AGRIBALYSE®: METHODOLOGY

Version 1.3

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THE AGRIBALYSE® PROGRAM
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Abstract

The AGRIBALYSE® program

Farmers, the food industry, policy makers and consumers are increasingly interested in the environmental impacts of food products. In 2009, following the "Grenelle de l'Environnement" organized by the Ministry of the Environment, it was clear that it was necessary to improve the understanding of the environmental impacts of agricultural products and share the resulting data. The French Environment and Energy Management Agency (ADEME) launched the AGRIBALYSE® program to create a Life Cycle Inventory (LCI) database of French agricultural products. This database is restricted to flow LCI data sets and data for life cycle impact assessments (LCIA) rather than full life cycle assessments (LCA), which would require several more steps: normalization, aggregation and interpretation of the results. Many partners contributed to the program, including research institutes (INRA, Agroscope, CIRAD) and Technical Institutes representing the whole of the agricultural industry.

AGRIBALYSE® was built with two aims: i) build an LCI database to provide data for environmental labeling of food products and ii) share the data to enable the agricultural and food industries to assess the production chain and reduce environmental impacts.

AGRIBALYSE® provides 136 LCI data sets for arable, horticultural and livestock products. The deliverables are:

- A database in ecospold_v1 formats.
- Two Excel files (one for animal production, one for crop production) provided for AGRIBALYSE v1.2 with LCI and LCIA indicators.
- A final report in French and English (Agribalyse: Assessment and lessons for the future, Colomb *et al,* 2013), describing the project stages and main findings and including two notes on the quality control for the LCI data sets and the results as well as a sample of the sensitivity analysis of the results for two products
- The AGRIBALYSE® data collection guide
- This report on the methodology

This report on the methodology

General aim of the report

This document presents the methodologies selected by the 14 partners during the construction of the AGRIBALYSE® database. Most of these were adopted unanimously, the others by a majority vote. In conjunction with the metadata with each LCI data set, this document ensures that the AGRIBALYSE® approach is transparent. It gives a detailed description of the methods selected but is not intended to be a manual. It should help LCA practitioners to assess the quality of the AGRIBALYSE® database and create LCI data sets that are comparable to those of the AGRIBALYSE® database.

LCI data set handling: data collection, conversion and calculation

The data for the production systems was entered by the Technical Institutes using the data collection module (DCM) developed for AGRIBALYSE® using Excel. This module was then coupled to the direct emission calculation models within the inventory data processing system (IDPS), also using Excel, to obtain the direct emission flows. The background processes were then added using Simapro® to obtain the LCI and LCIA data sets. In the future, a new tool Means-Inout will be used to perform calculations and will replace both "the data collection tool" and the "calculation chain » (INRA 2015). More user friendy, it is potentialy usable for people wiling to make new LCIs following AGRIBALYSE methodology.

Quality control

There were two levels of quality control. The quality of the production system data, entered by the Technical Institutes into the DCM, was checked by independent experts. The LCI data calculated by INRA and Agroscope was checked internally by the Technical Institutes. This two-stage quality control process significantly improved the quality of the LCI data sets.

Products assessed

AGRIBALYSE® created LCI data sets for the main French agricultural products (and three imported products), using a standardized hierarchy. "Product groups" were generalized products (e.g. wheat, maize, broilers, pigs, etc). The French average LCI data sets for most product groups were built by averaging the individual LCI data sets for varied production systems (e.g., conventional, organic, AOC, regional variants, etc). These average LCI data sets were constructed case by case. Including variations within product groups, the database contains a total of 136 LCI data sets: 80 for livestock production and 57 for arable and horticultural production (**Appendix A**).

Products inventoried in AGRIBALYSE®	
Annual crops	*Durum wheat, soft wheat, sugar beet, carrots, rapeseed, faba beans, grain maize, barley, peas, potatoes, sunflowers, triticale*
Forage/grassland	*Grass, alfalfa, silage maize*
Fruits and vineyard	*Peaches, apples, cider apples, wine grapes*
Special crops	*Roses, tomatoes, ornamental shrubs*
Tropical special crops	*Coffee, clementines, jasmine rice, cocoa,oil palm fruit, mango*
Arable and horticultural total: 28 product groups	
Cattle	*Cow's milk, beef cattle*
Sheep	*Sheep's milk, lambs*
Goats	*Goat's milk*
Poultry	*Eggs, broilers, turkeys, ducks for roasting, ducks for foie gras*
Rabbits	*Rabbits*
Aquaculture	*Trout, sea bass/sea bream*
Pigs	*Pigs*
Livestock total: 14 product groups	

Representativeness

AGRIBALYSE® originally aimed to provide LCI datasets for agricultural products representative of the French market. However, due to the variability of farming practices, soils and climate in France, it was often difficult to construct a realistic "national average" production system. This was one reason for creating several LCI data sets for the same product, for different farming practices or regions. Where possible, they were then averaged to obtain “national average” products but, even so, an LCI data set representative of the whole of France was not possible for all products. Representativeness should always be considered when using the LCI data sets.

System boundaries (space and time)
The system boundaries for the AGRIBALYSE® LCI data sets are from cradle to farm gate. For crops, all up-stream processes (input production) are included but 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 processing phase is included (e.g., slaughter, cheese making).

To build LCI data sets representative of current production systems, the reference period chosen was from 2005 to 2009. Direct emissions, linked to animal and crop production, on the farm itself were modeled in AGRIBALYSE®, whereas indirect emissions associated with inputs were based on existing data, mainly from ecoinvent®. Additional work was required for indirect emissions associated with some feed ingredients (**Appendix L**).

Models used to calculate direct emissions
Farming activities cause direct emissions (e.g., CO_2, NH_3, trace metals, P, pesticides) and use resources (e.g., water, land). Emissions to environmental compartments (i.e., water, soil, air) were calculated using models. Each emission was calculated using a specific model chosen to be the most suitable for the requirements of the program. **Table 15** shows the emissions and resources included, the source and consumers and the models used.

Allocation
The allocation rules follow international recommendations. For arable and horticultural crops, most co-products are generated in the processing phase, which is not included in AGRIBALYSE®. For livestock production, a “biophysical” allocation method was used. If possible, allocation was avoided by breaking the system down into animal classes, characterized by animal’s age/physiological stage and management. Then, for animal classes requiring allocation (e.g., dairy cows during milk production), allocation was based on the metabolic energy required to produce each co-product (e.g., calf, milk). However, impacts of animal classes producing a single product were allocated 100% to this product. For example, all the impacts of the “dairy heifer” class were allocated to the “cull cow” product.

Résumé

Le programme AGRIBALYSE®

Les impacts environnementaux des produits agricoles est un sujet qui intéresse de plus en plus les agriculteurs, les filières, les pouvoirs publics et les consommateurs. Suite aux décisions prises dans le cadre du Grenelle de l'Environnement et à la volonté de mutualiser et d'améliorer les connaissances des impacts environnementaux des produits agricoles, l'ADEME a décidé de lancer un programme pour réaliser une base de données (BDD) d'Inventaires de Cycle de Vie (ICV) des produits agricoles, nommée AGRIBALYSE®. Cette base de données se limite à la production d'indicateurs de flux (ICV) et d'impacts (AICV) par opposition à la production d'Analyses du Cycle de Vie (ACV) complète, incluant les étapes de normalisation, d'agrégation et d'interprétation des résultats. Le programme a été monté en collaboration étroite avec les partenaires de la recherche (INRA, Agroscope et CIRAD) et avec les Instituts Techniques des principales filières agricoles.

Le but de ce travail est double : i) constitution d'une base de données d'ICV pour renseigner l'affichage environnemental des produits alimentaires ; ii) mutualisation des connaissances pour aider les professionnels du monde agricole et agro-alimentaire dans l'analyse des filières et la réduction de leurs impacts environnementaux.

Le programme a permis la mise à disposition de 136 ICV de produits agricoles animaux et végétaux. Les livrables sont :

- ✓ Une base de données ICV sous format ecospold_v1.
- ✓ Un fichier de synthèse Excel mis à disposition dans la version AGRIBALYSEv1.2 contenant les résultats ICV et IACV. .
- ✓ Un rapport « Bilan et enseignements » (Colomb *et al,* 2013), présentant le déroulement et les principaux résultats du programme, et incluant deux notes sur le contrôle qualité des ICV et des résultats ainsi qu'une analyse exemplaire de sensibilité des résultats pour deux productions.
- ✓ Le guide de collecte « AGRIBALYSE® » (Biard *et al,* 2011a).
- ✓ Ce rapport méthodologique.

Le rapport méthodologique

Objectif général du rapport

Ce rapport documente les choix méthodologiques effectués par les 14 partenaires du programme lors de l'établissement de la base de données AGRIBALYSE®. Ces choix ont été approuvés généralement à l'unanimité, sinon à la majorité. En complément des métadonnées disponibles pour chaque ICV, ce rapport assure la transparence de la démarche. Il présente la démarche et les choix retenus mais n'est pas conçu comme un guide de préconisation. Il doit permettre à des personnes extérieures d'évaluer la qualité des données fournies et de réaliser des ICV comparables à celles d'AGRIBALYSE®.

Calcul des ICV : données collectées, chaine de traitement

Les données d'inventaires décrivant les itinéraires techniques ont été saisies par les instituts techniques dans l'Outil Informatique de Saisie (OIS), développé pour AGRIBALYSE® sous Excel. L'OIS a ensuite été couplé à l'ensemble des modèles de calcul des émissions directes

au sein de la chaine de traitement des données (CDT), développée également sous Excel. Le couplage des données d'inventaires avec les modèles a permis d'obtenir les flux d'émissions directs. Les processus d'arrière plan indirects ont ensuite été intégrés via Simapro®, ce qui a permis le calcul des ICV et AICV. A l'avenir, l'outil Means-Inout (INRA) sera utilisé pour réaliser les calculs et remplacera l'OIS et la CDT (INRA 2015). Plus facile d'utilisation, il est potentiellement accessible pour des utilisateurs souhaitant réaliser de nouvelles ACV selon méthodologie AGRIBALYSE.

Contrôle qualité

Un contrôle qualité des données a été réalisé à deux niveaux. Dans un premier temps, les données d'itinéraires techniques, renseignées par les Instituts Techniques dans l'OIS, ont été contrôlées par des experts extérieurs au programme AGRIBALYSE®. Dans un deuxième temps, les données ICV calculées par l'INRA et Agroscope ont été contrôlées en interne par les instituts techniques. Ce double contrôle a permis d'améliorer significativement la qualité des inventaires produits.

Produits étudiés

AGRIBALYSE® a permis de réaliser l'ICV des principaux produits agricoles français (et trois produits importés), selon une méthodologie homogène. Les « groupes de produits » font références aux cultures ou aux animaux (ex : blé, maïs, poulet de chair, porc, etc.). La construction d'ICV représentatifs France pour la plupart des « groupe de produits » s'est faite en agrégeant des ICV unitaires correspondants à des systèmes contrastés (conventionnel, biologique, AOC, déclinaisons régionales, etc.). Cette agrégation s'est faite au cas par cas pour chaque production. En tenant compte des déclinaisons (systèmes de productions spécifiques), la base de données contient au total 136 ICV : 80 ICV de productions animales et 57 de productions végétales **(Annexe A)**.

Les produits étudiés dans AGRIBALYSE®	
Cultures annuelles	*Blé dur, blé tendre, betterave sucrière, carotte, rapeseed, féverole, maïs, orge, pois, pomme de terre, tournesol, triticale*
Prairies/Fourrages	*Herbe, luzerne, maïs ensilage*
Fruits et vigne	*Pêche/nectarine, pomme, pomme à cidre, raisin de cuve**
Cultures spéciales métropolitaines	*Rose, tomate, arbuste*
Cultures spéciales tropicales	*Coffee, clémentine, riz jasmin, mangue, cacao, fruit du palmier à huile*
Production végétale : 28 groupes de produits	
Bovins	*Lait de vache, bovin viande*
Ovins	*Lait de brebis, agneau*
Caprins	*Lait de chèvre*
Volailles	*Œuf, poulet de chair, dinde, canard à rôtir, canard à gaver*
Cuniculture	*Lapin*
Aquaculture	*Truite, bar / dorade*
Porcs	*Porcs*
Production animale : 14 groupes de produits	

Représentativité
L'objectif initial d'AGRIBALYSE® était d'obtenir des ICV de produits agricoles représentatifs du marché français. Cependant, au regard de la variabilité des pratiques et des conditions pédoclimatiques sur le territoire, il est souvent difficile de construire une description agronomique pertinente d'un produit moyen français. Ainsi, des déclinaisons régionales, ou par mode de production et pertinentes au niveau agronomique ont été définies, et ont permis de construire un produit moyen France. Cependant, la représentativité française n'a pas pu être obtenue pour l'ensemble des produits. L'utilisation des ICV AGRIBALYSE® doit donc tenir compte de leur représentativité.

Limite des systèmes (spatiale/temporelle)
Le système considéré pour les ICV d'AGRIBALYSE® est du berceau jusqu'à la sortie du champ (pour les inventaires de productions végétales) ou sortie de l'atelier de production (pour les inventaires de productions animales). Ceci implique pour les productions végétales l'intégration de l'ensemble des processus amonts (fabrication des intrants) et sur champ (opérations culturales) mais l'exclusion des processus post-récoltes éventuellement effectués à la ferme (ex : stockage des pommes de terre, séchage des céréales). Les ateliers animaux sont à considérer au sens strict. L'ensemble des processus nécessaires au fonctionnement de l'atelier (bâtiments d'élevage, stockage et fabrications des aliments d'élevage sur la ferme, fonctionnement de la salle de traite et du tank à lait, etc.) sont inclus mais les opérations de transformation pour l'alimentation humaine (transformation fromagère, etc.) sont exclues.
Dans l'objectif de réaliser des ICV aussi représentatifs que possible des productions agricoles actuelles, la période de référence retenue est la période 2005-2009.
Les émissions directes, associées aux productions animales et végétales, sur leur site de production ont été modélisées (see point suivant), alors que les émissions indirectes liées à la production des intrants utilisés sur le site de production ont été intégrées à partir des données de bases d'inventaires pré-existantes, principalement ecoinvent®. Un travail a spécifique a été réalisé concernant l'alimentation animale (**Annexe L**).

Modèles de calculs des émissions directes
Les activités de production agricole engendrent des émissions directes (ex : CO_2, NH_3, ETM, P, molécules phytosanitaires, etc.) ainsi qu'une consommation de ressources nécessaires aux processus de production (consommation d'eau, occupation des terres, etc.). Ces flux émis dans les différents compartiments (eau, sol, air) ont été calculés à l'aide de modèles. Chaque flux de substance a été modélisé par un modèle spécifique, qui a été choisi comme étant le plus adapté par rapport aux objectifs du programme AGRIBALYSE®. Le **Table 14** présente les émissions et consommations retenues, les postes considérés et les modèles retenus.

Allocation

La procédure concernant la gestion des allocations s'inscrit dans le respect des standards internationaux. Pour les filières végétales, les coproduits sont souvent générés lors de la transformation agro-industrielle du produit agricole brut. Le périmètre d'AGRIBALYSE® se limitant à la phase de production agricole (produit « sortie champ »), la question de l'allocation des impacts aux différents coproduits ne se posait pas pour la majorité des produits végétaux. Pour les productions animales, une allocation dite « biophysique » a été mise en œuvre. Dans un premier temps, l'allocation est évitée en décomposant le système en classes d'animaux conduites de manière similaire. Dans un second temps, pour les phases où l'allocation ne peut être évitée (ex : phase vache laitière en production), une allocation des impacts entre les différents coproduits est réalisée au prorata de l'énergie nécessaire à leur élaboration. Les impacts environnementaux des classes d'animaux ne produisant qu'un seul produit sont intégralement affectés à celui-ci. Ainsi les impacts d'une classe « génisse laitière » seront affectés au produit « vache de réforme ».

