L-Threonine	0,136	
	L-Tryptophan	0,007	
Pig,pig with run syst,fattening feed,Label Rouge prod, at farm gate	Soft wheat	49,88	local mp for the FAF part-70% purchase and 30 FAF
	Barley	14,96	local mp for the FAF part-70% purchase and 30 FAF
	Grain corn	4,76	local mp for the FAF part-70% purchase and 30 FAF
	Soft wheat bran	4	70% purchase and 30 FAF
	Soft wheat remoulding	5,04	70% purchase and 30 FAF
	Protein peas	2,4	local mp for the FAF part-70% purchase and 30 FAF
	Soybean meal	2,5	70% purchase and 30 FAF
	Rapeseed meal	12,66	70% purchase and 30 FAF
	Unhulled sunflower meal	0,7	70% purchase and 30 FAF
	Cane molasses	0,96	70% purchase and 30 FAF
	Calcium carbonate	1,208	70% purchase and 30 FAF
	Salt (NaCl)	0,3	70% purchase and 30 FAF

	L-Lysine HCl	0,358	70% purchase and 30 FAF
	DL Methionine	0,0096	70% purchase and 30 FAF
	L-Threonine	0,091	70% purchase and 30 FAF
Sow,outdoor syst,gestating feed,Label Rouge prod, at farm gate	Soft wheat	33,4	for locally produced FAF mp-75% purchase and 25% FAF
	Barley	24,56	for locally produced FAF mp-75% purchase and 25% FAF
	Grain corn	6,64	for locally produced FAF mp-75% purchase and 25% FAF
	Soft wheat bran	11	75% purchase and 25% FAF
	Soft wheat remoulding	4,74	75% purchase and 25% FAF
	Protein peas	4,72	for locally produced FAF mp-75% purchase and 25% FAF
	Rapeseed meal	1,05	75% purchase and 25% FAF
	Semi-shelled sunflower meal	1,1	75% purchase and 25% FAF
	Unhulled sunflower meal	5,9	75% purchase and 25% FAF
	Dehydrated beet pulp	3	75% purchase and 25% FAF
	Cane molasses	0,8	75% purchase and 25% FAF
	Calcium carbonate	2,146	75% purchase and 25% FAF
	Dicalcium phosphate	0,238	75% purchase and 25% FAF
	Salt (NaCl)	0,4	75% purchase and 25% FAF
	L-Lysine HCl	0,164	75% purchase and 25% FAF
	DL Methionine	0,042	75% purchase and 25% FAF
Sow,outdoor syst,lactating feed,Label Rouge prod, at farm gate	Soft wheat	43,56	for locally produced FAF mp-75% purchase and 25% FAF
	Barley	18	for locally produced FAF mp-75% purchase and 25% FAF
	Grain corn	4,34	for locally produced FAF mp-75% purchase and 25% FAF
	Soft wheat bran	5	75% purchase and 25% FAF
	Soft wheat remoulding	4,96	75% purchase and 25% FAF

	Protein peas	3	for locally produced FAF mp-75% purchase and 25% FAF
	Soybean meal	8,92	75% purchase and 25% FAF
	Rapeseed meal	8,16	75% purchase and 25% FAF
	Rapeseed	0,76	75% purchase and 25% FAF
	Cane molasses	0,12	75% purchase and 25% FAF
	Calcium carbonate	1,542	75% purchase and 25% FAF
	Dicalcium phosphate	0,74	75% purchase and 25% FAF
	Salt (NaCl)	0,4	75% purchase and 25% FAF
	L-Lysine HCl	0,278	75% purchase and 25% FAF
	DL Methionine	0,017	75% purchase and 25% FAF
	L-Threonine	0,07	75% purchase and 25% FAF
Weaned piglet,outdoor syst,WP 1st phase feed,Label Rouge prod, at farm gate	Soft wheat	41,9	
	Grain corn	20	
	Soybean meal	15,3	
	Potato protein concentrate	3	
	Soy protein concentrate	3	
	Sweet whey powder	10	
	Palm oil	2,6	
	Calcium carbonate	1,01	
	Dicalcium phosphate	1,33	
	Salt (NaCl)	0,3	
	L-Lysine HCl	0,56	
	DL Methionine	0,22	
	L-Threonine	0,22	
	L-Tryptophan	0,06	
Weaned piglet,outdoor syst,WP 2nd phase feed,Label Rouge prod, at farm gate	Soft wheat	62,4	
	Barley	10	
	Soft wheat remoulding	1,98	

	Soybean meal	17	
	Rapeseed meal	4,38	
	Rapeseed	0,36	
	Calcium carbonate	1,044	
	Dicalcium phosphate	0,94	
	Salt (NaCl)	0,4	
	L-Lysine HCl	0,444	
	DL Methionine	0,077	
	L-Threonine	0,136	
	L-Tryptophan	0,007	
Pig,outdoor syst,fattening feed,Label Rouge prod, at farm gate	Soft wheat	49,88	local mp for the FAF part-70% purchase and 30 FAF
	Barley	14,96	local mp for the FAF part-70% purchase and 30 FAF
	Grain corn	4,76	local mp for the FAF part-70% purchase and 30 FAF
	Soft wheat bran	4	70% purchase and 30 FAF
	Soft wheat remoulding	5,04	70% purchase and 30 FAF
	Protein peas	2,4	local mp for the FAF part-70% purchase and 30 FAF
	Soybean meal	2,5	70% purchase and 30 FAF
	Rapeseed meal	12,66	70% purchase and 30 FAF
	Unhulled sunflower meal	0,7	70% purchase and 30 FAF
	Cane molasses	0,96	70% purchase and 30 FAF
	Calcium carbonate	1,208	70% purchase and 30 FAF
	Salt (NaCl)	0,3	70% purchase and 30 FAF
	L-Lysine HCl	0,358	70% purchase and 30 FAF
	DL Methionine	0,0096	70% purchase and 30 FAF
	L-Threonine	0,091	70% purchase and 30 FAF
	Organic barley	70	local mp for the FAF part-70% purchase and 30 FAF