Abbreviations

ACTA	Association de Coordination Technique Agricole – United Agricultural Technical Institutes
ADEME	Agence de l'Environnement et de la Maitrise de l'Energie – French Environment and Energy Management Agency
AFNOR	Association Française de NORmalisation – French Standards Institute
AGRESTE	French Ministry of Agriculture, Food and Forestry agricultural statistics, assessment and forecasting service
AOX	Adsorbable Organic Halogen
ASTREDHOR	Horticultural Institute
BDAT	Soil Analysis Database
BOD	Biological Oxygen Demand
CASDAR	Compte d'Affectation Spécial pour le Développement Agricole et Rural – Agricultural and Rural Development Fund
Cd	Cadmium
CED	Cumulative Energy Demand
TERRES INOVIA	Centre Technique Interprofessionnel des Oléagineux et du Chanvre - Technical center for research and development of production procedures for oilseed and industrial hemp
CH	Switzerland
CH_4	Methane
CIRAD	Centre de coopération Internationale en Recherche Agronomique pour le Développement – International Co-ordination Center for Agricultural Research for Development
CITEPA	Centre Interprofessionnel Technique d'Etudes de la Pollution Atmosphérique – Atmospheric Pollution Institute
CML	Centrum voor Milieuwetenschappen Leiden – Institute of Environmental Sciences
CN	China
CO_2	Carbon dioxide
COD	Chemical Oxygen Demand
COMIFER	Comité Français d'Etude et de Développement de la Fertilisation Raisonnée – French committee for research and development into rational fertilizer use
CORPEN	Comité d'Orientation pour des Pratiques agricoles respectueuse de l'ENvironnement – French government committee for environmentally friendly agricultural practices
CPS	Crop production system
Cr	Chromium
CTIFL	Centre Technique Interprofessionnel des Fruits et Légumes – Fruit and Vegetable Institute
CTU_e	Comparative toxic units – ecotoxicity
CTU_h	Comparative toxic unit – human toxicity
Cu	Copper
DB	Database
DCB eq	DiChloroBenzene equivalent

DCM	Data collection module
DM	Dry Matter
EAA	Effective agricultural area
EDIP	Environmental Design of Industrial Products
EMEP/CORINAIR	European Monitoring and Evaluation Programme / CORe INventory of AIR emissions
EMEP/EEA	European Monitoring and Evaluation Programme / European Environment Agency
ESA Angers	Ecole supérieure d'Agriculture d'Angers - Angers Agricultural School
FR	France
GDC	Biard et al 2011, Guide De Collecte des données – Data Collection Guide
GGELS	Greenhouse Gas from the European Livestock Sector
GLO	GLObale, country code for ecoinvent® data sets with a worldwide scope
GT1	ADEME-AFNOR Working Group 1: Alimentation et aliments pour animaux domestiques – Nutrition and fodder for domestic animals
GWP	Global Warming Potential
h	Hour
ha	Hectare
Hg	Mercury
IDELE	Institut De L'ELEvage – Breeding Institute
IDF	International Dairy Federation
IDPS	Inventory Data Processing System
IES	Institute for Environment and Sustainability
IFV	Institut Français de la Vigne et du Vin – French Vine and Wine Institute
ILCD	International Reference Life Cycle Data System
INRA	Institut National de la Recherche Agronomique – French National Institute for Agricultural Research
IPCC	Intergovernmental Panel of Climate Change
IRSTEA	Institut national de Recherche en Sciences et Technologies pour l'Environnement et l'Agriculture – National Research Institute of Science and Technology for Environment and Agriculture
ISO	International Organization for Standardization
ITAB	Institut Technique de l'Agriculture Biologique – Organic Agriculture Institute
ITAVI	Institut Technique de l'AVIculture – Poultry Breeding Institute
ITB	Institut Technique de la Betterave – Sugarbeet Institute
JRC	Joint Research Center
K	Potassium
kg	Kilogram
km	Kilometer
L	Liter
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment

LUC	Land use change
m^2	Square meters
m^2yr	Square meter years
MELODIE	Modélisation des Elevages en Langage Objet pour la Détermination des Impacts Environnementaux – Object Oriented Language Model of Livestock Farms for Determining the Environmental Impact
N	Nitrogen
N_2O	Dinitrogen monoxide
NH_3	Ammonia (azane IUPAC)
Ni	Nickel
NO	Nitric oxide (nitrogen monoxide)
NO_3^-	Nitrate
NOx	Mono-nitrogen oxides (nitrogen oxides NO and NO_2)
OFP	On-Farm Production
OM	Organic matter
P	Phosphorus
P_2O_5	Phosphorus pentoxide
PAN	Plant-available nitrogen
PAS	Publicly Available Specification drawn up to British Standards
Pb	Lead
PO_4^{3-}	Phosphate
RER	Europe, country code for ecoinvent® data sets with a European scope
RM	Raw Materials
RMQS	Réseau de mesure de la Qualité des Sols – French soil quality measurement network
RUSLE	Revised Universal Soil Loss Equation
SALCA	Swiss Agricultural Life Cycle Assessment
SALCA-ETM-Fr	Swiss Agricultural Life Cycle Assessment, trace metal flux model for France
SALCA-N	Swiss Agricultural Life Cycle Assessment, nitrate flux model
SALCA-P	Swiss Agricultural Life Cycle Assessment, phosphorus flux model
SALCA-SM	Swiss Agricultural Life Cycle Assessment, trace metal flux model
SCEES	Service Central des Enquêtes et Etudes Statistiques – Central Statistical Service
SFP	Main forage area (Surface fourragère principale)
SO_2 eq	Sulfur dioxide equivalent
SQCB	Sustainable Quick Check for Biofuels
SSP	Service de la Statistique et de la Prospective – French Ministry of Agriculture Statistical and Forecasting Service
STICS	Interdisciplinary simulator for standard crops
t	Tonne
TAN	Total Ammoniacal Nitrogen
TM	Transport Model
TN	Total nitrogen
TSS	Total Suspended Solids

UMR-SAS	Unité Mixte de Recherche – Sol, Agro et hydrosystème Spatialisation – Joint Research Unit – Soil, agriculture and hydrosystem spatialization
UNIFA	Union des industries de la fertilisation – Union of fertilizer producers
UP	Unprocessed products
VA	Suckler cow
VBA	Visual Basic for Applications
VL	Dairy cow
WM	Whole Matter (dry matter + water)
XML	eXtensible Markup Language
Zn	Zinc

Introduction

Background and aim of this report

When producing Life Cycle Assessments (LCA) for agricultural processes, it is necessary to select the methodology to be used for defining the systems studied, the functional units, the system boundaries and assessment period, as well as the models and their parameters to be used for calculating direct emissions (foreground), impact indicators and characterization methods. This report gives a detailed description of the choices made for the AGRIBALYSE® program. It is not a guide and its contents are not intended to be used as recommendations. However, it could subsequently serve as a basis for drawing up a guide to the AGRIBALYSE® methodology.

The methodology described here was applied to produce Life Cycle Inventories (LCI) for agricultural products in France and for certain crops grown overseas, as part of the AGRIBALYSE® program.

This report is intended for those wishing to produce an LCI using the AGRIBALYSE® methodology.

This report covers the four phases of Life Cycle Assessment defined in ISO 14040 (ISO, 2006a) and ISO 14044 (ISO, 2006b).

Life Cycle Assessment

LCA is a technique for assessing the environmental impact of a product or service throughout its life time. An LCA is carried out in four distinct phases and can be used to compare different products and determine how their environmental performance can be improved. According to the ISO standards (ISO, 2006a and ISO, 2006b), the four phases are:

- Definition of the aims and scope of the study. This phase presents the problem and defines the aims and scope of the study
- The inputs (extraction of resources, means of production) and the outputs (emissions, products) required to produce the function of the system studied
- The impact assessment based on the inputs and outputs identified in the previous phase
- The interpretation of the results from the previous phases and evaluation of the uncertainties

Part A – **Defining the aims and scope of the study**

A.1 Aims

A.1.1 The AGRIBALYSE® program and background to this report

There is currently an increasing awareness in Europe of the environmental impact of economic activities, in particular agriculture. In France, the Grenelle de l’Environnement marked a major turning point setting out ambitious aims, in particular that of labeling current consumer products with their environmental impact. The law applying the Grenelle de l’Environnement required that, after an experimental phase of at least one year with effect from 1 July 2011, consumer products including food should be labeled to show the environmental footprint of the product, including greenhouse gas emissions. The ADEME was commissioned to develop the methodology for this program in cooperation with AFNOR. This resulted in a definition of the general principles and a methodology for labeling products with their environmental footprint: BPX30-323 (AFNOR, 2011).
This work was also part of more general international actions on the environmental impact of products: the European LCD database and the ILCD (JRC and IES, 2010a).
The diversity of agricultural products and the need to harmonize the assessment methodologies used in different types of farming requires coordination and aggregation of the LCI data sets.

The ADEME also produced a bibliographical analysis of LCA for agricultural products (Ecointesys-ADEME, 2008) and organized a conference to present and discuss the results in October 2008. The conference concluded that LCA was suitable for assessing the environmental impact of agricultural products, that the results depended on the production systems and the methodology used, that certain indicators needed further improvement and that there was a lack of LCA studies on agricultural products in France. It was also clear that there was a need to harmonize methods and valorize the data by incorporation into a database.

It was clear that a joint program needed to be set up to create a database for a French agricultural product LCI using a harmonized methodology.

This report sets out the choices made by the 14 partners in the AGRIBALYSE® program when drawing up the AGRIBALYSE® database. These choices reflect:

- the requirements, recommendations and considerations defined in the AGRIBALYSE® Data Collection Guide,
- the decisions taken on methodology by the AGRIBALYSE® Steering Committee,
- the assessments carried out and decisions taken at the seminars on methods for calculating direct emissions and the quality control of the results.

A.1.2 Aims of the AGRIBALYSE® program

The aim of the program was to create a **uniform, public** LCI database of French agricultural products and develop a **method for LCAs that was suitable for the agricultural sector**. A method was sought that would provide **harmonized, widely accepted** results for different types of farming so that it could be used by as many businesses as possible.

AGRIBALYSE® had two aims.

- **1. Provide the information necessary for environmental labeling** of food products. AGRIBALYSE® LCI data sets will be available for incorporation into the IMPACTS® public database. The final selection of the AGRIBALYSE® data sets for incorporation into the IMPACTS® database depends on the IMPACTS® database steering committee.
- **2. Provide standards for the agroindustry to help environmental assessments and actions to reduce environmental impacts.** The collection of methodologies selected will provide a starting point and standards for subsequent LCAs and will provide support for projects seeking to improve agricultural practices (ecodesign).

This database should improve the international visibility of French research into life cycle inventories. Details of the organization, timetable and achievements of the program can be found in the report "AGRIBALYSE®: Assessment and lessons for the future" (Colomb *et al*, 2013).

A.1.3 Deliverables

To meet these two aims and ensure the confidentiality of certain information, the processes were grouped into three classes, depending on the aim:

- Affichage (Labeling), information made available for environmental labeling
- "AGRIBALYSE®, information not made available for labeling but published in the AGRIBALYSE® database
- Interne (Internal), for unpublished, confidential information.

The three outputs from the AGRIBALYSE® program were:

- The AGRIBALYSE® database in Ecospold/ILCD format containing the LCI data sets for unit processes, drawn up and classified AGRIBALYSE® (136 LCI data sets, see A.2.1), and around one hundred LCI data sets for agricultural inputs obtained mainly by converting LCI data sets taken from databases external to the project.
- For each LCI data set, a summary was produced giving the scope and key data for the production systems together with a list of inputs and certain results from the LCI and LCIA.
- A list detailing which of the 136 data sets produced were available for labeling.

An overall summary of the data sets produced and their classification is attached at **Appendix A**. Information on accessing the data sets and summaries is set out in the report "AGRIBALYSE®: Assessment and lessons for the future" (Colomb *et al*, 2013).

Note on ILCD format: The AGRIBALYSE® database complies with ISO 14040 (ISO, 2006a) and the ILCD handbook (JRC and IES, 2010a). The recommendations in the ILCD handbook depend on the goal and main application of the LCA study (defined as "situations"). Given aim 2 of the AGRIBALYSE® program (supplying data for agroindustry environmental studies), the LCI data sets in the AGRIBALYSE® database are targeted for situation A "Micro-level decision support" (JRC and IES, 2010a).

A.1.4 Users of the results from the AGRIBALYSE® program

The LCI data sets in AGRIBALYSE®, that will be made available for incorporation into the IMPACTS® database, are intended to be used by:

- Consumers, to be able to compare everyday consumer products using the information on environmental labeling,
- The agroindustry, for actions to improve the environmental performance of the business,
- Policy makers, for defining government policy.

A.2 Scope

The scope of the study was defined to ensure that its breadth, depth and level of detail were compatible with, and able to meet, the aims of the study. The following chapters provide the information required by ISO 14040 and ISO 14044 (ISO, 2006a and ISO, 2006b). "In defining the scope of an LCA study, the following items shall be considered and clearly described":

- The product systems to be studied (see A.2.1)
- The functions of the product systems (see A.2.1)
- The functional units (see A.2.1)
- The product system boundaries (see A.2.2)
- The data requirements (see A.2.3)
- The data quality requirements (see A.2.4)
- The type of critical review (see A.2.5)
- The type and format of the report required for the study (see A.2.6)
- The allocation procedures (see B.3)
- The types of impact and methodology of impact assessment (see Part C).

A.2.1 Product systems studied and their functions

A.2.1.1 Product systems studied

AGRIBALYSE® focuses exclusively on agricultural product systems in France and certain products imported from tropical countries. ISO 14044 (ISO, 2006b) and the ILCD Handbook (JRC and IES 2010a) both give a very broad definition of a "product". When the ISO/ILCD definition of "product" is applied, each AGRIBALYSE® data set represents one product.
Given the considerable diversity in agricultural product systems, AGRIBALYSE® introduced a hierarchical classification to present the results more simply. The hierarchical levels "**product group"** and "**product"** are defined as follows:

- A **product group** brings together similar **product variants**.
- The **product variants** distinguish different product systems according to parameters such as the production region, the production system and the production method.

The product groups were selected by analyzing the agricultural products most commonly consumed in France (BIO IS, 2010). The product variants were defined according to three criteria: (1) typical product system, (2) unusual product system and (3) new product system. The product variants were selected by each Institute depending on its expertise and its resources within the framework of the program, and then considered and approved by the project leaders and ADEME.

The analysis of the agricultural product systems presented in **Table 1** is based on this terminology.

Table 1: Product groups and variants inventoried in the AGRIBALYSE® program. The detailed list of LCI data sets is attached at **Appendix A**

Sector	Type (the product groups are given in brackets)	Number of product groups	Number of product variants	Total number of data sets
Arable / horticultural	**Annual crops** *(durum wheat, soft wheat, sugar beet, carrots, rapeseed, faba beans, grain maize, barley, peas, potatoes, sunflowers, triticale)*	12	28	48
	Grassland/forage *(grass, alfalfa, silage maize)*	3	16	20
	Fruit *(peaches/nectarines, apples, cider apples, wine grapes)*	4	13	35
	Special crops grown in France *(roses, tomatoes, ornamental shrubs[a])*	3	6	21
	Special tropical crops *(coffee, clementines, jasmine rice, cocoa, mago, oil palm fruit)*	6	6	11
Total	**Arable / horticultural**	**28**	**69**	**136**
Livestock	**Cattle** *(cow's milk, beef cattle, veal)*	3	14	26
	Sheep *(sheep's milk, lambs)*	2	2	7
	Goats *(goat's milk)*	1	1	3
	Poultry *(eggs, broilers, turkeys, ducks for roasting, ducks for foie gras)*	5	15	21
	Rabbits *(rabbits)*	1	1	2
	Aquaculture *(trout, sea bass / sea bream)*	3	3	3
	Pigs *(conventional, Label Rouge, organic)*	3	8	16
Total	**Livestock**	**18**	**44**	**78**

a) The term "shrubs" denotes ornamental container grown plants. For simplification, the term "shrub" is used throughout this report.

The difference between the "number of product variants" and the "total number of data sets" in **Table 1** is the number of internal data sets.

Agricultural production systems are often used for several purposes: a single production system may provide several co-products (for example: milk – veal – cull cows). To allocate the environmental impacts satisfactorily, these production systems were broken down into several units. For livestock, classes of animals were defined (for example: *veal/heifer/dairy cow* for a dairy farm). For horticultural systems, a distinction was drawn between the various production phases for vineyards and orchards (for example *nursery/established orchard*). The LCI data set for an AGRIBALYSE® product may, therefore, be based on:

- a specific data set: veal or durum wheat
- the average of several data sets (production phases or internal data sets): lowland cow's milk, cider apples or carrots (see **Appendix B**)
- a data set created by allocation to a co-product: cull dairy cow

A.2.1.2 Defining functions of production systems

Given the aims of the AGRIBALYSE® program, the studies were focused on production systems for the provision of food, i.e. the supply of agricultural products for human and animal consumption. In general, the function of the system can be defined as "the provision of a given quantity of agricultural product (animal or plant), at farm gate, (1) with a precisely defined level of quality or (2) with a defined composition".

The term "with a defined composition" applies to products that come from an variety of different production systems and represent a mix of these different systems. The term "with a precisely defined level of quality" applies to all other products (see following examples).

Defined level of quality (sugar beet) or defined composition of a product (potato), documented in the summaries:
Sugar beet (specific data set): data set for the production of 1 kg sugar beet with 16% sugar content.
Potato (average data set): data set for the production of 1 kg potatoes with different production systems, at 80% moisture content. This is an average of the data sets for potatoes grown for the food industry (28%), potatoes for the fresh market excluding firm flesh varieties (52%) and starch potatoes (20%).

This distinction cannot be applied to two special French plant products (roses and shrubs) as their function is not intended to be used for food but to meet other consumer demands.

Other functions of agricultural production systems, such as their contribution to biodiversity, land development and the generation of income for farmers, are not considered as co-products and flows have not been allocated to these functions.

A.2.1.3 Naming convention

The data sets are named in accordance with the recommendations in the ILCD handbook (JRC and IES, 2010b). As English is the official language of the ILCD, all the data sets in the AGRIBALYSE® are in English and French. The naming convention used is (see rule 17 – JRC and IES, 2010b): Base name; Treatment, standards, routes; Quantitative flow properties; Mix type and location type" (**Table 2**). For compatibility with other naming conventions (for example ecoinvent® 3.2), the order of the last two elements has been inverted with respect to Rule 17.

Table 2: Naming convention

Element	Français	English
Base name	Blé tendre, grain;	Soft wheat, grain;
Treatment, etc	conventionnel, panifiable ;	conventional, breadmaking quality;
Flow properties	15% d'humidité ;	15% moisture;
Mix and location type	sortie champ.	at farm gate.

The final name in this example is "Soft wheat grain; conventional; breadmaking quality, 15% moisture; at farm gate" in English and "Blé tendre, grain ; conventionnel, panifiable ; 15% d'humidité ; sortie champ" in French.

A.2.1.4 Functional unit

The functional unit quantifies the system function and its performance characteristics. It is used to provide a measure for normalizing (in the mathematical sense) the inputs and outputs.

As was appropriate for the product functions (see chapter A.2.1), the functional units in the AGRIBALYSE® data sets are usually defined as units of mass or volume (provided that the density is specified): 1 kg or 1 liter of product. Depending on the nature of the product, additional information is given (for example the moisture content or fat content) in the LCI data set name and in the metadata.
The functional units used are:

- For arable and horticultural production: kg of whole matter to the standards required (moisture, sugar, protein contents) of the product at the farm gate.
- For livestock:
  - for meat animals: kg of live weight
  - for milk: kg of milk corrected to 4% fat and 3.3% protein)
  - for eggs and wool: kg

Specific functional units were selected for the following cases:

- Where the normal sales unit is not by weight:
  1. **Shrubs**: the functional units for shrubs are "1 container grown shrub".
  2. **Roses:** the functional units for roses are "100 cut flower stems" (which is approximately the annual yield from 1 m^2).
- Where the calculation unit is the dry matter (forage)
  1. **Hay**: the functional units are 1 kg of dry matter after deduction of harvesting losses (cutting and baling, details **Table 166 Appendix L**). To ensure that the LCI assessments for livestock and arable are compatible, the functional units for grazed grass are defined as "kg whole matter (with 20% dry matter)".
  2. **Alfalfa and silage maize**: the functional units are 1 kg of dry matter.
- Special cases
  1. **Coffee**: The functional units are 1 kg of green coffee beans after drying and removing the pulp, as most economic statistics use these units.
  2. **Carrots and fruit**: the functional units are 1 kg of whole product sold for fresh consumption (1^{st} grade) or for the food industry (2^{nd} grade).
  3. **Clementines**: The functional units are 1 kg of whole product for export.

A.2.2 System boundaries

A.2.2.1 General rule: from cradle to gate

AGRIBALYSE® was set up to produce LCI data sets for the main French agricultural products for incorporation into the ADEME IMPACTS® database. This data is intended for use by businesses downstream of the farm gate. AGRIBALYSE® did not, therefore, take account of the processing, consumption and end of life of food products. As a result, the **general rule** for AGRIBALYSE® LCI is to use the **cradle to gate** system boundaries.

This implies that for **arable farming and horticultural products** (produced in France or abroad for tropical products) account is not taken of post-harvest processes which may be carried out on the farm (such as storing potatoes or drying grain).

To be consistent between products, transportation between the field and the storage area in the farm is accounted for all crops, except for products going directly to processing units without onfarm storage (grapes and beetroots). More detail is provided Appendix D, Datasheet 16.

A.2.2.2 Production system boundaries

a) Processes included

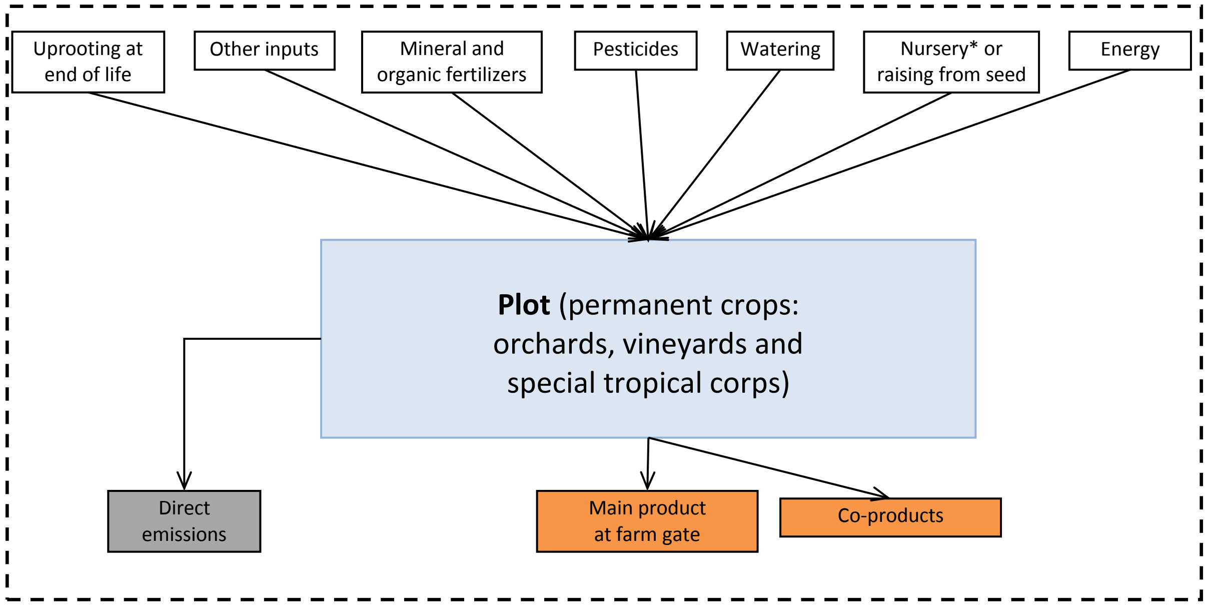
In AGRIBALYSE®, each data set takes account of all the processes and inputs required for the production of an agricultural product from cradle to gate. This definition of the boundaries is consistent with those used for GESTIM (Gac *et al*, 2010) and ecoinvent® (Nemecek and Kägi, 2007).

The processes considered are:

- **For arable and horticultural products**
  - ✓ Production of seed and plants (nursery for horticultural plants and fruit trees)
  - ✓ Production and application of active substances in pesticides (herbicides, fungicides, insecticides and others)
  - ✓ Production and application of mineral fertilizers
  - ✓ Application of organic fertilizers. The production and/or processing of organic fertilizers were taken into account where suitable LCI data sets were available (eg: feather meal, see **Appendix G**). For the application of organic fertilizer from the farm, phantom data sets, processes without any environmental impact, were set up to ensure that direct emissions resulting from their application were calculated correctly and to simplify the verification of the data sets
  - ✓ All operations such as: preparation of the soil, drilling, pesticide application, fertilizer application, tending the crops, harvesting, transport to the storage area, managing intercrops (if appropriate), including the manufacturing of the machinery and construction of buildings, maintenance and storage (sheds/barns or open storage space) as well as the fuel required for the operations
  - ✓ Irrigation including the water used and the energy consumed (see chapter B.2.2)
  - ✓ Direct emissions (emissions from the fields and emissions from the fuel used for power and heating)

- **For livestock**
  - The fabrication of feed (production of raw materials and processing) and transport to the farm for bought-in feed and raw materials
  - The production, harvest, storage and distribution of fodder
  - The use of grassland including for grazing; access to outdoor runs for poultry and fields for pigs
  - Watering in terms of water consumed by the animals
  - Breeding genitors and production of young animals
  - Livestock buildings and the machinery required (milking parlors including milk tank, stabling, waste storage systems, feed storage silos, etc.), including the manufacturing of the machines, construction of buildings, their operation and storage areas (shed/barn/garage)
  - Cleaning equipment and buildings and cooling systems
  - Direct emissions associated with the animals (rumination), waste management in the buildings/storage areas/pastures/runs/fields and from the fuel used for power
  - Fossil fuels required for heating buildings, etc.

Figures 1 to 9 show the boundaries for the various types of system covered by AGRIBALYSE®.



*Nurseries are also modeled as permanent crops

Figure 1: Boundaries for permanent crop systems such as orchards, vineyards and special tropical crops (coffee, clementines)

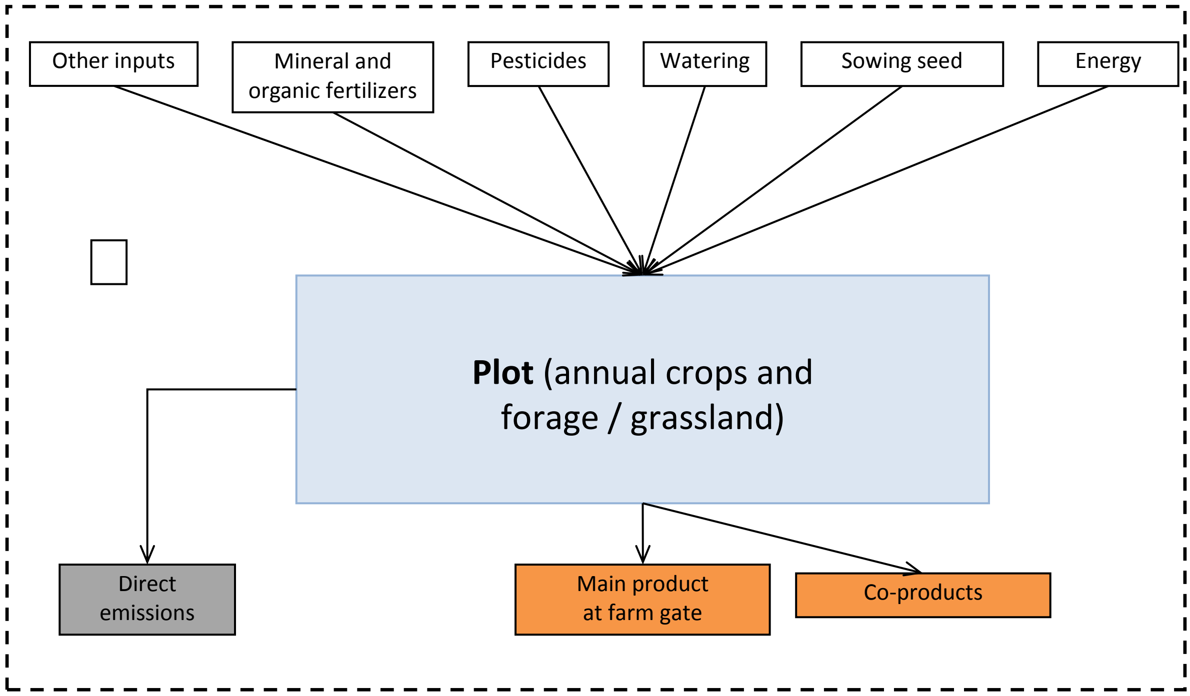


Figure 2: Boundaries for annual crop systems such as forage and grassland

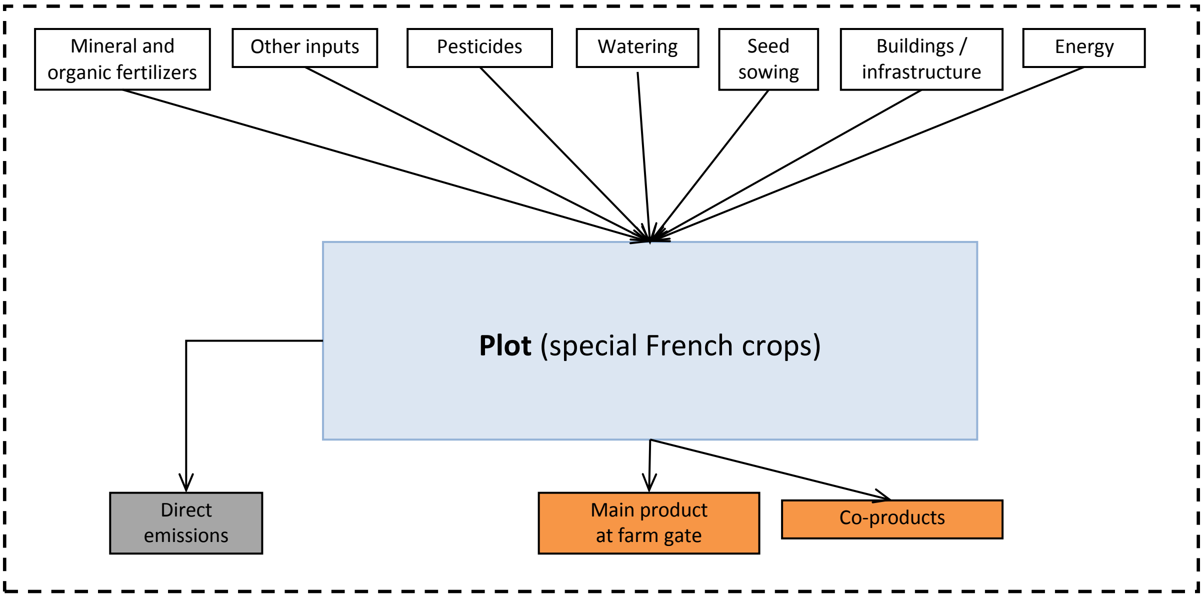


Figure 3: Boundaries for special French crops (shrubs, roses and tomatoes)

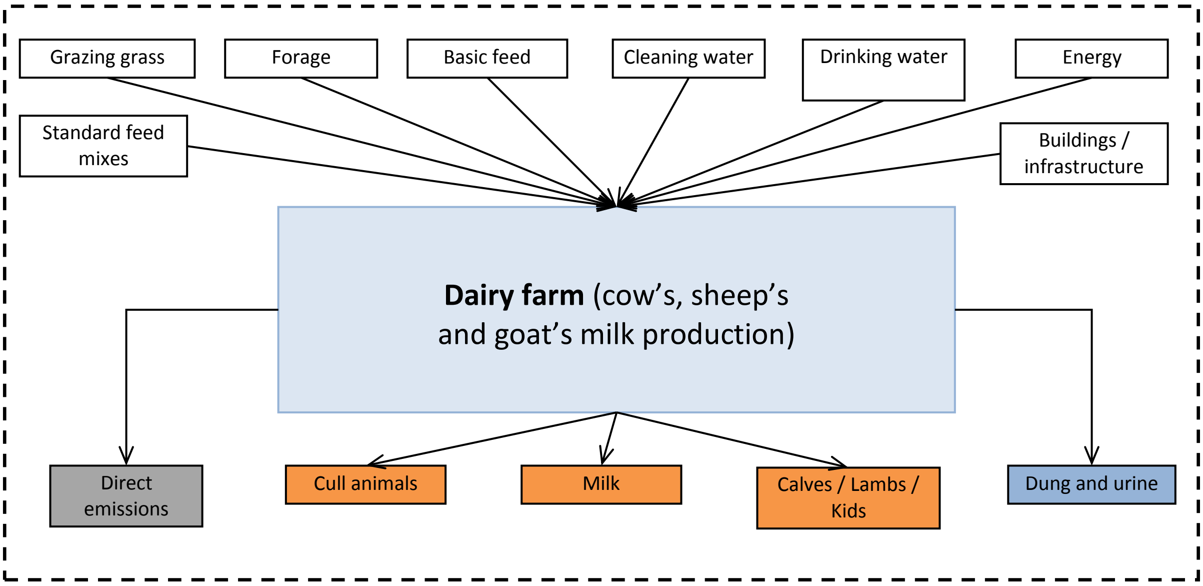


Figure 4: Boundaries for milk production systems (cows, sheep and goats).