Sow,gestating feed,organic prod, at farm gate	Organic protein peas	18	local mp for the FAF part-70% purchase and 30 FAF
	Organic soybean meal	5	70% purchase and 30 FAF
	Organic rapeseed meal	3	70% purchase and 30 FAF
	Salt (NaCl)	0,48	70% purchase and 30 FAF
	Calcium carbonate	1,44	70% purchase and 30 FAF
	Dicalcium phosphate	0,96	70% purchase and 30 FAF
	Clay	0,52	70% purchase and 30 FAF
	Oligovitamin core	0,6	70% purchase and 30 FAF
Sow,lactating feed,organic prod, at farm gate	Organic barley	30	local mp for the FAF part-70% purchase and 30 FAF
	Organic triticale	28	local mp for the FAF part-70% purchase and 30 FAF
	Organic protein peas	20	local mp for the FAF part-70% purchase and 30 FAF
	Organic soybean meal	17	70% purchase and 30 FAF
	Salt (NaCl)	0,48	70% purchase and 30 FAF
	Calcium carbonate	1,44	70% purchase and 30 FAF
	Dicalcium phosphate	0,96	70% purchase and 30 FAF
	Clay	0,52	70% purchase and 30 FAF
	Oligovitamin core	0,6	70% purchase and 30 FAF
Weaned piglet,WP feed,organic prod, at farm gate	Organic soft wheat	20	local mp for the FAF-90% purchase and 10 FAF part
	Organic barley	10	local mp for the FAF-90% purchase and 10 FAF part
	Organic triticale	21,5	local mp for the FAF-90% purchase and 10 FAF part
	Organic protein peas	10	local mp for the FAF-90% purchase and 10 FAF part
	Organic coloured faba bean	10	local mp for the FAF-90% purchase and 10 FAF part
	Organic soybean meal	20	90% purchase and 10 FAF
	Potato protein concentrate	5	90% purchase and 10 FAF

	Calcium carbonate	1,26	90% purchase and 10 FAF
	Dicalcium phosphate	0,84	90% purchase and 10 FAF
	Salt (NaCl)	0,42	90% purchase and 10 FAF
	Clay	0,455	90% purchase and 10 FAF
	Oligovitamin core	0,525	90% purchase and 10 FAF
Pig,growing feed,organic prod, at farm gate	Organic soft wheat	20	local mp for the FAF-60% purchase and 40 FAF part
	Organic barley	10	local mp for the FAF-60% purchase and 40 FAF part
	Organic triticale	27	local mp for the FAF-60% purchase and 40 FAF part
	Organic protein peas	25	local mp for the FAF-60% purchase and 40 FAF part
	Organic soybean meal	15	60% purchase and 40 FAF
	Calcium carbonate	1,08	60% purchase and 40 FAF
	Dicalcium phosphate	0,72	60% purchase and 40 FAF
	Salt (NaCl)	0,36	60% purchase and 40 FAF
	Clay	0,39	60% purchase and 40 FAF
	Oligovitamin core	0,45	60% purchase and 40 FAF
Pig,finishing feed,organic prod, at farm gate	Organic soft wheat	20	local mp for the FAF-60% purchase and 40 FAF part
	Organic barley	15	local mp for the FAF-60% purchase and 40 FAF part
	Organic triticale	27	local mp for the FAF-60% purchase and 40 FAF part
	Organic protein peas	25	local mp for the FAF-60% purchase and 40 FAF part
	Organic soybean meal	10	60% purchase and 40 FAF
	Calcium carbonate	1,08	60% purchase and 40 FAF
	Dicalcium phosphate	0,72	60% purchase and 40 FAF
	Salt (NaCl)	0,36	60% purchase and 40 FAF
	Clay	0,39	60% purchase and 40 FAF
	Oligovitamin core	0,45	60% purchase and 40 FAF

Table147: AGRIBALYSE® compound feed processes for the poultry and rabbit sectors. Feed formulation.

SimaPro process	Raw materials	% composition
Reproductive,reproductive feed, at farm gate	Soft wheat	25,652
	Grain corn	37,517
	Soybean meal	19,115
	Calcium carbonate	8,846
	Protein peas	1,319
	Soybean oil	0,597
	Extruded soybeans	0,733
	Rapeseed	1,313
	Dicalcium phosphate	0,474
	Salt (NaCl)	0,315
	Sunflower seed	0,11
	DL Methionine	0,113
	Rapeseed meal	0,767
	Sunflower seed	0,987
	Semi-shelled sunflower meal	0,382
	Corn flour	0,081
	Rapeseed oil	0,069
	L-Lysine HCl	0,004
	L-Tryptophan	0
	Other: alfalfa protein concentrate	1,1
	Others: Natuphos 5000 (phytase)	0,006
	Autes COV + Xynalase (phytase)	0,5
Poulette,poulette feed,conv prod, at farm gate	Soft wheat	41,651
	Grain corn	31,351
	Soybean meal	19,684
	Triticale	0,861
	Calcium carbonate	1,204
	Corn gluten feed	0,664
	Soft wheat bran	2,351
	Dicalcium phosphate	0,522

	Salt (NaCl)	0,314
	Protein peas	0,077
	Rapeseed meal	0,182
	DL Methionine	0,184
	L-Lysine HCl	0,105
	L-Threonine	0,01
	Corn flour	0,092
	Barley	0,113
	Rapeseed	0,101
	Extruded soybeans	0,024
	Others: Phytase (Naphtulos and VOC 0.5%)	0,51
Laying hen,laying hen feed,organic prod, at farm gate	Organic soft wheat	16,4
	Organic grain corn	25
	Organic rapeseed meal	1
	Organic sunflower meal	10
	Organic protein peas	3
	Organic soybean meal	8,8
	Organic soybeans	5,8
	Organic triticale	6
	Organic oats	2
	Organic soft wheat bran	3
	Corn gluten feed	4
	Organic sunflower seed	1
	Organic dehydrated alfalfa	3
	Calcium carbonate	8
	Other	3
Laying hen,outdoor laying hen feed,conv prod, at farm gate	Soft wheat	21
	Grain corn	35
	Sunflower meal	3

	Soybean meal	20
	Oats	5
	Organic soft wheat bran	3
	Corn gluten feed	1
	Calcium carbonate	10
	Other	2
Laying hen,laying hen feed,conv prod, at farm gate	Soft wheat	25,652
	Grain corn	37,517
	Soybean meal	19,115
	Calcium carbonate	8,846
	Protein peas	1,319
	Soybean oil	0,598
	Extruded soybeans	0,733
	Dicalcium phosphate	0,474
	Salt (NaCl)	0,315
	Sunflower seed	1,097
	DL Methionine	0,113
	Rapeseed meal	0,767
	Semi-shelled sunflower meal	0,382
	Corn flour	0,081
	Rapeseed oil	0,069
	L-Lysine HCl	0,004
	L-Tryptophan	0
	Rapeseed	1,313
	Other: Alfalfa protein concentrate	1,1
	Others: phytase (Natuphos 5000 and COV 0.5 + xynalase)	0,506
Broiler,broiler feed,conv prod, at farm gate	Soft wheat	25,75
	Grain corn	38,32