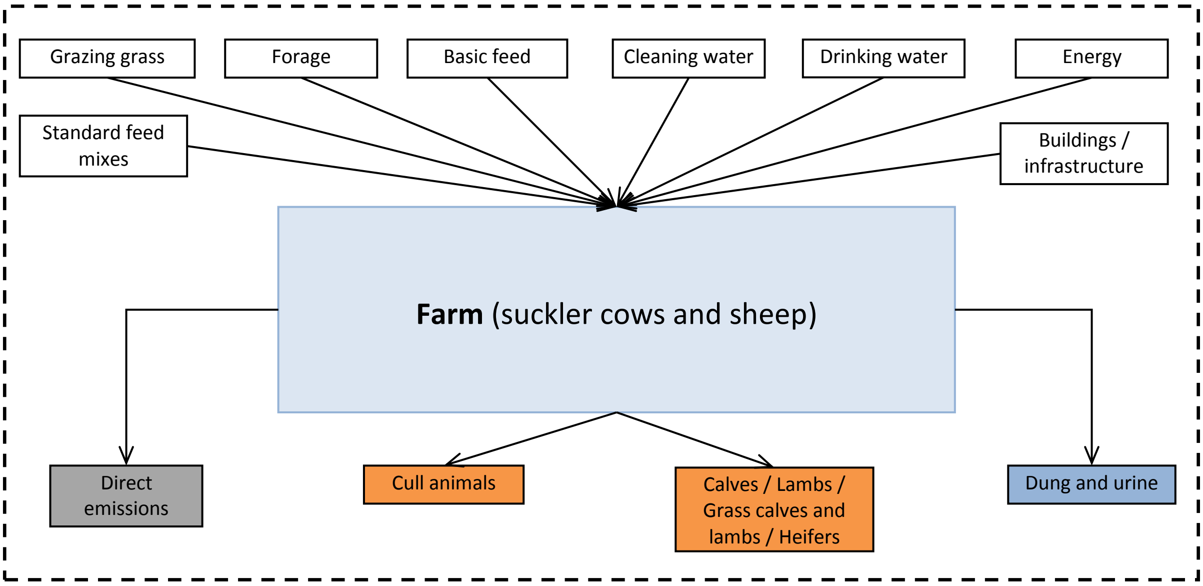


Figure 5: Boundaries for beef and lamb/mutton production

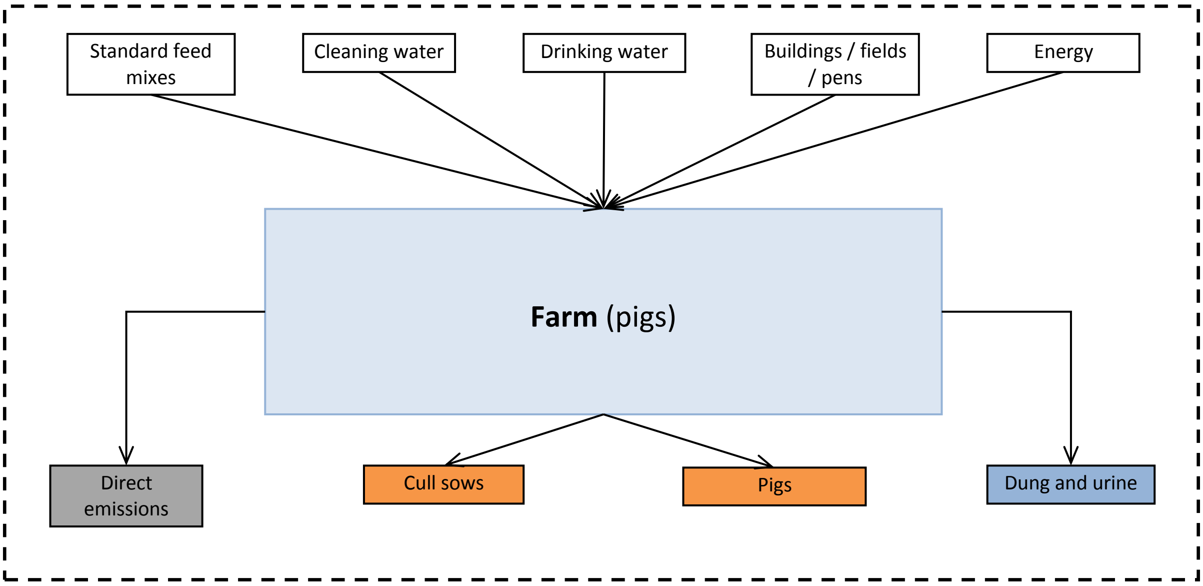


Figure 6: Boundaries for pig production systems

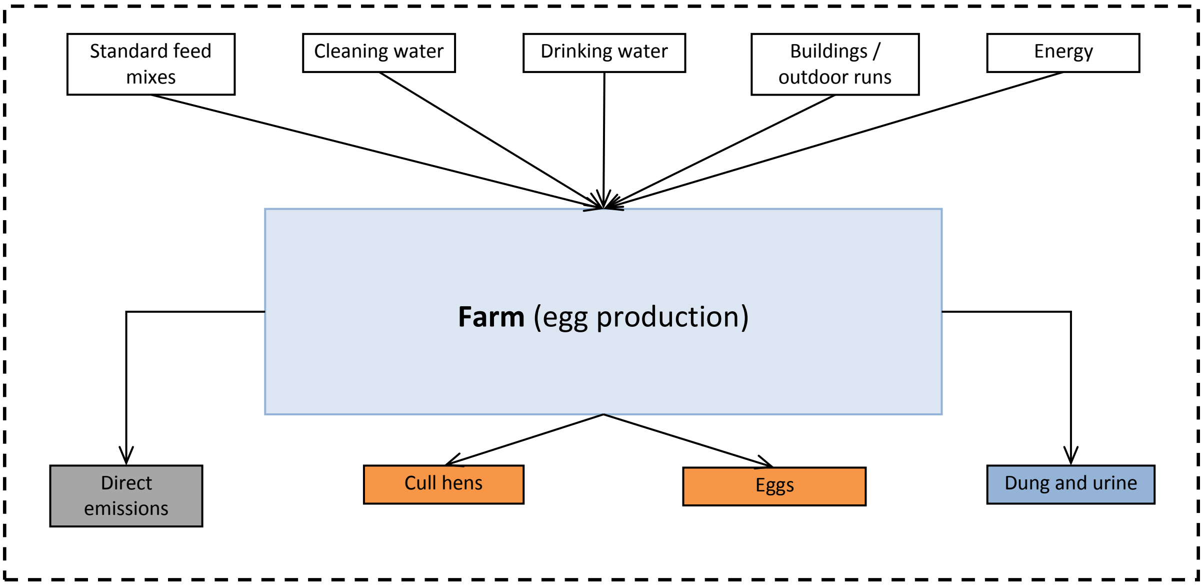


Figure 7: Boundaries for egg production

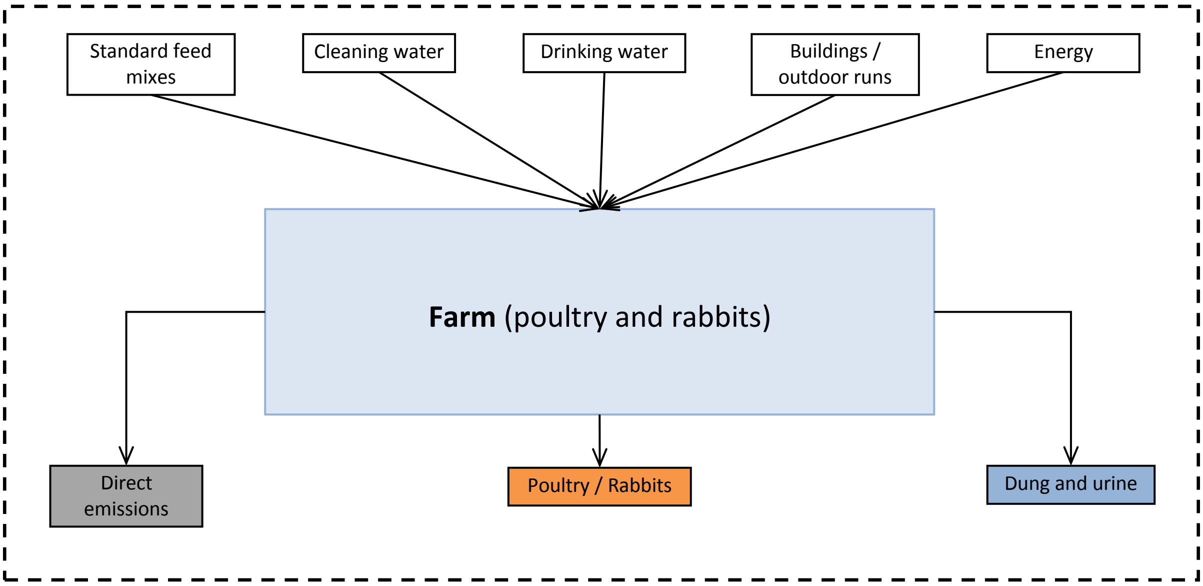


Figure 8: Boundaries for the production of poultry (chicken, turkeys, ducks, geese, etc) and rabbits

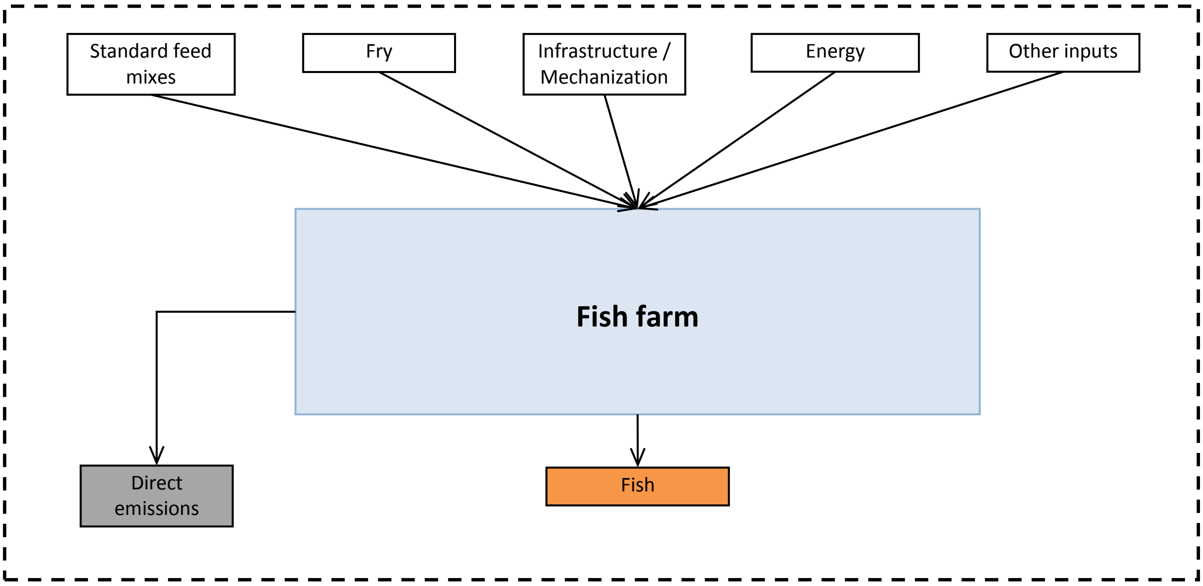


Figure 9: Boundaries for fish farming production

b) Processes excluded

The following production processes (**Table 3**) were not considered for at least one of the following reasons:

- They are independent of agricultural production (column 1, "IP")
- No LCI data sets are available (column 2, no LCI data set "NL")
- No characterization methods are available (column 3, no method "NM")
- The processes were considered to have a negligible impact (column 4, negligible impact "NI")
- No data available for the inputs considered (column 5, "ND")

Table 3: Processes and production methods not taken into account in the AGRIBALYSE® program

Process / production method not taken into account	IP	NL	NM	NI	ND
(a) livestock, arable, horticultural and tropical products					
Residential buildings or systems or activities that are not strictly agricultural	X				
Cleaning products				X	
Labor	X				
(b) livestock production					
Veterinary products and treatment		X	X		
Artificial insemination of animals		X			
Small tooling, consumables					X
Electric wiring in the buildings					X
(c) arable and horticultural production					
Production (and transport) of biological pest control agents (auxiliary insects), pollination agents used in market gardening and arboriculture		X			
Pesticide additives		X			
Irrigation equipment for outdoor crops					X
Small tooling, consumables					X
Application of trace elements					X

A.2.2.3 Assessment period

a) Arable and horticultural products

The plant datasheets were drawn up for individual crops and not for cropping sequences. This corresponds to the purpose for which AGRIBALYSE® was designed: to produce a database for agricultural products.
In general, plant datasheets were drawn up for the period "harvest to harvest" and not "seed to seed" because this is generally accepted for LCA (used, for example, for ecoinvent® data sets). However, certain flows were allocated between crops for the cropping sequences reported in the 2006 Service de la Statistique et de la Prospective (SSP) crop practice study, AGRESTE, 2006 (see B.3.3).

The assessment periods depended on the type of product:

- For annual crops
  The period is harvest to harvest. Depending on the data collection guide, the data set for a crop starts at the time the previous crop was harvested, unless an intermediate catch crop is grown for sale. As intermediate crops are rarely sold, the date when the previous crop was harvested is used as the start date for annual crop LCI data sets.
- For grassland
  a) For permanent meadow: the period is one year from January 1st to December 31st

b) For temporary grassland and alfalfa: the period is the time taken to plant and produce the meadow until it is replaced (four years).

- For fruit, grapevines, clementines and coffee:
  The period is the lifetime of the plants, from the time they are planted until they are replaced.
- For the special cases (1) (roses, tomatoes and rice): the period for crops with several harvests a year (regardless of whether these are – as for tomatoes and roses – harvests of the same crop that last over several months or harvests of several crops sown successively – as for rice) was extended to one year. This allows for differences between the various growth cycles within the year (eg 3rd rice harvest with low yield).
- For the special cases (2)
  For crops such as shrubs which do not have a harvest, the period is the growing time, from the start of production to removal from the field.

b) Livestock

For livestock, the production system was subdivided into “animal classes” (**Figure 10**). This made it possible to define the inputs and outputs of each component in livestock production and take account of the changes in the groups of animals (herds, batches, etc.).

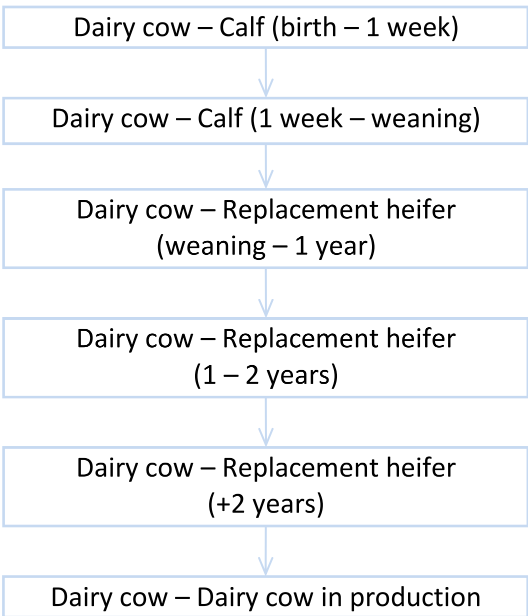


Figure 10: Sequence of the various classes of animals for a dairy farm

As a general rule, the period runs from January 1st to December 31st.

If the production cycle is less than one year (rabbits, pigs, calves, poultry and layers), the data is collected for a complete year taking account of several batches[1]. This longer period makes it possible to take account of variations in production over a year, as for crops. In order to "initiate" the animal production systems, it is necessary to account for incoming animals "at birth stage", with the impacts related to their "production". These animals are "Animals with 0 day" and their enbeded impacts is defined following the biophysical allocation rule. The detail is provided Annex D,

A.2.2.4 Boundary between plant and animal production (for allocating flows)

a) Management of manure

For managing manure, the distinction between animal and plant production was defined in the usual way (Figure 11, based on GESTIM). The various stages of managing manure were identified and allocated to plant or animal production as appropriate.

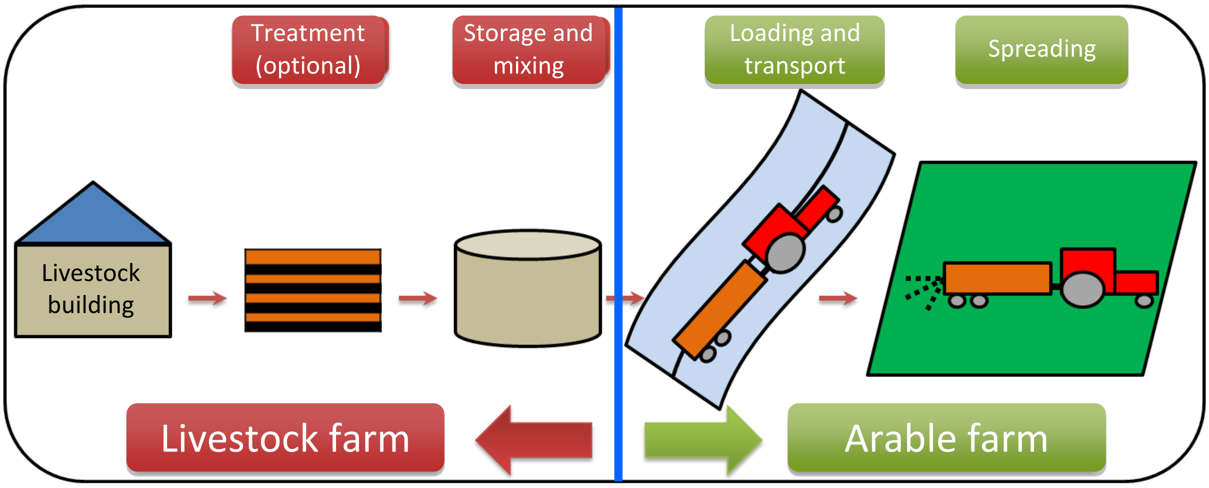


Figure 11: Boundaries of livestock and plant production businesses for managing manure

Emissions from any forms of treatment (nitrogen reduction, composting or anaerobic digestion), storage and mixing manure are allocated to the livestock production system and the emissions associated with loading, transport and spreading are allocated to the plant production system which applies the manure.
An average distance of 10 km is used for transporting the manure (and other organic fertilizers) between the two types of farm (default distance used by ecoinvent® for transport between the point of sale and the farm).

b) Forage produced on the farm

Forage and other basic feed produced and used on the farm (cattle fodder) and grazing grass were treated in the same way as forage to be sold. The LCI was allocated between livestock and arable farms / horticultural businesses in the following way:

[1] The batch as such is not an environmental impact analysis level in AGRIBALYSE®.

- Arable farm: production of forage and “treatment” (silage, haylage, hay)
- Livestock: storage and distribution to the animals

A transport process was added for forage purchased by the farm (see B.2.3).