	Soybean meal	20,99
	Corn gluten feed	3,08
	Extruded soybeans	2,04
	Triticale	0,44
	Soybean oil	1,47
	Protein peas	0,31
	Calcium carbonate	0,85
	Rapeseed meal	3,15
	Dicalcium phosphate	0,58
	Palm oil	0,26
	Salt (NaCl)	0,32
	Soft wheat bran	0,39
	DL Methionine	0,22
	L-Lysine HCl	0,2
	L-Threonine	0,003
	L-Tryptophan	0,001
	Rapeseed	0,64
	Rapeseed oil	0,25
	Unhulled sunflower meal	0,136
	Other: Alfalfa protein concentrate	0,09
	Others: phytase (Natuphos 5000 and COV 0.5 + xynalase)	0,51
Future reproductive,future reproductive feed, at farm gate	Soft wheat	41,651
	Grain corn	31,351
	Soybean meal	19,684
	Triticale	0,861
	Calcium carbonate	1,204
	Corn gluten feed	0,664
	Soft wheat bran	2,351

	Dicalcium phosphate	0,522
	Salt (NaCl)	0,314
	Protein peas	0,077
	Rapeseed meal	0,182
	DL Methionine	0,184
	L-Lysine HCl	0,105
	L-Threonine	0,01
	Corn flour	0,092
	Barley	0,113
	Rapeseed	0,101
	Extruded soybeans	0,024
	Others: Phytase (Naphtulos and VOC 0.5%)	0,51
Broiler,broiler feed,Label Rouge prod, at farm gate	Soft wheat	41,651
	Grain corn	31,351
	Soybean meal	19,684
	Triticale	0,861
	Calcium carbonate	1,204
	Corn gluten feed	0,664
	Soft wheat bran	2,351
	Dicalcium phosphate	0,522
	Salt (NaCl)	0,314
	Protein peas	0,077
	Rapeseed meal	0,182
	DL Methionine	0,184
	L-Lysine HCl	0,105
	L-Threonine	0,01
	Corn flour	0,092
	Barley	0,113
	Rapeseed	0,101

	Extruded soybeans	0,024
	Others: Phytase (Naphtulos and VOC 0.5%)	0,51
Broiler,broiler feed,organic prod, at farm gate	Organic soft wheat	10
	Organic grain corn	39
	Organic triticale	8
	Organic protein peas	2,5
	Organic coloured faba bean	2,5
	Organic soft wheat bran	3
	Organic sunflower meal	5
	Organic soybeans	5
	Organic soybean meal	14,5
	Salt (NaCl)	0,3
	Corn flour	2,5
	Potato protein concentrate	2,5
	DL Methionine	0,2
	L-Lysine HCl	0,1
	L-Threonine	0,01
	Autes ingredients	4,89
Turkey,reproductive feed,conv prod, at farm gate	Soft wheat	35,286
	Soybean meal	28,245
	Grain corn	16,428
	Protein peas	3,901
	Soybean oil	2,65
	Extruded soybeans	3,406
	Rapeseed	4,754
	Calcium carbonate	0,783
	Dicalcium phosphate	0,663
	DL Methionine	0,296
	Salt (NaCl)	0,298

	L-Lysine HCl	0,224
	L-Threonine	0,054
	Corn flour	0,699
	Palm oil	0,167
	Rapeseed oil	0,353
	Rapeseed meal	0,583
	Sunflower seed	0,4
	Other: Alfalfa protein concentrate	0,3
	Others: Phytase (Natuphos 5000 and COV0.5 + xynalase)	0,51
Turkey,turkey feed,conv prod, at farm gate	Soft wheat	35,286
	Soybean meal	28,245
	Grain corn	16,428
	Protein peas	3,901
	Soybean oil	2,65
	Extruded soybeans	3,406
	Rapeseed	4,754
	Calcium carbonate	0,783
	Dicalcium phosphate	0,663
	DL Methionine	0,296
	Salt (NaCl)	0,298
	L-Lysine HCl	0,224
	L-Threonine	0,054
	Corn flour	0,699
	Palm oil	0,167
	Rapeseed oil	0,353
	Rapeseed meal	0,583
	Sunflower seed	0,4
	Other: Alfalfa protein concentrate	0,3

	Others: Phytase (Natuphos 5000 and COV0.5 + xynalase)	0,51
Turkey,turkey feed,Label Rouge prod, at farm gate	Soft wheat	35,286
	Soybean meal	28,245
	Grain corn	16,428
	Protein peas	3,901
	Soybean oil	2,65
	Extruded soybeans	3,406
	Rapeseed	4,754
	Calcium carbonate	0,783
	Dicalcium phosphate	0,663
	DL Methionine	0,296
	Salt (NaCl)	0,298
	L-Lysine HCl	0,224
	L-Threonine	0,054
	Corn flour	0,699
	Palm oil	0,167
	Rapeseed oil	0,353
	Rapeseed meal	0,583
	Sunflower seed	0,4
	Other: Alfalfa protein concentrate	0,3
	Others: Phytase (Natuphos 5000 and COV0.5 + xynalase)	0,51
Duck,future reproductive feed,conv prod, at farm gate	Soft wheat	44,166
	Grain corn	27,613
	Soybean meal	15,001
	Protein peas	1,551
	Corn flour	0,957
	Soybean oil	1,275
	Rapeseed meal	3,606

	Calcium carbonate	1,186
	Soft wheat bran	0,488
	Dicalcium phosphate	0,535
	Salt (NaCl)	0,311
	Soya bean	0,61
	DL Methionine	0,101
	L-Lysine HCl	0,105
	Sunflower meal	1,105
	Rapeseed	0,486
	Rapeseed oil	0,2
	Palm oil	0,025
	Barley	0,169
	Others: phytase (Natuphos 5000 and COV 0.5 + xynalase)	0,51
Duck,PAG feed,conv prod, at farm gate	Soft wheat	44,164
	Grain corn	27,6
	Soybean meal	15
	Calcium carbonate	1,2
	Protein peas	1,6
	Soybean oil	1,3
	Extruded soybeans	0,6
	Rapeseed	0,5
	Dicalcium phosphate	0,5
	Salt (NaCl)	0,3
	Sunflower meal	1,044
	DL Methionine	0,1
	Rapeseed meal	3,6
	Corn flour	0,957
	Rapeseed oil	0,2

	L-Lysine HCl	0,1
	Palm oil	0,025
	L-Threonine	0,0
	Barley	0,2
	Soft wheat bran	0,5
	Others: Natuphos 5000 (phytase)	0,01
	Autes COV + Xynalase (phytase)	0,5
Duck,fattening feed,conv prod, at farm gate	Wet grain corn	100
Duck,duck feed,conv prod, at farm gate	Soft wheat	44,164
	Grain corn	27,6
	Soybean meal	15
	Calcium carbonate	1,2
	Protein peas	1,6
	Soybean oil	1,3
	Extruded soybeans	0,6
	Rapeseed	0,5
	Dicalcium phosphate	0,5
	Salt (NaCl)	0,3
	Sunflower meal	1,044
	DL Methionine	0,1
	Rapeseed meal	3,6
	Corn flour	0,957
	Rapeseed oil	0,2
	L-Lysine HCl	0,1
	Palm oil	0,025
	L-Threonine	0
	Others: Natuphos 5000 (phytase)	0,01
	Autes COV + Xynalase (phytase)	0,5
	Barley	0,2

	Soft wheat bran	0,5
Rabbit,maternity feed,conv prod, at farm gate	Sunflower meal	20
	Dehydrated alfalfa	17,95
	Dehydrated beet pulp	13,96
	Soft wheat bran	10,01
	Barley	9,97
	Rapeseed meal	5
	Soft wheat	6,64
	Other: Citrus	4,58
	Soya bean	3,78
	Cane molasses	3
	Protein peas	1,14
	Soybean oil	0,53
	Other: VOCs	0,5
	Calcium carbonate	0,39
	Dicalcium phosphate	0,23
	Soybean meal	0,81
	DL Methionine	0,01
	Untreated straw	1,499
	Rapeseed oil	0,001
Rabbit,fattening feed,conv prod, at farm gate	Sunflower meal	20
	Dehydrated alfalfa	17,95
	Dehydrated beet pulp	13,96
	Soft wheat bran	10,01
	Barley	9,97
	Rapeseed meal	5
	Soft wheat	6,64
	Other: Citrus	4,58
	Soya bean	3,78

	Cane molasses	3
	Protein peas	1,14
	Soybean oil	0,53
	Other: VOCs	0,5
	Calcium carbonate	0,39
	Dicalcium phosphate	0,23
	Soybean meal	0,81
	DL Methionine	0,01
	Untreated straw	1,499
	Rapeseed oil	0,001

Table148: AGRIBALYSE® compound feed processes for the sheep and goat sectors. Feed formulation.

SimaPro process	Raw materials	% composition	Comment
Bovine feed,BV40, at farm gate	Soft wheat	2,4	According to GESTIM
	Grain corn	5,2	According to GESTIM
	Oats	0,1	According to GESTIM
	Barley	5,8	According to GESTIM
	Corn gluten feed	0,8	According to GESTIM
	Soft wheat bran	6,9	According to GESTIM
	Cane molasses	1,3	According to GESTIM
	Dehydrated beet pulp	2,5	According to GESTIM
	Linseed oil	0,1	According to GESTIM
	Protein peas	0,0	According to GESTIM
	Dehydrated alfalfa	1,0	According to GESTIM
	Peanut cake	1,8	According to GESTIM
	Rapeseed meal	32,6	According to GESTIM
	Soybean meal	13,1	According to GESTIM
	Sunflower meal	13,3	According to GESTIM
	Soya bean	0,1	According to GESTIM
	Calcium carbonate	13,0	According to GESTIM
Bovine feed,CMV 5-25-5, at farm gate	Monocalcium phosphate	10,0	
	Dicalcium phosphate	19,16	
	Calcium carbonate	59,41	
	Calcium carbonate	2,0	
	Selenium	0,44	
	Iodine	0,02	
	Zinc	0,19	
	Copper	0,72	

	Cobalt	0,09	
	Vitamins	1,31	
	Cane molasses	6	
Bovine feed,MAT18, at farm gate	Soft wheat	4,8	According to GESTIM
	Grain corn	16,1	According to GESTIM
	Oats	0,7	According to GESTIM
	Barley	6,7	According to GESTIM
	Corn gluten feed	8,8	According to GESTIM
	Soft wheat bran	29,1	According to GESTIM
	Cane molasses	3,5	According to GESTIM
	Dehydrated beet pulp	4,8	According to GESTIM
	Linseed oil	0,5	According to GESTIM
	Protein peas	0	According to GESTIM
	Dehydrated alfalfa	0,2	According to GESTIM
	Peanut meal	1,2	According to GESTIM
	Rapeseed meal	11,9	According to GESTIM
	Soybean meal	7,6	According to GESTIM
	Sunflower meal	0,7	According to GESTIM
	Soya bean	0,1	According to GESTIM
	Calcium carbonate	3,3	According to GESTIM
Bovine feed,Melo, at farm gate	Organic triticale	52,0	File created by Yann Pitois (CIVAM Bio 53) Cereal mix harvested on the farm - Without transport
	Organic oats	6	File created by Yann Pitois (CIVAM Bio 53) Cereal mix harvested on the farm - Without transport
	Organic protein peas	42	Normally vetch (27%) + pea (16%) but no information is given in the table so it is assimilated to pea -Drafted by Yann Pitois (CIVAM Bio 53) Cereal mix harvested on the farm - Without transport
Bovine feed,suckler feed, at farm gate	Skim milk powder	20	Expert opinion from Idele and Syndicat de la Vitelerie