When the forage is an input for the livestock farm, an individual LCI data set was set up for each type of forage. Consequently, the pasture, or more precisely the grazed grass, is also represented by a unit process. For operations, the direct emissions associated with grazing are divided into two categories (see Figure 12):

- Volatilization and leaching from excretions (see green arrows in figure 12). These emissions are included in the unit grazed grass process as they are considered as emissions due to a fertilization process. For all types of grassland studied, only cattle are considered to be grazing animals (see B.3.2.8).
- Emissions of methane from enteric fermentation and methane associated with excretion of feces (brown arrows, Figure 12). These emissions are included in the animal production process.

This distinction is technical rather than practical. Once the grass has been grazed by the animal, all the emissions associated with grazing are allocated to the animal.

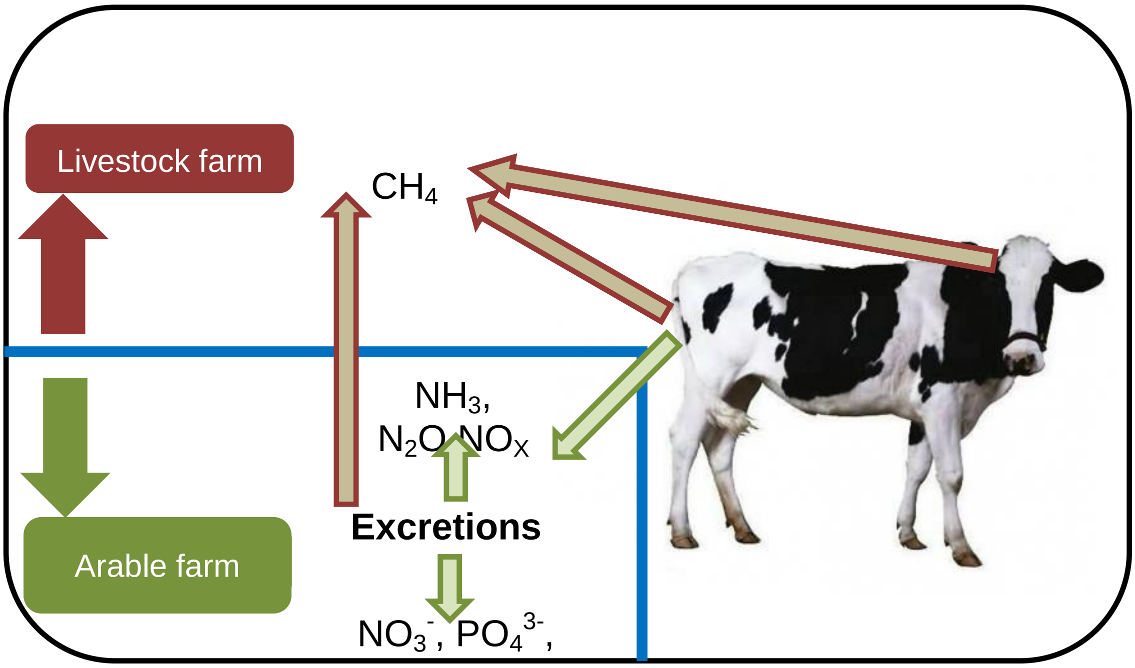


Figure 12: Boundaries for livestock and arable / horticultural products for grazing emissions

A.2.3 Data requirements

A.2.3.1 Time-related representativeness

The reference period is the period represented by the data. As a basic rule, in accordance with the AGRIBALYSE® data collection guide, the data collected covers the years from 2005 to 2009. This period was selected to ensure that the data collected:

- Was sufficiently recent at the time it was collected to ensure that the LCI data sets provided the best representation of current agricultural practices,
- Covered several years to prevent any bias arising in the LCI data sets owing to an exceptional year.

The source data statistics for annual crop growing practices only cover part of this period. The representativeness of this part of the data collected was ensured by adjusting the data according to expert opinion. This also applied to the data sets for fruit, vegetables and shrubs, most of which were based on expert opinion (with specific exceptions such as data relating to pesticide inputs).
The data sets for special tropical crops and French crops (roses) were based on specific studies undertaken during the reference period.

A.2.3.2 Geographical and technological representativeness

The spatial representativeness of the data sets is given in the metadata and their name. When a data set is said to be representative at national scale (data set with national scope = "national data set"), this has always been achieved by taking account of the agricultural practices of various production systems. This was done either by entering the data directly into a single data set, indicating the frequency of each production practice (using the "area concerned"), or by averaging several individual data sets.
The "national data sets" were, therefore, set up using (**Table 4**):

- statistical data entered directly into the data collection module: sugar beet[2], durum wheat, soft wheat, rapeseed, faba beans, silage maize, grain maize, sunflower, triticale, standard pork - France.
- a typical or average case based on expert opinion or a single study: shrubs, coffee, clementines, all plant data sets for organic farming (soft wheat, faba beans, peaches/nectarines, apples, tomatoes, triticale), cider apples, grassland.
- an average of products with different production systems: conventional carrots, alfalfa, malting barley, feed barley, conventional peaches/nectarines, peas, conventional apples, potatoes (excluding starch), grapes for wine-making, roses, Thai rice, tomatoes for the fresh market, tomatoes for the fresh market in unheated greenhouse, French milk, French beef, eggs, poultry, turkeys.
- For palm oil fruits, a modular approach as been followed (Bessou et al. 2013). Data come from one plantation extended on two districts, which is divided into several plantation « blocks » corresponding to different plantation phases. Climate and soil, as well as farming practices are considered homogenous in all blocks. Compiling the blocks enable to have data for each phase of the plantation cycle.

[2] Five annual data sets were set up for sugar beet and then averaged.

Table 4: Overview of the main data sources for the data sets and the approach for setting up the data sets.

Note: (1) The carrot LCI data sets (several regional variants: Aquitaine, Lower Normandy and production periods: spring, fall, winter) were based mainly on expert opinion ("X (E)"), whereas the national LCI data set ("X (ND)") was set up by averaging variants. (cf **Appendix B** also).

(2) The LCI data sets for other annual crops (soft wheat, durum wheat, etc) were based mainly on data from agricultural statistics. The product variants and national data sets were based on directly entered data ("X").

Data set	Approach		Main data source		
ND =National data set V = Product variant	Average 1)	Direct data entry 2)	Statistics	Typical case	Expert opinion
Arable and horticultural					
Annual crops					
Sugar beet, barley, peas potatoes, alfalfa	X (ND)	X (V)	X		
Carrots, triticale	X (ND)	X (V)			X
Organic farming data sets		X		X	X
All others		X	X		
Grassland)		X (V)		X	
Fruit					
Apples, peaches, grapevines	X (ND)	X (V)			X
Cider apples		X		X	
Special French crops	X (ND)	X (E)		X	
Tomatoes and roses	X (ND)	X (V)		X	
Shrubs		X		X	
Special tropical crops					
Rice	X (ND)	X (V)		X	
Clementines and coffee		X		X	
Livestock					
Cow's milk	X (ND)			X	
Beef	X (ND)			X	
Sheep's milk				X	
Lamb				X	
Goat's milk				X	
Poultry	X (ND)			X	
Rabbits				X	
Fish	X (ND)			X	
Pigs		X (V)	X		

1) Special unit processes were set up for the various standard cases. The national data set is an average of the special unit processes.

2) The various standard cases were averaged directly into one single process indicating the area concerned for each crop production practice.

3) There are no national data sets for grasslands in France as the grassland data sets were set up to meet the needs of livestock production data sets.

Appendix B gives the various methods used in AGRIBALYSE® for calculating the national data sets.

A.2.3.3 Direct emissions

For direct emissions into the environment, the flows of substances (NO_3, active substances in pesticides, etc) were taken into account and not the indicators (AOX, COD, BOD, etc). These flows were calculated using various models (see Chapter B.2.4).

A.2.4 Data quality requirements

A.2.4.1 Individual data quality and overall quality of the LCI data sets

AGRIBALYSE® uses three quality levels:

- **Quality of individual data input**

  The ecoinvent® 2.0 pedigree matrix (Frischknecht *et al,* 2007) was used to assess the quality of data entered directly into the data collection module (eg: quantity of fertilizer applied, daily quantity of feed mix distributed to animals). This approach was used to determine the confidence interval for data and define the data quality uniformly across the various data sets in the database. For efficiency and uniformity, only the type of the source from which particular data was taken was assessed and this assessment was then applied to all data taken from this source.
- **Quality of direct emissions in the field and on the farm (calculated data)**

  For the direct emissions that were calculated using models (see B.2.4), the ecoinvent® 2.0 pedigree matrix was applied to the model concerned.
- **Overall quality of the whole LCI data set**

  To meet the ILCD requirements, the score for the overall quality of the LCI data sets was calculated by applying the methods defined in the ILCD Handbook (JRC and IES 2010a).

A.2.4.2 Quality of individual data entered

In accordance with the AGRIBALYSE® data collection guide (Biard *et al*, 2011a) the various types of data sources were classified as follows (**Table 5**):

- Statistical sources, divided into:

  - Well documented statistics accessible to the public,

  - Statistics with limited access or scientific literature, accessible to the public
- Typical cases, divided into:

  - Well documented typical case

  - Typical case with little supporting documentation
- Expert opinion
- Individual case / estimate

The pedigree-matrix (**Table 6**) was used as a standard by ecoinvent® (Frischknecht *et al,* 2007) to describe the variance of data and assess the quality. The values of five indicators are processed using a mathematical formula to give a confidence interval of 95%.

Table 5: Types of data source used in the AGRIBALYSE® program and their "quality score" (lognormal distribution confidence interval) based on the ecoinvent® 2.0 pedigree matrix (**Table 6**). A low value indicates greater precision.

Type of data source	Basic uncertainty	Pedigree matrix values	Quality score (95% confidence interval)
Well documented statistics accessible to the public	**1.05**	{1,1,1,1,1}	**1.050**
Statistics with limited access or scientific literature, accessible to the public	**1.05**	{2,3,2,2,2}	**1.108**
Well documented typical case	**1.05**	{1,2,1,1,1}	**1.054**
Typical case with little supporting documentation	**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 draws a distinction depending on the type of data, was taken from Table 7.2 of the ecoinvent® report (Frischknecht *et al,* 2007). For most inputs, the basic uncertainty is 1.05. For transport it is 2 and for infrastructure (buildings) it is 3.

Table 6: Pedigree-matrix, based on 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

A.2.4.3 Quality of the models for direct emissions in the field and on the farm (calculated data)

The quality of the models used was also assessed using the pedigree matrix. The criterion for completeness (**Table 6**) was adjusted by evaluating the number of major parameters considered in the model in question.

Table 7: Models for calculating direct emissions (see B.2.4 for details) used for the AGRIBALYSE® program and their "quality score" (lognormal distribution confidence interval) based on the ecoinvent® 2.0 pedigree matrix (**Table 6**)

Type of source	Model	Basic uncertainty	Pedigree matrix values	Quality score (95% confidence interval)
Fixing of carbon dioxide by the products (CO_2)	ecoinvent® v2	**1.2**	{2,2,1,2,1}	**1.209**
Land occupation m^2.yr and transformation m^2	ecoinvent® v2	**1.2**	{2,2,2,1,1}	**1.212**
Emissions of ammonia (NH_3)	EMEP/EEA 2009 Tier 2	**1.2**	{2,3,2,2,1}	**1.218**
Nitrogen excreted by the animals	CORPEN	**1.2**	{2,2,3,3,1}	**1.238**
Emissions of methane (CH_4)	IPCC 2006b Tier 2	**1.2**	{2,2,3,3,1}	**1.238**
Emissions of carbon dioxide (CO_2) from liming	IPCC 2006b Tier 1	**1.2**	{2,3,3,4,1}	**1.249**
Emissions of active substances from pesticides	ecoinvent® v2	**1.2**	{4,5,1,3,1}	**1.372**
Emissions of nitric oxide (NO)	EMEP/EEA 2009 Tier 1	**1.4**	{2,4,2,2,1}	**1.425**
Emissions of dinitrogen oxide (N_2O)	IPCC 2006b Tier 1	**1.4**	{2,4,3,4,1}	**1.446**
Emissions of nitrate (NO_3^-) – modified Comifer grill	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**
Emissions of nitrate (NO_3^-) – perennial crops	SQCB (Faist *et al*, 2009)	**1.5**	{2,3,1,5,1}	**1.525**
Emissions of nitrate (NO_3^-) – tropical crops	GIEC	**1.5**	{3,3,1,3,2}	**1.855**
Emissions of trace metals	SALCA-SM modified	**1.5**	{2,2,3,4,1}	**1.526**
Emissions of phosphorus and phosphate (P, PO_4^{3-})	SALCA-P	**1.5**	{2,3,3,4,1}	**1.530**
Emissions of nitrate (NO_3^-) – soilless crops	This report	**1.5**	{4,3,1,1,1}	**1.564**
Land use change (CO_2)	This report	**1.8**	{4,3,2,1,1}	**1.855**

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

A.2.4.4 Overall quality of the LCI data sets in accordance with ILCD

To comply with ILCD requirements, the overall ILCD quality score for the data sets was calculated according to the following six criteria:

- Technological representativeness (TeR)
- Geographical representativeness (GR)
- Time-related representativeness (TiR)
- Completeness (C)
- Precision / uncertainty (P)
- Methodological appropriateness and consistency (M)

These six criteria were evaluated for all the data in a data set, assessing the extent to which the data set met the requirements (on a scale of 1 to 5, 0 for not applicable). The final score was calculated in accordance with the ILCD recommendations. A data set was considered to be "High quality" if the score is ≤ 1.6, "Basic quality" for a score >1.6 to ≤3 and "Data estimate" for a score of >3 to ≤4.

As the scales proposed by the ILCD were very generic, to ensure consistent evaluation, the scores for the criterion to be evaluated were specified as follows:

- Technological representativeness (TeR): The various agricultural practices considered in the inventory are representative of the total number of production systems used to complete the production considered (considering their distribution / importance).
  1 = Very good: nearly all the possible production systems are included in the data set
  2 = Good: most of the production systems are considered
  3 = Satisfactory: it is not certain that most of the productions systems are considered
  4 = Not very satisfactory: Only a few production systems are considered
  5 = Unsatisfactory: the data set is based on only one production system

- Geographical representativeness (GR): The distribution of production regions for the crop considered in a data set was evaluated, based on the area cultivated (ha), the number of departments covered, or the quantity produced, depending on the data available.
  1 = (very good): ≥95%
  2 = (good): ≥85% and <95%
  3 = (satisfactory/acceptable): ≥75% and <85%
  4 = (not very satisfactory): ≥50% and <75%
  5 = (unsatisfactory): <50%

- Time-related representativeness (TiR): The extent to which the reference period (2005 to 2009) was representative was assessed as:
  1 = Very good: data for all five years in the reference period
  2 = Good: data for at least three years in the reference period with little change/variation in the production systems
  3 = Satisfactory: data on at least two years in the reference period with little change/variation in the production systems

4 = Not very satisfactory: data on two or three years in the reference period but with major changes in the production systems which are not included
5 = Unsatisfactory: data on only one year in the reference period

- Completeness (C): this criterion is used to evaluate the flows taken account of in the data set with respect to those given in the data collection guide (GDC).
  1 = Very good: all the flows in the data collection guide and major inputs are included
  2 = Good: several inputs are not considered but they are not of great importance
  3 = Average: some major inputs are not considered
  4 = Poor: several major inputs are not considered
  5 = Very poor: many major inputs are not considered

Default scores (identical for all data sets) were used for Precision and Methodological appropriateness and consistency.

- Precision / uncertainty (P)= 3: "acceptable", given that the precision of the data was assessed using the pedigree-matrix and all AGRIBALYSE® data sets are subject to natural processes resulting in a certain variance.
- Methodological appropriateness and consistency (M)= 2: "good", given that the calculation models, the system boundaries and the modeling were selected to suit the aims of the study.

A.2.5 Type of critical review – Quality control

A critical review as defined in ISO 14040/14044 (ISO, 2006a and ISO, 2006b) for situation ILCD-A (see A.1.3) was carried out for the AGRIBALYSE® program. This review concentrated on quality control.

- Production system data entered into the data collection module
- The direct emissions calculation models
- LCI and LCIA results

Quality control was carried out in three phases:

1. Internal verification: For the AGRIBALYSE® program the data for the LCI data sets and LCIAs was collected and calculated by different people: "authors" (see metadata: "author") and "data generators". The data collected by the "authors" was verified by the "data generators"(Colomb *et al*, 2013).
2. Quality control of the data describing the production systems for the French agricultural production processes carried out where possible by experts from organizations external to the project.
3. Quality control of the results of the LCI and LCIA and of the direct emissions calculation models, carried out by the Technical Institutes.

Phases 2 and 3 each ended with a working seminar.

A.2.5.1 Quality control of French production system data

a) The experts

An independent expert was appointed for each review of a group of similar agricultural production processes (eg: set of oleaginous crop production processes).

Experts approached

The experts who were selected belonged mainly to an organization external to the AGRIBALYSE® program (**Table 8**). In several cases, it was not possible to find experts in organizations other than those involved in the program. However, AGRIBALYSE® made every effort to check that they were not involved with setting up the data sets. For tropical products, the control procedure was simplified with only internal control within CIRAD.