	Delactosed whey powder	18	Expert opinion from Idele and Syndicat de la Vitelerie
	Sweet whey powder	29	Expert opinion from Idele and Syndicat de la Vitelerie
	Tallow	6	Expert opinion from Idele and Syndicat de la Vitelerie
	Lard	6	Expert opinion from Idele and Syndicat de la Vitelerie
	Palm oil	4	Expert opinion from Idele and Syndicat de la Vitelerie
	coconut oil	4	Expert opinion from Idele and Syndicat de la Vitelerie
	potato starch	3	Expert opinion from Idele and Syndicat de la Vitelerie
	Wheat gluten feed	3	Expert opinion from Idele and Syndicat de la Vitelerie
	soy protein (flour)	4,5	Expert opinion from Idele and Syndicat de la Vitelerie
	L-Lysine HCl	0,3	Expert opinion from Idele and Syndicat de la Vitelerie-compo in cmv based on feed formulation from Idele Le Rheu experimental station
	DL Methionine	0,1	Expert opinion from Idele and Syndicat de la Vitelerie-compo in cmv based on feed formulation from Idele Le Rheu experimental station
	Calcium carbonate	0,5	Expert opinion from Idele and Syndicat de la Vitelerie-compo in cmv based on feed formulation from Idele Le Rheu experimental station
	Vitamins	1,6	Expert opinion from Idele and Syndicat de la Vitelerie-actually 1.5% mineral-vitamin and prebiotic concentrate + 0.2% silica (but ingredient not available).
Calf,fiber diet, at farm gate	Soft wheat	35	Expert opinion from Idele and Syndicat de la Vitelerie
	Barley	20	Expert opinion from Idele and Syndicat de la Vitelerie
	Protein peas	10	Expert opinion from Idele and Syndicat de la Vitelerie

	Untreated straw	5	Expert opinion from Idele and Syndicat de la Vitelerie
	Grain corn	30	aplati ou farine-Avis d'expert Idele et Syndicat de la Vitelerie
Calf,suckler feed, at farm gate	Skim milk powder	20	Expert opinion from Idele and Syndicat de la Vitelerie
	Delactosed whey powder	17	Expert opinion from Idele and Syndicat de la Vitelerie
	Sweet whey powder	30	Expert opinion from Idele and Syndicat de la Vitelerie
	Tallow	8,	Expert opinion from Idele and Syndicat de la Vitelerie
	Lard	8	Expert opinion from Idele and Syndicat de la Vitelerie
	coconut oil	4	Expert opinion from Idele and Syndicat de la Vitelerie
	Soft wheat flour	3	pregelatinized wheat starch (or flour, but it must be soluble flour)-Expert advice from Idele and Syndicat de la Vitelerie
	Wheat gluten feed	3	Expert opinion from Idele and Syndicat de la Vitelerie
	soy protein (flour)	4,5	Soy concentrate - Expert opinion from Idele and Syndicat de la Vitelerie
	L-Lysine HCl	0,3	compo in cmv according to feed formulation from Idele Le Rheu experimental station - Expert opinion from Idele and Syndicat de la Vitelerie
	DL Methionine	0,1	compo in cmv according to feed formulation from Idele Le Rheu experimental station - Expert opinion from Idele and Syndicat de la Vitelerie
	Calcium carbonate	0,5	compo in cmv according to feed formulation from Idele Le Rheu experimental station - Expert opinion from Idele and Syndicat de la Vitelerie
	Vitamins	1,6	actually 1.5% mineral-vitamin and prebiotic concentrate + 0.2% silica (but ingredient not available)-Idele and Syndicat de la Vitelerie expert opinion
Caprine,replacement goat,CL 25 % feed, at farm gate	Soft wheat	3,8	According to GESTIM
	Grain corn	12,7	According to GESTIM

	Oats	0,5	According to GESTIM
	Barley	5,3	According to GESTIM
	Corn gluten feed	6,9	According to GESTIM
	Soft wheat bran	23	According to GESTIM
	Cane molasses	2,8	According to GESTIM
	Dehydrated beet pulp	3,8	According to GESTIM
	Linseed oil	0,3	According to GESTIM
	Protein peas	0,1	According to GESTIM
	Dehydrated alfalfa	0,3	According to GESTIM
	Peanut meal	2	According to GESTIM
	Rapeseed meal	19,5	According to GESTIM
	Soybean meal	12,5	According to GESTIM
	Sunflower meal	1,1	According to GESTIM
	Soya bean	0,2	According to GESTIM
	Calcium carbonate	3,3	According to GESTIM
	Magnesia	1	According to GESTIM
	Vitamins	0,1	According to GESTIM
	Dehydrated citrus pulp	0,8	According to GESTIM
Caprine,in milk goat,CL 25 % feed, at farm gate	Soft wheat	3,8	According to GESTIM
	Grain corn	12,7	According to GESTIM
	Oats	0,5	According to GESTIM
	Barley	5,3	According to GESTIM
	Corn gluten feed	6,9	According to GESTIM
	Soft wheat bran	23	According to GESTIM
	Cane molasses	2,8	According to GESTIM
	Dehydrated beet pulp	3,8	According to GESTIM
	Linseed oil	0,3	According to GESTIM
	Protein peas	0,1	According to GESTIM
	Dehydrated alfalfa	0,3	According to GESTIM

	Peanut meal	2	According to GESTIM
	Rapeseed meal	19,5	According to GESTIM
	Soybean meal	12,5	According to GESTIM
	Sunflower meal	1,1	According to GESTIM
	Soya bean	0,2	According to GESTIM
	Calcium carbonate	3,3	According to GESTIM
	Magnesia	1	According to GESTIM
	Vitamins	0,1	According to GESTIM
	Dehydrated citrus pulp	0,8	According to GESTIM
Ovine,purchased concentred feed, at farm gate	Soft wheat	4,8	According to GESTIM
	Grain corn	16,1	According to GESTIM
	Oats	0,7	According to GESTIM
	Barley	6,7	According to GESTIM
	Corn gluten feed	8,8	According to GESTIM
	Soft wheat bran	29,1	According to GESTIM
	Cane molasses	3,5	According to GESTIM
	Dehydrated beet pulp	4,8	According to GESTIM
	Linseed oil	0,5	According to GESTIM
	Protein peas	0	According to GESTIM
	Dehydrated alfalfa	0,2	According to GESTIM
	Peanut meal	1,2	According to GESTIM
	Rapeseed meal	11,9	According to GESTIM
	Soybean meal	7,6	According to GESTIM
	Sunflower meal	0,7	According to GESTIM
	Soya bean	0,1	According to GESTIM
	Calcium carbonate	3,3	According to GESTIM

Table149 List of compound feed processes created for AGRIBALYSE® fish farming. Feed formulation.

SimaPro process	Raw materials	% composition

Small trout,fattening feed 1,conv prod, at farm gate	North Atlantic fish meal	20,1
	Fish meal South America	20,1
	soy protein (flour)	10,1
	Blood flour	10,6
	Cutting fish oil (Europe)	12,9
	Wheat gluten feed	17
	Corn gluten feed	0,9
	Vitamins	0,3
	North Atlantic fish oil	8
Small trout,fattening feed 2,conv prod, at farm gate	Fish meal South America	20,9
	North Atlantic fish meal	22
	North Atlantic fish oil	18,8
	Rapeseed meal	9
	White faba bean	12
	Wheat gluten feed	9
	Rapeseed oil	5
	L-Lysine HCl	3,3
Small trout,fattening feed 3,conv prod, at farm gate	Fish meal South America	30,5
	North Atlantic fish meal	30,5
	North Atlantic fish oil	13,9
	Protein peas	12,6
	Wheat gluten feed	11,5
	L-Lysine HCl	0,5
	Vitamins	0,5
Small trout,fattening feed 4,conv prod, at farm gate	Fish meal South America	10,2
	North Atlantic fish meal	10,2
	North Atlantic fish oil	11,6
	Rapeseed meal	3
	White faba bean	9,9

	Wheat gluten feed	13,8
	Rapeseed oil	16,9
	L-Lysine HCl	0
	Soybean meal	18,9
	Vitamins	5,5
Large trout,fattening feed 1,conv prod, at farm gate	Fish meal South America	8,5
	North Atlantic fish meal	8,5
	Wheat gluten feed	2
	soy protein (flour)	9,3
	Soy protein concentrate	16,5
	North Atlantic fish oil	14
	Corn gluten feed	15
	Rapeseed oil	14
	Vitamins	0,5
	L-Lysine HCl	0,6
	Soft wheat flour	11,1
Large trout,fattening feed 2,conv prod, at farm gate	Fish meal South America	11,1
	North Atlantic fish meal	11,1
	Fish protein concentrate (FPC)	10
	soy protein (flour)	16,2
	North Atlantic fish oil	10,5
	Wheat gluten feed	17,7
	Soy protein concentrate	15,4
	Rapeseed oil	0,9
	Rapeseed meal	0,9
	Vitamins	0,2
	Cutting fish oil (Europe)	6
Large trout,fattening feed 3,conv prod, at farm gate	Fish meal South America	18,5
	North Atlantic fish meal	18,5

	Rapeseed meal	10
	soy protein (flour)	12
	Fish oil South America	9
	Rapeseed oil	9
	Corn flour	5
	Wheat gluten feed	10
	Vitamins	0,5
	Protein peas	2
	Soy protein concentrate	5,5
Large trout,fattening feed 4,conv prod, at farm gate	Fish meal South America	22
	North Atlantic fish meal	22
	Wheat gluten feed	1
	Rapeseed oil	0,5
	soy protein (flour)	0,5
	North Atlantic fish oil	0,6
	Wheat gluten feed	17
	Corn gluten feed	0,5
	Protein peas	0,5
	L-Lysine HCl	0,2
	Vitamins	0,2
	Cut fish meal (Europe)	10
	Cutting fish oil (Europe)	20
	soy protein (flour)	5
Sea bass or sea bream,fattening feed 1,conv prod, at farm gate	Fish meal South America	40,7
	North Atlantic fish meal	20,4
	North Atlantic fish oil	5,2
	Soybean meal	8,5
	White faba bean	24,7
	Vitamins	0,5

Sea bass or sea bream,fattening feed 2,conv prod, at farm gate	Fish meal South America	42
	Cut fish meal (Europe)	16
	Cutting fish oil (Europe)	6,4
	Corn gluten feed	6
	Soybean meal	10
	Rapeseed meal	11
	Fish protein concentrate (FPC)	8
	Vitamins	0,5

3. Forages

The inventories created as part of AGRIBALYSE® (seeAppendix EE) were used as raw material for the forages. As the LCIs calculated for the plant sector include losses in the field, only losses during forage storage and distribution were considered for the animal sector. The**Table150** presents the loss rates retained, according to forage type and type of use.

Table150: Loss rates used to calculate forage distribution quantities. Loss rates are expressed as a % of field yield (i.e. losses in the field are implicitly considered). For meadows, losses due to grazing are specified (difference between harvestable quantity and grazing quantity).

Type of	Harvest losses (in the field)	Storage losses (% of field output)	Recovery and distribution losses (% of field output)	Total losses (% of field output)
Prairie without legumes				
Hay	15	2,3	5,75	8,75
Silage	5	13,26	10,2	30,65
Wrapping	5	7,14	5,1	13,95
Meadow with legumes				
Hay	25	2,5	6,25	9.59
Silage	3	22,66	10,3	49.16
Wrapping	7	10,7	5,35	19,12
Alfalfa				
Hay	-	2,62	6,55	9,17
Silage	-	9,064	10,3	19,364
Wrapping	-	3,159	5,85	9,009
Corn				
Silage	-	13	1	16.28

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APPENDIX JJ: ALLOCATION KEYS USED IN AGRIBALYSE®.

PIG PRODUCTION

The calculation of allocation keys between piglets and cull sows is based on the amount of feed required to produce each of the two co-products. The keys calculated in this way are presented in**Table151**

Table151: Percentage of each type of feed used in the maternity class required to manufacture each of the two co-products.

Co-produc	Gilt feed	Pregnant feed	Suckling feed
Cull sows	100 %	75 %	40 %
Piglet	-	25 %	60 %

Table152: Allocation keys used for pig production.

Co-product no.	Co-product	Allocation
Axxx-132.171	Cull sows - Standard pigs - Rape-dominant feed - Bretagne or generic	69.3% of maternity class impacts
Axxx-133.172	Cull sows - Standard pigs - Mainly soy feed - Bretagne or generic	69.4% of maternity class impacts
Axxx-134.173	Cull sows - Standard pigs from local cereal/pig farms - Poitou Charente	69.9% of maternity class impacts
Axxx-135.174	Cull sow - Specialized standard pig with organic treatment - 100% purchase - Bretagne	69.2% of maternity class impacts
Axxx-136.175	Cull sow - Standard pig -France	69.3% of maternity class impacts
Axxx-137.176	Cull sow - Farm pig, red label, litter - France (Courette building)	69.5% of maternity class impacts
Axxx-137.177	Cull sow - Farm pig - label rouge, litter - France (Plein air)	69.8% of maternity class impacts
Axxx-138.178	Cull sow - Organic pig - France	69.8% of maternity class impacts

RABBIT PRODUCTION

Calculation of the allocation key between cull rabbits and young rabbits is based on the quantity of feed required to produce each of the two co-products (Table153). The impacts of the maternity class are then distributed as follows:

- Spent rabbit: 56.44
- Lapereau: 43.56

Table153: Percentage of each type of feed used in the maternity class required to manufacture each of the two co-products.