Table 8: Organizations to which the experts who checked the quality of the production system data belonged

Organization to which experts belonged			
Agrial	Farming cooperative	**Chambre Régionale d'Agriculture de Bretagne**	Agricultural development
Agrocampus Ouest	Educational and research institute	**Chambre Régionale d'Agriculture des Pays-de-la-Loire**	Agricultural development
Agro-Pithiviers	Farming cooperative	**ESA Angers**	Education
Agro-Transfert Picardie	Technology transfer	**IDELE**	Technical Institute
Axereal	Farming cooperative	**INRA**	Research Institute
Biomar	Feed manufacturer	**InVivo**	Farming cooperative
Chambre d'Agriculture 44	Agricultural development	**IRBAB (Institut Royal Belge pour l'Amélioration de la Betterave)**	Technical Institute
Chambre d'Agriculture 53	Agricultural development	**ITAB**	Technical Institute
Chambre d'Agriculture 66	Agricultural development	**Lycée de Guérande**	Education
Coop de France	Farming cooperative	**SILEBAN**	Regional experimental station

The main criteria for selecting the experts were their independence, their qualifications and their experience.

Procedure for selecting the experts

- Selection of organizations for quality control by the AGRIBALYSE® Strategic Committee
- Proposal of experts by the Technical Institutes
- Proposal of experts by the organizations selected for quality control
- Selection of the experts by the Strategic Committee from the proposals made by the organizations and Technical Institutes on the basis of the following criteria.

Expert selection criteria

The minimum criteria taken into account for selecting the experts were:

- Technical knowledge of the systems studied at regional level but above all at national level
- Independence with respect to AGRIBALYSE®
- Availability

b) Documentation

The following documents were produced for the quality control phase.

Specification for the experts

This was a technical document (**Appendix C**) to simplify the quality control work of the experts by detailing the data to be reviewed and the review process. This document defined the scope of quality control required. It also defined that, when modifications were required, the quality of the modifications should be subject to a second review.

Review forms

Review forms were sent to the experts to provide uniform results. These forms were specific to each livestock or arable / horticultural production system and are attached at **Appendix C**. One form was filled in for each data set checked. These forms have:

- A pre-printed section: to ensure that the experts check critical points
- A blank section: for comments by the expert on the general quality of the process

Confidentiality

The quality of the production system data was checked with the proviso that the data sent to the experts should remain confidential and be used only for quality control. Experts confirmed that data would be kept confidential by signing a confidentiality agreement before the data was sent.

c) Scope of the quality control procedure

The experts were requested to check the data describing the production systems. They were not asked to assess the methodological decisions made for the project (system boundaries, functional units, allocation, etc). Details of the data to be reviewed were defined in a specification.

The experts were also asked to comment on any omissions or incoherence in the descriptions of the production systems.

A.2.5.2 Quality control of LCI and LCIA results

The quality of the LCA/LCIA data calculated by Agroscope and INRA was checked by the Technical Institutes involved in the AGRIBALYSE® program according to a common procedure.

a) The experts

The data was checked by the Technical Institutes involved in the AGRIBALYSE® program.

b) Documentation

To carry out the quality control, files summarizing the results of the LCIA were drawn up and exchanged for each data set. These files also contained technical data (eg. results of nutritional components, results of fuel consumption, etc.) to check that the data entered into the data sets was processed correctly.
The Technical Institutes returned the results of their reviews using a specifically designed form.

c) Scope of the quality control

The quality control considered the relevance of the results of the LCIA and LCA and the parameters for the direct emissions calculation models. This was done in several stages: verifying the calculations, comparing the internal references and the results in the works cited in the bibliography.

The procedure ended by pooling the comments at a working seminar and by the Technical Institutes drawing up an evaluation report. This report is included in the report "AGRIBALYSE®: Assessment and lessons for the future" (Colomb *et al,* 2013).

A.2.6 Type and format of the report required for the study

ISO 14044 (ISO, 2006b) and the ILCD Handbook (JRC and IES, 2010a) give recommendations for the types of deliverables expected. In accordance with these recommendations, AGRIBALYSE® results were produced in the following formats:

- ✓ A report on the methodology setting out the bases for the study (this report)
- ✓ For each product, the results are given as:
  - ✓ impact indicator values (LCIA)
  - ✓ LCI flow data sets
- ✓ The report "AGRIBALYSE®: Assessment and lessons for the future" (Colomb *et al*, 2013), describing how the program was carried out and the main results of the program, including two notes on the quality control of the LCI data sets and the results as well as an exploratory sensitivity analysis for sugar beet and pork.

Incorporating the data sets into the IMPACTS® database requires the results to be in terms of flow (LCI) rather than impact indicators, as the impacts are calculated automatically from the flows and the characterization factors selected by the ADEME-AFNOR platform on the basis of JRC recommendations. However, it proved necessary to have the LCIA results in order to be able to analyze the results for each product in subsequent projects.

To simplify the distribution of the results, AGRIBALYSE® also provided the following documents:

- A summary for each product to give a rapid overview of the main results without requiring LCA software
- A database meeting ILCD requirements (for situation ILCD-A, see A.1.3), in the form of unit processes, containing the data sets produced during the program

Part B – **LCI data sets**

B.1 Data collection procedures and systems used for AGRIBALYSE®

AGRIBALYSE® was designed to ensure that the processes selected could be compared. The following procedures and systems were used to produce the LCI data sets using a consistent methodology to ensure that the data sets could be compared so far as possible.

- Common rules were set out for defining systems and data collection procedures and a special data collection module was developed. These rules are published in the Data Collection Guide (GDC, see B.2.1)
- A data collection module was used to input the data for the various livestock and arable / horticultural products in a uniform format (see B.2.1)
- A set of EXCEL spreadsheets was used for calculating direct emissions and systematic processing of the input data in ecospold format (calculation chain, see B.2.1)
- In the future, a new tool Means-Inout will be used to perform calculations and will replace both "the data collection tool" and the "calculation chain » (INRA 2015). More user friendy, it is potentialy usable for people wiling to make new LCIs following AGRIBALYSE methodology.
- Simapro® + ecoinvent®: Most of the upstream and indirect flows were calculated using Simapro® and the ecoinvent® database ® v3.2, cutt off version (called « allocation recyclesd content » in SimaPro).

B.2 Data collection

B.2.1 Data collection

B.2.1.1 Data collection module

The data collection module used Excel and VBA (Visual Basic for Applications) for entering the raw data in a standardized format. The data collection module was based on a form developed and used for a CASDAR project (CASDAR AAP 7-175 "Improving economic and environmental performance of pea, rapeseed and wheat production systems"). As this form only allowed data to be entered for production systems for annual French crops, it had to be modified to meet the requirements of the AGRIBALYSE® program:

- Design and incorporation of input spreadsheets for the various livestock and special products (greenhouse crops, permanent crop systems)
- Minimizing the diversity of inputs by defining default values (accessible using dropdown menus) to simplify data collection and ensure that descriptions were uniform
- Design to allow lists of inputs / dropdown menus to be extended
- Documentation of the production systems as required by the ILCD Handbook (JRC and IES, 2010a)
- Inclusion of the evaluation of the quality of each data item depending on its source
- Possibility of comparing the data sets/production systems entered

Two documents were produced describing how to use the data collection module: the Data Collection Guide (Biard *et al*, 2011a) and the Data Collection Module Manual (Biard *et al*, 2011b).

B.2.1.2 Data Collection Guide

The Data Collection Guide (Biard *et al*, 2011a) gave practical help during the data collection phase for the AGRIBALYSE® program. It ensured that all production system data was consistent. The Data Collection Guide is both a guide for data collection (Part A) and a guide to good practices for modeling the production systems covered (Part B). The rules set out in the guide were implemented in the data collection module.

B.2.1.3 Data collection module manual

This manual describes how to use the data collection module. It describes the various input fields and how the data collection module operates.

B.2.2 Input data categories

B.2.2.1 Inputs

The collection of all the data, i.e. the entry of all the information required to take account of the components on the system (see chapter A.2.2), was undertaken by the Technical Institutes, using the data collection module.

a) Arable and horticultural products

The following information was collected for each input:

- The name of the specific input (eg. ammonium nitrate, rabbit liquid manure or metolachlor). The names of items were selected from a predefined list which could be extended if necessary on condition that a definition was given for each new item.
- The quantity applied / consumed (specifying the units)
- The data source
- The percentage of area concerned, to take account of different practices in certain production systems (eg: 30% no till; 70% sowing with drill)
- The date of application and the minimum and maximum values of the data. This was optional, as the information was not strictly necessary for the LCI.
- Optional comments

Table 9 lists additional information require for each input category.

Table 9: Additional data collected for each input category

Input category	Additional data collected	Products concerned
Sowing seed	Proportion of farm seed sown	Annual crops
Fertilizer (organic/mineral)	Number of applications	All
Pesticides	Number of applications	All
Agricultural process - Tillage - Sowing seed - Fertilization - Applying pesticides - Tending crops - Harvest	Number of applications	All
- Irrigation	Amounts of water applied, source of energy used and amount of energy consumed	All
Buildings	Area	Special French crops (greenhouses)
Other inputs	Purpose	All

The data was entered using predefined lists. When a new item (fertilizer, active substance, process) was introduced, the following information was entered to build a specific LCI data set or modify an existing data set:

- New fertilizer: name, units, composition (total N, plant available N, P_2O_5), source.
- New agricultural process: name of process, description, units, machinery required (traction and no more than two machines), operation time, consumption and type of power, source.
- New machine: name of the machine, description, lifetime, weight of the machine, footprint, source.

b) Livestock production

Two types of data were collected for livestock production data sets

- Data describing the class of animal (eg: number of animals at start, age and weight of animal on acquisition and disposal, mortality, etc.)
- **Data on animal feed.** Data was entered in two stages. The first stage defined the feed mix and the second stage defined the annual ration. In the first stage, the raw materials and their proportions in the feed mix were defined. In the second stage, the feed mixes and/or the basic fodder (raw materials consumed directly by the animals including forage and grazed grass) were defined to give a precise record of the ration distributed to the animals.

B.2.2.2 Direct emissions

The flows of potentially polluting substances directly associated with the livestock and arable/horticultural production processes (direct emissions) are not entered but calculated by the inventory data processing system (IDPS), see chapter B.2.4. The data and parameters required for calculating direct emissions are described in the datasheets (**Appendix D**).

B.3 Calculating the LCI data sets

B.3.1 Data processing applications

The AGRIBALYSE® data sets were drawn up using a set of EXCEL spreadsheets, called Inventory data processing system (IDPS), to ensure that data was processed consistently and could be compared. The IDPS used the data from the data collection module and converted it into a "unit process" in ecospold format, adding the direct emissions and transport for the inputs. This format makes the data set compatible with LCA applications.

The IDPS had two main sections:

- **Software implementing the models for calculating the direct emissions**: 15 models were drawn up or modified for calculating the direct emissions (**Table 10**).

Table 10: Models for calculating direct emissions (see chapter B.2.4)

Substance emitted	Calculation procedure
CH_4	EXCEL spreadsheet, developed by AGRIBALYSE®
CO_2 biogenic	EXCEL spreadsheet, developed by AGRIBALYSE®
CO_2 due to land use change	Method developed by AGRIBALYSE®
CO_2 due to liming	EXCEL spreadsheet, developed by AGRIBALYSE®
ETM	Modified SALCA spreadsheet
N_2O	EXCEL spreadsheet, developed by AGRIBALYSE®
NH_3	EXCEL spreadsheet, developed by AGRIBALYSE®
NO3-	EXCEL spreadsheet, developed by AGRIBALYSE®
NO	EXCEL spreadsheet, developed by AGRIBALYSE®
Land occupation and transformation	EXCEL spreadsheet, developed by AGRIBALYSE®
P, P_2O_4	Modified SALCA spreadsheet
NPK reallocated	EXCEL spreadsheet, developed by AGRIBALYSE®
Active substances (pesticides)	EXCEL spreadsheet, developed by AGRIBALYSE®
Substances emitted by farmed fish (N_{total}, P_{total}, TSS/COD)	EXCEL spreadsheet, developed by AGRIBALYSE®
Intermediate spreadsheet	
Calculation of nitrogen excretions from animals	EXCEL spreadsheet, developed by AGRIBALYSE®
Calculation of soil loss	EXCEL spreadsheet, developed by AGRIBALYSE®

- **Data conversion module:** This module took the results of the direct emissions calculation procedures and the data on inputs from the data collection module and converted the information into a unit process in ecospold format. It was based on the SALCA system developed by Agroscope.

Figure 13 shows how these modules operate and interact.

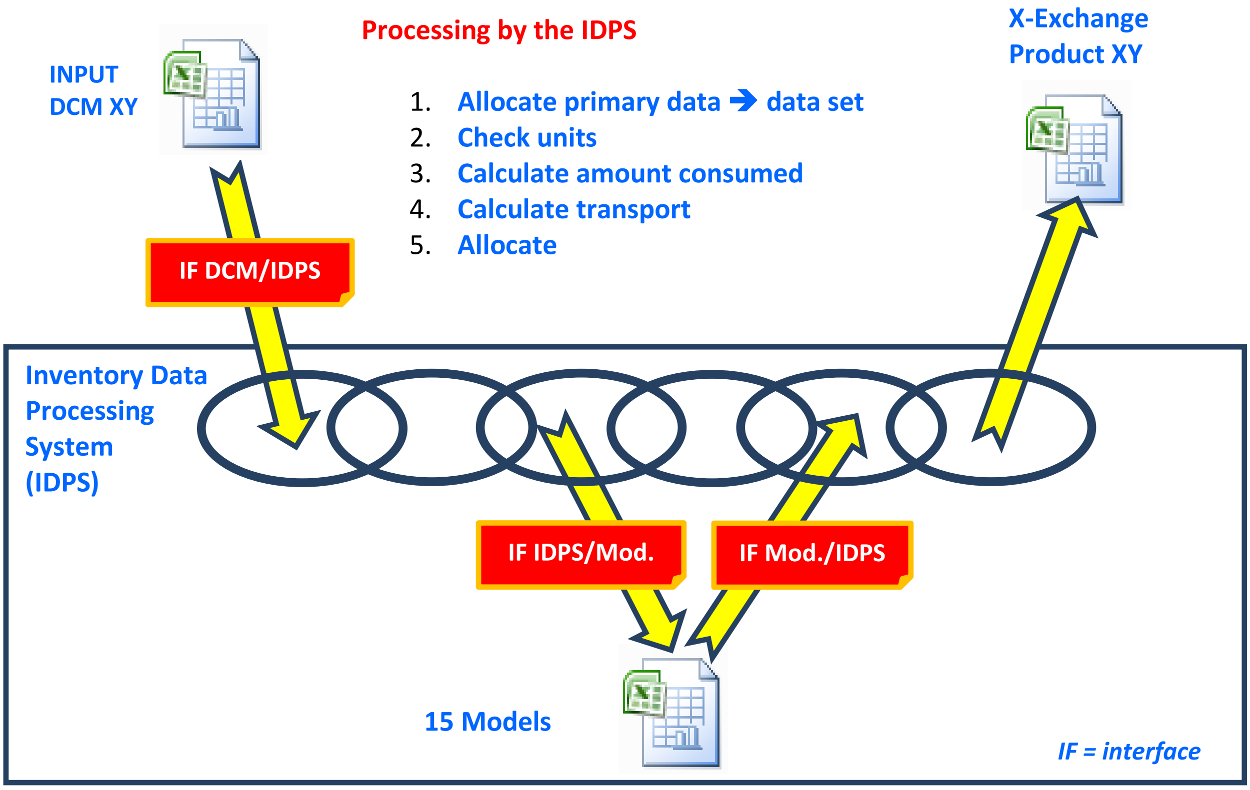


Figure 13: Components in the Inventory Data Processing System

Each component of the inventory data processing system was designed or specifically modified to meet the requirements of the AGRIBALYSE® program. Information about accessing the applications can be found in the report "AGRIBALYSE®: Assessment and lessons for the future" (Colomb *et al*, 2013).

B.3.2 Relating data to the functional units

In several cases, data was collected for the data collection unit which is different from the functional unit (in general, the data collection unit for arable / horticultural data sets is the hectare and that for livestock data sets is the herd). Data sets were related to the functional units using a conversion factor, based on the reference flow also defined during data collection.

B.3.3 Calculating the LCI data sets of inputs for agricultural production

AGRIBALYSE® distinguished three types of input for agricultural data sets:

1. Agricultural inputs (from France or elsewhere) – for example: forage barley, seed, etc. These inputs were taken from the agricultural sector and their data sets were developed by the AGRIBALYSE® program.
2. Non agricultural inputs specific to agriculture – for example: tractor, pesticides, fertilizers, etc.

3. Non agricultural inputs not specific to agriculture – for example: electricity, diesel, steel for fencing, tires for tractors. These inputs were produced outside the agricultural sector and are used by all economic sectors.

The basic principle of the AGRIBALYSE® program for the LCI data sets/ LCA for type (2) and (3) inputs was that priority should be given to data in the IMPACTS® database or, if not in this database, in other recognized databases. However, few data sets meeting the requirements for coherence with the AGRIBALYSE® methodology (boundaries, flows) and representativeness were found. For this reason, most of the data sets used came from the ecoinvent® database. However, as the ecoinvent® data sets were not always applicable to France, type (2) inputs were modified, where possible, using existing data sets (see following chapters). The correspondence "inputs <-> existing LCI data sets" is given in **Appendix G**.