Co-product	Gestation	Lactation
Spent rabbit	75 %	40 %
Lapereau	25 %	60 %

CATTLE, SHEEP AND GOAT PRODUCTION

Allocations were made in proportion to the energy required for different animal needs. The equations proposed by the IPCC (2006b) were used.

Energy for survival (cattle/cattle/goats)

$$EN_s = Cf_i * (poids)^{0,75}$$

With:

EN_s: Net energy required by the animal for survival (MJ/day)

Cf_i: Coefficient varying for all animal categories (MJ/day/kg), see**Table154**

Weight: Live weight of animal (kg)

Table154: Coefficient for calculating the net energy required for animal survival.

Survival coefficient	Cfi (MJ/day/kg)
Cattle - outside lactation period	0,322
Cattle - lactating	0,386
Cattle-bull	0,37
Sheep-lamb less than one year old	0,236
Sheep over one year old	0,217

Energy required for activities (cattle)

$$EN_a = C_a * EN_s$$

With:

EN_a: Net energy required for animal activities (MJ/day)

C_a: Coefficient corresponding to the animal's feeding conditions, see**Table155**

EN_s: Net energy required by the animal for survival (MJ/day)

Energy required for activities (sheep/goats)

$$EN_a = C_a * (poids)$$

With:

EN_a: Net energy required for animal activities (MJ/day)

C_a: Coefficient corresponding to the animal's feeding conditions, see**Table155**

Weight: Live weight of animal (kg)

Table155: Coefficient of activity corresponding to the animal's feeding conditions.

Activity coefficient	Definition	C_a
Cattle: dimensionless C_a		
Barn	Animals are restricted to small areas and expend very little energy on feeding themselves	0
Grazing	The animals are restricted to areas with sFUficient forage and spend an average amount of energy on feeding.	0,17
Open pasture	The animals graze in open pastures or on steep slopes, expending considerable energy to feed themselves.	0,36
Sheep: C_a in MJ/day/kg		
Ewes in a pen	The animals are confined for gestation during the last trimester (50 days).	0,009
Flat pasture	Animals travel a maximum of 1,000 metres a day, using very little energy to feed themselves.	0,0107
Steep pasture	Animals travel a maximum of 5,000 metres a day, expending considerable energy to feed themselves.	0,024
Fattening lambs	Lambs are confined for fattening purposes	0,0067

Energy for growth (cattle)

$$EN_{Cce} = 22{,}02 * \left(\frac{PV}{C * PM}\right)^{0{,}75} * PP^{1{,}097}$$

With:

- EN(Cce): Net energy required for animal growth (MJ/day)
- PV: Average live weight of animals in the population (kg)
- C: Coefficient of 0.8 for females, 1 for neutered animals and 1.2 for bulls.
- PM: Mature live weight of adult females in moderate body condition (kg)
- PP: Average daily weight gain of animals in the population (kg/day)

Energy required for growth (sheep/goats)

$$EN_{Cce} = \frac{PP * \left(a + 0{,}5b * \left(PV_i + PV_f\right)\right)}{Durée\ de\ présence}$$

With:

- EN(Cce): Net energy required for animal growth (MJ/day)
- PP: Weight gain, PV_f - PV_i, (kg/day)
- $PV_{i:}$ Live weight at weaning (kg)
- $PV_{f:}$ Live weight at slaughter (kg)
- a, b: Constants, see**Table156**

Table156: Coefficients used to calculate the energy required for sheep growth.

Animal category	a (MJ/kg)	b (MJ/kg)
Unneutered males	2,5	0,35
Castrated males	4,4	0,32
Females	2,1	0,45

Energy required for lactation (cattle)

$$EN_l = lait * (1{,}47 + 0{,}40 * matières\ grasses)$$

With:

- EN_l: Net energy required for lactation (MJ/day)
- Milk: Quantity of milk produced (kg/day)
- Fat: Milk fat content (% by weight)

Energy required for lactation (sheep/goats)

$$EN_l = lait * VE_{lait}$$

With:

- EN_l: Net energy required for lactation (MJ/day)
- Milk: Quantity of milk produced (kg/day)
- $VE_{milk:}$ Net energy required to produce one kg of milk = 4.6 MJ/kg, corresponds to a milk fat content of 7% by weight.

Energy for growth (cattle/cattle/goats)

$$EN_G = C_{gestation} * EN_s$$

With:

- EN_g: Net energy required for gestation (MJ/day)
- $C_{gestation:}$ Gestation coefficient, see**Table157**
- EN_s: Net energy required by the animal for survival (MJ/day)

Table157: Coefficients to be used to calculate the energy required for gestation.

Animal category	$C_{gestation}$
Dairy cattle	0,10
Ewes	
Unique birth	0,077
Double birth (twins)	0,126
Triple birth or more (triplets)	0,150

Energy required for wool production (sheep)

$$EN_{laine} = \left(\frac{VE_{laine} * Production_{laine}}{durée\ de\ présence}\right)$$

With:

- EN_{wool}: Net energy required for wool production (MJ/day)
- VE_{wool}: Energy value of each kg of wool produced = 24 MJ/kg
- $Production_{wool}$: Average wool production per sheep over the period (kg/duration of period)

Table158 shows the allocation keys used for cattle, sheep and goats.

Table158: Allocation keys calculated for cattle, sheep and goat production in the AGRIBALYSE® program.

Inventory	Ax class	Biophysical allocations Co-products (%)				Other benefits		
		Milk	Veal/lamb	Wool	Ax reform	Co-products	Key (%)	Type
Lowland dairy - Specialized western lowland, corn dominant (>30% corn /SFP) - conventional - System 109w: lowland specialized dairy >30%.	Dairy cattle - Dairy cows in production	94,5	5,5					
	Dairy cattle - Calf (birth - "8 days")					Calf renewal	50,81	Massive
	Dairy cattle - Calf (birth - "8 days")					Veal	49,19	Massive
Lait de plaine - Spécialisé de plaine de l'ouest, herbe- maïs (10-30% maïs / SFP) - conventionnel - Système 110w	Dairy cattle - Dairy cows in production	93,9	6,1					
	Dairy cattle - Calf (birth - "8 days")					Calf renewal	49,34	Massive
	Dairy cattle - Calf (birth - "8 days")					Veal	50,66	Massive
Lowland milk - Specialized lowland, grass (5 to 10% maize/SFP) - conventional - System 111: lowland, specialized milk <10% maize	Dairy cattle - Dairy cows in production	92,1	7,9					
	Dairy cattle - Calf (birth - "8 days")					Calf renewal	49,34	Massive
	Dairy cattle - Calf (birth - "8 days")					Veal	50,66	Massive

Lowland milk - Specialized western lowland, grass (5 to 10% corn/SFP) - organic - System 111w-4b	Dairy cattle - Dairy cows in production	92,8	7,2					
	Dairy cattle - Calf (birth - "8 days")					Calf renewal	37,41	Massive
	Dairy cattle - Calf (birth - "8 days")					Veal	62,59	Massive
Lait de montagne - Spécialisé de montagne, herbe -conventionnel - System 117: Mountain-piedmont specializing in grass-fed milk from the Massif Central	Dairy cattle - Dairy cows in production	91,6	8,4					
	Dairy cattle - Calf (birth - "8 days")					Calf renewal	29,29	Massive
	Dairy cattle - Calf (birth - "8 days")					Veal	70,71	Massive
Average ewe's milk France - Minor pastoral - Conventional - From Roquefort system - specialized	Ovin lait - Lambs (0-weaning)		100					
	Ovin lait - Renewal ewe lambs 0-1 year old			1,2	98,8			
	Ovin lait - Ewes in production	89	10	1				
Goat's milk - Intensive forage area, center west - specialized - conventional From Poitou-Charentes system	Caprin lait - Goats in production	97,3	2,7					
Lamb - specialized sheep-farming-conventional	Ovin viande - 0-weaning lambs					lamb renewal	17,1	mass
	Ovin viande - 0-weaning lambs					lamb butchery	82,9	mass
	Ovin viande - Weanling lambs for sale		100					
	Ovin viande - Agnelles de renouvellement sevrage-1an			1,5	98,5			

	Ovin viande - Renewal ewe lambs 1yr-2yrs			3,7	96,3			
	Ovin viande - Ewes in production		98,6	1,4				

MEADOWS / MOWN GRASS - GRAZED GRASS

Since the inventories for mown grass (hay, wrapped grass, ensiled grass) include practices for mixed diets (i.e. pasture/mow), an allocation between the main product (mown grass) and the co-product (grazed grass) is required. A mass allocation was carried out by calculating a generic allocation key (= yield of the main product divided by the sum of the yields of the main product and the co-product, see column 3**Table159**). This key is used for inputs that benefit the main product and the co-product. Harvesting work (mowing, swathing, packaging, transport, etc.) has been allocated 100% to mown grass, because this harvesting work is due solely to mowing (see last column**Table159**

Table159: Allocation between product and co-product for the 17 grass LCIs.

LCI / crop	Allocation	Generic allocation key[1)]
01 grazed grass, permanent meadow, no legumes, Auvergne	No, pure diet	100%
02 conserved grass - wrapping, permanent grassland, without legumes, Auvergne	Yes, mass	3,58/(2,41+3,58) = 60%
03 preserved grass - silage, permanent grassland, without legumes, Auvergne	Yes, mass	3,58/(2,41+3,58) = 60%
04 conserved grass - hay, permanent meadow, no legumes, Auvergne	Yes, mass	4,18/(2,41+4,18) = 63%
05 grazed grass, permanent meadow, no legumes, North-West	No, pure diet	100%
06 preserved grass - silage, permanent grassland, no legumes, Northwestern	Yes, mass	3,55/(4,92+3,55) = 42%
07 preserved grass - hay, permanent meadow, no legumes, Northwestern	Yes, mass	4,22/(4,96+4,22) = 46%
08 grazed grass, temporary meadow, no legumes, North-West	No, pure diet	100%
09 preserved grass - haylage, temporary grassland, no legumes, Northwestern	Yes, mass	17,16/(17,88+17,16) = 49%
10 preserved grass - hay, temporary meadow, no legumes, Northwestern	Yes, mass	20,88/(17,88+20,88) = 54%
11 grazed grass, permanent meadow, with legumes, North-West	No, pure diet	100%

12 conserved grass - silage, permanent grassland, with legumes, Northwestern	Yes, mass	3,29/(4,92+3,29) = 40%
13 preserved grass - hay, permanent grassland, with legumes, Northwestern	Yes, mass	4,87/(4,92+4,87) = 50%
14 grazed grass, temporary meadow, with legumes, Northwestern	No, pure diet	100%
15 preserved grass - haylage, temporary grassland, with legumes, Northwestern	Yes, mass	18,2/(19,68+18,2) = 48%
16 grass silage, temporary grassland, with legumes, North-West	Yes, mass	17,72/(17,88+17,72) = 50%
17 preserved grass - hay, temporary meadow, with legumes, Northwestern	Yes, mass	4*5,87/(17,88+4*5,87) = 57%

1) Yield in t per hectare and duration of inventory.

Clémentine

After the clementines have been harvested, the fruit is classified according to quality into two groups: "clementines for export" and "clementines for the local market". Allocation was carried out on an economic basis, by multiplying the quantities of the two groups with their respective prices. The result is an allocation key of 86% for clementines destined for export (**Table160).**

Table160: Allocation between products and co-products for the clementine inventory.

Draft	Yield	Price	Allocation
Clémentine, export, SN - Average	330,6 t	3,000 Dirham/t	991 800/1 147 100= 86%
Clementine, local market	115,3 t	1,000 Dirham/t	115 300/1 147 100= 14%

Cafe

The allocation between coffee beans and pulp (full production phase) was made on an economic basis: 4% was allocated to pulp.

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EXPERTISES

AGRIBALYSE 3 - Methodological report 3.2

AGRIBALYSE 3 is a French database of life cycle inventories (LCI) for agricultural products and food consumption. It is produced as part of the AGRIBALYSE program, run since 2009 by ADEME and INRAE, with the support of numerous organizations and experts. Since 2021, AGRIBALYSE has been updated with the support and expertise of the members of the REVALIM Scientific Interest Group (ADEME, INRAE, ACTA, ACTIA).

AGRIBALYSE provides LCIs for 2,500 food products registered in CIQUAL, the national nutritional database (ANSES, 2017). Each food has a similar identification number and limits, enabling consistent links to be made between nutritional and environmental properties.

In September 2024, AGRIBALYSE 3.2 was published as the successor to AGRIBALYSE 3.1.1. This report describes the methodology used for the agricultural products in the database.