When necessary, data sets for type (2) inputs were set up on the basis of existing data sets and modified to suit conditions in France. For example:

- Machines: the size of the machines and operation time were adjusted to conditions in France and the tropical production systems studied.
- Livestock buildings: the source data came mainly from the CASDAR project "Eco-construction and livestock buildings" (IE *et al*, 2009). The units used were the annual area used in m^2.yr or a space used for one year.
- Fish farm buildings: the data sets used for fish farm infrastructure was taken from the databases of UMR-SAS, INRA, Rennes.
- Plant production buildings: data sets based on data from French manufacturers were used for greenhouses (glass greenhouses, air-inflated double polyethylene film greenhouses and polytunnels), (Boulard *et al*, 2011).

The procedures implemented for building LCI data sets when existing data sets were not included in existing databases are described below.

B.3.3.1 Sowing seeds and growing plants

The following approaches were used to build seed and plant data sets:

1. Extrapolation by applying a factor to the data set for the crop grown for sale. The "seed" data set flows (resources required and emissions) were calculated by multiplying the "crop" data set by an extrapolation factor. Data on ten crops[3] was available from GESTIM (Gac *et al,* 2010) but the data sets were drawn up to study the impacts of primary energy consumption and climate change. Certain inputs and flows contributing to other impacts were not included or not sufficiently detailed. The quantities for the inputs and missing flows were obtained by multiplying the quantities obtained for the data set for the crop grown by an extrapolation factor. This factor was the ratio between the consumption of primary energy obtained from

[3] Durum wheat, soft wheat, sugar beet, rapeseed, maize, barley, peas, potatoes, triticale, sunflowers.

GESTIM for seed production and that for the product listed in the data collected for the AGRIBALYSE® program (see **Appendix D**, Datasheet 15).

2. Building a separate data set
3. If the information required was not present: substitution of the data set for the crop grown or use of an existing LCI data set.

The extrapolation approach was applied for ten annual crops: sugar beet, durum wheat, soft wheat, rapeseed, maize (grain and silage), barley (brewing and forage), peas, potatoes, sunflowers and triticale. For « similar crops », the most common se bought was used : all wheats have a seed extrapolated from the « average wheat », all maizes have a seed from « grain maize » and all barleys have a seed from « spring barley » (**Table 140**). Approach 2 was also applied to carrots and tomatoes using expert opinion.

Approach 3 was used for the other crops: for faba beans and organic annual crops (soft wheat, triticale), seed sowing was taken into account by substituting the data set for the final product. The ecoinvent® data sets were used for grassland and alfalfa. For orchards, grapevines, coffee and clementines, an equivalent area was calculated by working out the number of hectares of cuttings and grafts required to plant one hectare of orchard/enclosed area. The orchard/vineyard in full production data set was taken as a substitute.

B.3.3.2 Average fertilizer data sets

Three "average N/P/K fertilizer" data sets (average mineral fertilizer, as N/P/K, at regional storehouse, FR) were set up based on the average mineral fertilizer consumption from 2005 to 2009 in France for which an LCI data set was available (**Appendix I**). The UNIFA database was used for this, taking the data for deliveries of fertilizer for the years 2004/2005 to 2008/2009 (UNIFA, 2009). The non-specified 2 and 3 compound fertilizers categories (PK, NP, NK, NPK) were allocated to ecoinvent® data sets using more detailed analyses from GESTIM (Gac *et al*, 2010). Organo-mineral fertilizers were allocated to the other fertilizers depending on their N/P/K content. The transport distances from the place of production to the point of sale were also based on GESTIM analyses (Gac *et al*, 2010). Details are given in **Appendix I**.

For farm manure (manure, liquid manure) "phantom LCI data sets" with no environmental impact were set up to ensure that the direct emissions related to their application were calculated correctly and to make it easier to check the data sets.

B.3.3.3 Machine data sets

New data sets were calculated based on the information entered in the data collection module, by parameterizing the six machine data sets available in the ecoinvent® database. The machine datasets include the flows related to:

- Production
- Repair
- Maintenance of tires and engines (if appropriate)
- End of life (waste management)

Table 11 summarizes the parameters for the various components of these data sets. The flows related to maintenance are required only for powered machines (oil and filters) and wheeled machines (tires).

Table 11: Parameters for machine data sets using the available ecoinvent® data sets

Data set component	Parameter required	Tractors	Harvesters	Trailers	Slurry tankers	Agricultural machinery, general	Agricultural machinery, tillage
Production	Weight	yes	yes	yes	yes	yes	yes
Waste management		yes	yes	yes	yes	yes	yes
Repair	Weight and lifetime (repair factor)	yes	yes	yes	yes	yes	yes
Waste management		yes	yes	yes	yes	yes	yes
Maintenance (tires)	Weight and lifetime of machine/tire	yes	yes	yes	yes	yes	no
Waste management		yes	yes	yes	yes	yes	no
Maintenance (filters, oil)	Weight and lifetime of machine	yes	yes	no	no	no	no
Waste management		yes	yes	no	no	no	no

The 213 machines defined in the data collection module were divided into the following 14 groups[4] depending on: i) ecoinvent class of machine (tractors; harvesters; trailers; agricultural machinery, general; agricultural machinery, tillage; slurry tankers) and ii) the lifetime.

1. Tractors, 7,500 h
2. Tractors, 10,000 h
3. Tractors, 12,000 h
4. Harvesters, <5000 h
5. Harvesters, 5,000 – 10,000 h
6. Harvesters, > 10,000 h
7. Trailers <20 t
8. Trailers, >20 t
9. Slurry tankers, 5000 l,
10. Agricultural machinery, general, <2,500 h
11. Agricultural machinery, general, 2,500 -5,000 h
12. Agricultural machinery, general, >5,000 h
13. Agricultural machinery, tillage
14. Machine with electric motor

The functional unit for machine data sets is always "1 kg machine for the total lifetime". Details are given in **Appendix J**.

B.3.3.4 Agricultural process data sets

An agricultural process covers the flows related to the use of the infrastructure for tilling, maintenance and harvesting:

[4] Four standard ecoinvent® data sets are used for lorries (lorry 16t/RER/I U, lorry 40t/RER/I U), vans (van <3.5t/RER/I U) and helicopters (Helicopter/GLO/I U).

- Production, maintenance and end of life of the machines used for the process (eg. a tractor and a plow with five blades for the “plowing” process).
- All the inputs and outputs required for the operation of the infrastructure, i.e. energy (diesel, electricity) and emissions from burning fuel. However, variable products, distributed or applied by the processes, such as the fertilizers or active substances, are not included. These inputs were specified separately.
- The storage facilities for machinery: shed or open air area.

New data sets were set up based on the information entered in the data collection module (operation time, diesel fuel consumption etc.). The 258 agricultural processes specified initially in the data collection module were harmonized and grouped into 139 final processes, in collaboration with the technical Institutes (**Appendix K**).

For coherence with ecoinvent®, an “agricultural process” data set covered the following elements:

- The requirements for one or more machines
- The power requirement (fuel/electricity, etc.)
- Emissions related to the use of the fuel (if appropriate)
- Wear on the tires (if appropriate)
- The requirement for a garage to house tractors and automotive machines or the area required for attachments and trailers (open air storage).

The functional unit for agricultural processes was “one hour of work”, which is different from the ecoinvent® convention where in most cases the functional unit is “one hectare”. This convention is more flexible and makes it possible to take account of different times required (h/ha) for the same process (for example for tilling different types of soil). The machine requirement for one hour of process is calculated by dividing its weight by its lifetime (because the functional unit for the machine LCI data set is kg machine for the whole lifetime).

$$\text{Machine requirement} = \frac{\text{Weight of the machine}}{\text{Lifetime of the machine}}$$

B.3.3.5 Active substances

The active substances used in pesticides were assigned to existing LCI data sets. Based on the pesticide index (ACTA, 2005 and ACTA, 2009), an active substance was assigned to an existing data set (eg: “cyclic N-compounds, at regional storehouse/kg/RER”, “Pyridine-compounds, at regional storehouse/kg/RER”) using its chemical family. When this was not possible, it was assigned to a more generic data set (“pesticides unspecified, RER at regional storehouse”, “herbicides unspecified …” etc.).

Examples Fluazinam ➔ chemical family: pyridinamine ➔ Pyridine compounds, at regional storehouse RER Flurtamone ➔ chemical family: furanone ➔ Pesticides unspecified, at regional storehouse, RER

The assignment of all active substances covered in the AGRIBALYSE® program is given in **Appendix G**.

B.3.3.6 Greenhouse LCI data sets

Existing data sets were used and modified for greenhouses (glass greenhouses, air-inflated double polyethylene film greenhouses and polytunnels) (Boulard *et al*, 2011). These had to be modified for reasons of coherence, uniformity and consistency. In the original data sets, several inputs were linked to non ecoinvent® data sets. For example, for steel, the LCI data set “X12Cr13 (DIN 1.4005, AISI 416)” in the IdeMAT database (IdeMAT, 2001) was used whereas in AGRIBALYSE® the steel considered was always “steel, low-alloyed, at plant/kg/RER”. The modified greenhouse data sets are available in the AGRIBALYSE® database.

B.3.3.7 Livestock building data sets

The livestock building data sets used:

- Were taken from the internal databases of UMR SAS (INRA, Rennes) for infrastructure related to aquaculture
- Were built using data from the CASDAR project “Eco-construction of livestock buildings” (IDELE *et al*, 2009)

B.3.3.8 Animal feed data sets

Most of the LCI data sets for elementary feed, grazing and forage were produced for the AGRIBALYSE® program, adding transport if necessary.

The feed mixes contain many raw feed materials (RM) for which LCI data sets were not produced within the program and so the RM data sets used for the formulation (fabrication) of commercially available food concentrates came from:

- LCI data sets for products from the arable sector of AGRIBALYSE®: soft wheat, organic soft wheat, faba beans, organic faba beans, rapeseed, sunflower seed, cut grass (silage or haylage), grazed grass, alfalfa for dehydration, maize silage, maize grain, forage barley, peas, sugar beet, triticale and organic triticale.

- LCI data sets from internal databases from the UMR SAS (INRA, Rennes) that were processed by the AGRIBALYSE® inventory data processing system. The production system data contained in these databases was entered into the data collection module and the LCI data sets were generated by the AGRIBALYSE® inventory data processing system (IDPS). These data sets were for forage, cereals and oil and protein crops.
- LCI data sets from internal databases from the UMR SAS (INRA, Rennes) that were used without being processed by the IDPS. These are products other than raw plant materials that could have been processed by the IDPS, or products that had been subject of specific studies (eg: soybean from Brazil).
- LCI data sets from commercial databases (ecoinvent®, etc). These were sometimes modified to comply with the project requirements.

The data sets for feed mixes, in the system data set format, were made available for use in AGRIBALYSE®. The procedure for carrying out these processes is described in **Appendix L**.

Note on calculating grazed grass data sets. For the AGRIBALYSE® program, grassland and grazed grass were treated in the same way as other forages, which meant that a special data set was set up (see A.2.2.4b). The data collected for the AGRIBALYSE® program strictly only covers grazing for cattle. The grazed grass data sets were also used without modification for sheep and goats considering that:

a) in France, most ruminants are cattle
b) the accounting (expressed in large cattle units) is comparable, which means that the overall yields and excretion can be compared
c) for calculating the direct emissions linked to excretions, the composition of cattle manure was used.

The losses at harvest were taken into account in the data sets for grass that was grazed or used for hay, silage or haylage. To calculate the yield, the losses on collection, storage and consumption of forage by the animals were subtracted (**Appendix L**, §3).

B.3.4 Transport of inputs

Transport of inputs from the point of purchase to the farm was taken into account using transport models. A transport model brought together the information on the means of transport used and the distances travelled and was applied to groups of inputs. The following types of input were considered:

- Fertilizers (mineral and organic)
- Pesticides
- Other inputs
- Raw materials for feed (note: when the forage and raw materials were produced on the farm, transport was not considered).
-

In these models, the journey from the “point of purchase” (storage / distribution site) to the “farm” may cover the two components shown in **Table 12**.

For the weight transported, the gross weight was taken into account. In accordance with ecoinvent® (Nemecek and Kägi, 2007), an average content of active substances in pesticides of 50% was used to estimate the weight of the pesticide based on the amount of active substance applied.

Table 12: Assumptions for transport of inputs

<table>
<tr><th>Type of input</th><th>Transport from point of purchase outside France to point of purchase in France</th><th>Transport from point of purchase in France to the farm</th></tr>
<tr><td>Inputs produced on the farm</td><td>No</td><td>No</td></tr>
<tr><td>Inputs produced in France (FR type data set)</td><td>No</td><td rowspan="3">Yes: 15 km with tractor and trailer</td></tr>
<tr><td>Fertilizers, raw materials for imported feed</td><td>Yes (see details in Erreur ! Source du renvoi introuvable. and Table 13)</td></tr>
<tr><td>Other imported inputs (RER type data set)</td><td>Yes based on Ecoinvent “v3 market processes”</td></tr>
</table>

For AGRIBALYSE® data sets for France, the distance between the point of purchase and the farm considered was 15 km with tractor with trailer/tank. For organic fertilizers which come from the farm itself or a nearby farm, 10 km transport with tractor and trailer was assumed. In addition, on farm transport (farm-field) is included in “agricultural process” LCIs data sets, also amounting to about 10 km (Appendix K).
As no data was available, the same assumptions were applied for tropical crops: clementines, coffee and rice.

For imported inputs, default assumptions from ecoinvent have been used through “market processes”, except for mineral fertilizers and feeds where specific transportation data could be defined based on GESTIM (Gac *et al*, 2010) **(Table 13)**.

For animal feed:

- ✓ Transport from the place of production/storage of the raw material to the feed fabrication plant
- ✓ Transport of the feed from the feed fabrication plant to the farm

For feed produced on the farm, only the transport of raw materials from their place of production/storage to the farm was considered.
An average transport distance in France, depending on the means of transport, was calculated according to Nguyen *et al* (2012). For raw materials coming from abroad, the transport distance proposed by GESTIM (Gac *et al*, 2010) was used.

Table 13: AGRIBALYSE® transport models (TM) used for animal feed

ecoinvent® process	Place of fabrication of raw material ⇨ Fabrication plant	Fabrication plant ⇨ Farm
Transport, lorry >32t, EURO3/RER U	110 km[a] + GESTIM[b] assumption	130 km[b]
Transport, freight, rail/RER U	390 km[a] + GESTIM[b] assumption	-
Transport, transoceanic freight ship/OCE U	GESTIM[b] assumption	-

[a] transport distance in France calculated according to Nguyen *et al* (2012).

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

B.3.5 Calculation models for the consumption of resources and direct emissions from polluting substances

B.3.5.1 General principles and overview of the models used

In AGRIBALYSE®, direct emissions were defined as flows of potentially polluting substances into the environment, directly associated with livestock and arable/horticultural production, on their production site. This was, however, extended to cover the consumption of resources required for the production processes (water consumption, land occupation, etc).
As recommended in the ILCD Handbook (JRC and IES, 2010a) and ISO standards (2006a and 2006b), so far as possible, only the flows of elementary substances were calculated. COD (chemical oxygen demand) indicators and AOX (adsorbable organic halogens) were not considered.
Indirect emissions, flows of potentially pollution substances into the environment associated with the production of inputs used on the production site, were not modeled in AGRIBALYSE®. These indirect emissions are part of the generic data in existing databases (ecoinvent®, etc).

AGRIBALYSE® was based on the recommendations in international standards to rationalize the choice of models used for the program. According to the recommendations of IPCC (2006a) and EMEP/EEA (2009), the models used should make it possible to produce an estimate that is as precise and correct as possible. Models that introduced a systematic bias could not be used. Several criteria were taken into account when selecting models for calculating direct emissions and consumption of resources:

- The scientific validity: AGRIBALYSE® aimed to be recognized internationally and so the methods used had to be recognized scientifically and be subject of international consensus.
- The scope of validity: as AGRIBALYSE® set up data sets mainly for French agricultural products, the models used must, at least, be applicable to conditions in France.
- Technical feasibility: AGRIBALYSE® focuses on using models that are easy to apply in particular concerning the quantity of data required to use the calculation models. The granularity of the models selected must be compatible with the input data collected.

The models for calculating direct emissions and the consumption of resources for tropical products were selected on the same principles, the scope of validity being adapted to each product considered.

This section of the report presents the main requirements for each substance emitted, the models identified in the literature which could possibly be used in AGRIBALYSE® and the models and the sources of emissions finally selected. The parameters for all the models are described in **Appendices D, E and F**.

a) *Substances / direct emissions considered*

Agricultural production operations generate direct emissions and consume resources. **Table 14** presents the emissions and resources consumed and the sources of the emissions considered and the models selected. The choice of model does not indicate that a given model is considered to be scientifically better than the other models. The models were selected to meet the requirements and aims of the AGRIBALYSE® program.

Table 14: Substances emitted/resources consumed, sources of emissions and models used in AGRIBALYSE®

Substance emitted / Resource consumed	Source of emissions / consumer of resource	Model used
Ammonia (NH_3)	Animal excretion (building/ storage) - calculation of nitrogen excreted - emission factors	CORPEN 2006, 2003, 2001, 1999a and 1999b EMEP/EEA 2009 Tier 2
	Organic fertilizers and excretion on grassland	EMEP/EEA 2009 Tier 2
	Mineral fertilizers	EMEP/CORINAIR 2006 Tier 2
	Thai rice	Yan *et al*, 2003b
Carbon dioxide (CO_2)	Absorption by the plants	ecoinvent® v2 (Nemecek and Kägi, 2007)
	Addition of lime and urea	IPCC 2006b Tier 1
Trace metals (Cd, Cu, Cr, Hg, Ni, Pb, Zn)	Leaching: French crops	SALCA-SM adapted for France (Freiermuth, 2006 and SOGREAH, 2007)
	Runoff: French crops	
	Accumulation in the soil: French crops	
Energy stored by the plants	All arable and horticultural production	Higher heating value (HHV) of the product
Combustion gas	CO_2	ecoinvent® v2 (Nemecek and Kägi, 2007), using an LCI "combustion of diesel/kerosene" data set
	Other air pollutants (metals, VOC, SO_X, NO_X…)	
Methane (CH_4)	Animal excretion (building/ storage/grassland/outdoor run)	IPCC 2006b Tier 2
	Emissions from enteric fermentation: cattle and sheep	IPCC 2006b Tier 2
	Emissions from enteric fermentation: other animals	IPCC 2006b Tier 1
	Thai rice	IPCC 2006b Tier 2
Nitrate (NO_3)	Leaching: annual crops	Tailleur *et al*, 2012
	Leaching: special orchard crops, vineyards	SQCB (Faist *et al,* 2009)
	Leaching: special soilless crops	This report: based on waste water/losses
	Leaching: grassland	This report
	Leaching: tropical crops (except rice)	IPCC 2006b Tier 1
	Thai rice	This report: based on water balance
	Livestock production: outdoor runs	Basset-Mens *et al*, 2007
Land occupation	All types of production	ecoinvent® v2 (Frischknecht *et al*, 2007)
Nitric oxide (NO)	Livestock and arable/horticultural production	EMEP/EEA 2009 Tier 1
	Thai rice	IPCC 2006b Tier 2
Phosphorus (P)	Leaching: French crops	SALCA-P (Nemecek and Kägi, 2007 and Prasuhn *et al*, 2006)
	Run-off: French crops	
	Emissions from grazing and grassland	
	Tropical crops (except rice)	
	Special soilless crops	This report: based on waste water / losses
	Thai rice	This report: based on water balance
Pesticides	Application of the product: French crops, clementines, coffee	ecoinvent® v2 (Nemecek et Kägi, 2007)
	Application of the product: Thai rice	This report
Dinitrogen oxide (N_2O)	Arable / horticultural production	IPCC 2006b Tier 1

Substance emitted / Resource consumed	Source of emissions / consumer of resource	Model used
	Special French crops	IPCC 2006b Tier 1
	Tropical crops (except rice)	IPCC 2006b Tier 1
	Thai rice	IPCC 2006b Tier 2
	Livestock production (buildings and storage)	IPCC 2006b Tier 2
Soil lost	French arable / horticultural production in open fields	RUSLE (Foster, 2005)
	Soilless production	Loss set to 0
	Tropical products	Loss set to 0
Land transformation	All types of production	ecoinvent® v2 (Frischknecht *et al*, 2007)
Phosphorus , nitrogen, total suspended solids (TSS)	Aquaculture	Papatryphon *et al*, 2005

b) Flows not considered

Several flows were not taken into account by AGRIBALYSE®

- **CO_2 emissions produced by animal respiration**: in accordance with the recommendations of IPCC (2006b). The CO_2 absorbed by the plants during photosynthesis, and therefore contained in cattle feed, was considered to be restored to the atmosphere in this form. As this is not a long-term storage process, this type of emission did not need to be considered.
- **Carbon sequestration in the wood of permanent crops (grapevines and trees):** it is difficult to evaluate the fate of the wood (storage or short cycle), the amounts of CO_2 involved are low, in accordance with the calculations carried out by CITEPA for national data sets (CITEPA, 2011).
- **Changes in biomass and soil carbon stocks after land use change (LUC) in France:** although two methods were developed for taking account of the changes in soil carbon stocks (Salou *et al*, 2012: **Appendix E**), **this source / sink of emissions was not included in the data sets in the database**.
- **Water sampling flows:** More precise methods for including the water footprint (green, blue and gray) in LCI data sets are currently being developed (**Appendix F**). The method considered to be the most efficient at the moment is that developed by Pfister *et al* (2009). However, it was not considered to be applicable for AGRIBALYSE®. The direct consumption of water was, therefore, only taken into account for irrigation, fertigation and drinking and cleaning water.
- **Gaseous emissions from fish farming** were not taken into account as insufficient data was available for trout and no data was available for the production of sea bass / sea bream. Data is being collected for these types of emissions.
- **Only Cd, Cu, Cr, Hg, Ni, Pb and Zn, were included for trace metals**, as no reliable data was available for the other metals .

- **Particulate emissions from activities on the farm (animal and plant production)**. The data currently available in France and Europe was considered to be insufficient to take satisfactory account of these emissions (Faburé *et al*, 2011).
- **Parameters could not be defined for the trace metal and soil loss models** for tropical products as there was a lack of information/data.
- **Of the various NOx gases only NO** was considered for direct flows, owing to the lack of appropriate models for the other gases.

A detailed description of the parameters for models for calculating NH_3 emissions is given in **Appendix D** – Datasheet 1.

B.3.5.2 Calculation of ammonia emissions (NH_3)

a) Challenges and requirements

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

- In mineral and organic fertilizers
- In excretions from animals while grazing or in buildings
- In animal excretions during storage

These emissions depend on the type of fertilizer applied or the type of excretion and on soil, climatic and microbiological conditions.

b) Available models

Several models were found 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

c) Models selected and sources of emissions

Existing models were evaluated, taking account of the selection criteria (see B.2.4), and the following models were selected (**Table 15**). The models were selected mainly on the basis of (a) appropriate granularity and (b) international recognition.

Table 15: Models selected for each source of NH_3 emissions

Source of NH_3 emissions	Model selected

Excretions in buildings and outdoor runs	**CORPEN 2006, 2003, 2001, 1999a and 1999b:** for calculating the amount of nitrogen excreted by the animals
	EMEP/EEA 2009 Tier 2: for emission factors
Storage of excreta	**EMEP/EEA 2009 Tier 2:** for emission factors
Organic fertilizers and excretion while grazing	**EMEP/EEA 2009 Tier 2**
Mineral fertilizers	**EMEP/CORINAIR 2006 Tier 2**
Thai rice	**Yan *et al*, 2003b**

EMEP/EEA (2009) and EMEP/CORINAIR (2006) proposed a mass flow rate approach to distinguish between the emissions for each source considered.
The methodology proposed for rice is based on the IPCC method (2006b) which uses the emission factors specific to rice growing proposed by Yan *et al* (2003b).

d) Calculating the livestock nitrogen excretion emissions

A detailed description of the parameters for calculating the livestock nitrogen excretion emissions is given in **Appendix D** – Datasheet 2.

The model used to calculate the direct NH_3 emissions was based on the nitrogen excreted by the animals. It was, therefore, necessary to estimate this parameter as precisely as possible. The most recent equations in CORPEN for each type of animal were used. These equations determine the amount of nitrogen excreted using mass balance. The amounts of nitrogen ingested are determined from the composition of the food rations distributed. The nitrogen fixed by the animals is based on the species and development stage. The models are given in **Table 16**.

Table 16: Models used for livestock nitrogen excretion

Type of animal	Model used
Dairy cows	**CORPEN 1999a**
Suckler beef, growing or fattening (suckler and dairy)	**CORPEN 2001**
Pigs	**CORPEN 2003**
Poultry	**CORPEN 2006**
Rabbits	**CORPEN 1999b**

B.3.5.3 Calculating the carbon dioxide (CO_2) flows and emissions

A detailed description of the parameters for models for calculating CO_2 emissions is given in **Appendix D** – Datasheet 3.

a) Challenges and requirements

Several processes in agricultural production systems result in CO_2 emissions.

- Liming and application of urea
- Type of land use / occupation and land management (**Appendix E**)
- Processes that use fossil fuels for power (agricultural machinery, livestock buildings, greenhouses), see also B.2.4.5

The ILCD makes many recommendations regarding CO_2 emissions:

- Distinction between CO_2 from fossil fuel emissions and biogenic CO_2: i) to improve transparency and methodological flexibility; ii) as biogenic CO_2 only comes into the GWP category during evaluation
- Carbon assimilated by the plants in the data set as "Resources from air"
- Changes in biomass and soil carbon stocks associated with land use change (LUC) or change in farming practices, inventoried as "Carbon dioxide (land transformation)"
- Use of the most recent IPCC method or a more appropriate methods if available to quantify changes in soil carbon stocks

Another major challenge was taking account of soil carbon dynamics, mainly associated with LUC and changes in farming practices. However, as no satisfactory methods of taking account of these sources of emissions was found, these flows were not included in the data sets in the AGRIBALYSE® database. A working group was set up within the AGRIBALYSE® program to consider this matter. This led to the proposal of two methods for quantifying soil carbon flows. These two methods and their results are given in **Appendix E**.

b) Available models

Several models were found 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

c) Models selected and sources of emissions

Existing models were evaluated, taking account of the aims of the AGRIBALYSE® program, see B.2.4, and the following models were selected (**Table 17**).

Table 17: Models selected for each source of CO_2 emissions

Source of CO_2 emissions	Model selected
Absorption by the plants	**ecoinvent® v2** (Nemecek and Kägi, 2007)
Application of lime and liquid manure	**IPCC 2006b Tier 1**

The methods proposed by Vertregt and Penning de Vries (1987) and Nemecek and Kägi (2007) could be used to determine the amount of carbon fixed in the plant biomass from the carbohydrate, lipid, protein fiber and mineral content in the plants.
The CO_2 emissions associated with the application of lime and liquid manure were determined using an emission factor, specific to each of the substances considered, applied to the amount applied. Liming was considered only for carrots, cider apples and alfalfa.

B.3.5.4 Calculating trace metal emissions

A detailed description of the parameters for calculating trace metal emissions is given in **Appendix D** – Datasheet n°4.

a) *Challenges and requirements*

The ILCD Handbook recommends taking account of the absorption of trace metals by the plants by setting up data sets for the various flows for each metal. It also recommends setting up data sets for the net accumulation of substances in the soil, in particular trace metals (see chapter 7.4.4.1 “Modeling agro- and forestry systems”, JRC and IES 2010a).

b) *Available models*

Two data sources / models were identified:

- A data source: **Estimating average flows** of trace metals (As, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Se, Zn) to the soils based on the SOGREAH study (2007).
- A flow calculation model: **SALCA-SM/ecoinvent®**: calculation of trace metal flows (Cd, Cu, Zn, Pb, Ni, Cr, Hg) based on mass balance (Freiermuth, 2006).

c) *Modifications*

SALCA-SM is a model for quantifying flows of trace metals affected by farming activities. It was modified to suit conditions in France using SOGREAH data, and the AGRIBALYSE® program developed “SALCA-ETM-Fr”.

d) *Models selected and sources of emissions*

The main source of emissions of trace metals is the agricultural plot. In accordance with JRC and IES 2010a, the following sources of emissions were identified (**Table 18**):

- Emissions in surface water (due to soil loss)
- Emissions by leaching
- The mass balance: emissions to the soil

Table 18: Models selected for each source of trace metal emissions

Source of trace metal emissions	Model selected
Leaching: French crops	**SALCA-SM modified for conditions in France** (Freiermuth, 2006 et SOGREAH, 2007)
Run-off and soil losses: French crops	
Accumulation in or losses from the soil: French crops	
Tropical crops	**Not considered** (see B.2.4.1)

e) *Calculation of trace metal emissions by soil loss: calculation of the amount of soil lost*

Trace metal emissions by soil loss were calculated partly by the model for calculating the amount of soil lost.
A detailed description of the parameters for calculating the amounts of soil lost is given in **Appendix D** – Datasheet 5.

Challenges and requirements

The amount of soil lost was not a flow included in the AGRIBALYSE® LCI data sets. Soil loss was considered as a source of emissions of various substances contained in the soil lost which is an important parameter for calculating the flows of trace metals and losses of phosphorus due to erosion.
JRC and IES (2010a) recommend treating the various substances lost in the soil as flows to the “surface water” and “air” compartments (JRC and IES, 2010a).

Available models

The following models were evaluated:

- ecoinvent® v2 (Oberholzer *et al*, 2006)
- Study of water erosion of soils in French soils (Le Bissonnais *et al*, 2002)
- LANCA (Beck *et al*, 2008)
- RUSLE (Foster, 2005)

Model selected

The RUSLE model was selected partly because it met the AGRIBALYSE® selection criteria and partly because its granularity was particularly suitable for the work carried out.

B.3.5.5 Calculation of combustion gas emissions

A detailed description of the parameters for calculating combustion gas emissions during farming activities is given in **Appendix D** – Datasheet 6.

a) Challenges and requirements

A significant part of polluting emissions to the air comes from the fuel used by tractors and automotive machines (using diesel) or when burning fossil fuels for heating (eg. greenhouses).

b) Models selected and sources of emissions

The model proposed by ecoinvent® v2 (Nemecek and Kägi, 2007) was selected for fuel used for power and heating. For each type of substance, an emission factor was applied to the amount of fuel. The emissions associated with the power consumption in livestock buildings and for heating greenhouses was taken into account using existing LCI data sets.

B.3.5.6 Calculating methane (CH_4) emissions

A detailed description of the parameters for CH_4 emissions is given in **Appendix D** – Datasheet 7.

a) A) Challenges and requirements

Emissions from enteric fermentation in ruminants are a major source of greenhouse gases accounting for 6% of emissions quantified in France in 2009 (CITEPA, 2011). They are, therefore, a key source, according to IPCC. It is recommended that they should be taken into account by methods above Tier 1.
Methane emissions are also significant in the paddy fields in south east Asia. A Tier 2 approach is recommended.

b) Available models

Two models were identified in the literature:

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

c) Models selected and sources of emissions

These models were evaluated to determine whether they met the requirements of the AGRIBALYSE® program, see B.2.4, and the following were selected (**Table 19**).

Table 19: Models selected for each source of CH_4 emissions

Source of CH_4 emissions	Model selected
Emissions from enteric fermentation	
Cattle	**IPCC 2006b Tier 2**
Sheep	**IPCC 2006b Tier 2**
Goats	**IPCC 2006b Tier 1**
Pigs	**IPCC 2006b Tier 1**
Poultry	**IPCC 2006b Tier 1**
Excretions in buildings and during storage	**IPCC 2006b Tier 2**
Excretions in grasslands and outdoor runs	**IPCC 2006b Tier 2**
Thai rice	**IPCC 2006b Tier 2**

For methane emissions from enteric fermentation, a specific emission factor was calculated based on the composition of the rations distributed to each type of animal. This was expressed in kg CH_4 emitted/head/year.

The emissions from excretions depend on the type of excretion produced and the systems for managing excretion in the livestock buildings, during storage and on grassland.

The IPCC method calculates the emissions from rice growing using a basic emission factor that depends on: i) the watering system, ii) the type and quantity of organic matter applied and iii) the type of soil and the cultivar.

B.3.5.7 Calculating nitrate emissions (NO_3)

A detailed description of the parameters for models for calculating NO_3 emissions is given in **Appendix D** – Datasheet 8.

a) Challenges and requirements

This flow was included in the AGRIBALYSE® program given the contribution of nitrate emissions to eutrophication. They also contribute to greenhouse gas emissions (indirect dinitrogen oxide emissions).

Leaching affects the nitrogen received by a crop and takes place mainly during the draining period which follows the crop harvest. To estimate nitrogen leaching, this period was taken into account, although it is outside the assessment period defined for the plant LCI data sets (from the harvest of the previous crop to the harvest of the crop concerned, see chapter A.2.2.3).

b) Available models

Two types of model for estimating NO_3 were found:

Dynamic models and dynamic mass balances

- DEAC (Cariolle, 2002, Cohan *et al*, 2011) and SALCA-N (Richner *et al*, 2006). These models require input data for the soil-climatic conditions and for farming practices.
- Nitrogen + water balance
- SQCB – Sustainable quick check for biofuels (Faist *et al*, 2009)

Fixed emission factor models

- COMIFER table (2001)

- INRA table (Basset-Mens *et al*, 2007)
- IPCC (2006b), Tier 1

c) *Models selected and sources of emissions*

None of the models covered the particular requirements of all the crops considered (annual, permanent, tropical) and so different models were selected to calculate the nitrate leaching depending on the type of crop.

French annual crops

Dynamic models gave a precise simulation of the emissions at plot scale depending on the farming practices and the conditions. However, using them required a considerable quantity of data, not always available from the data collected for the program, as well as considerable amount of work for parameterization which did not fit into the AGRIBALYSE® SCHEDULE. The INRA table was drawn up for a specific soil-climatic background and particular production systems.

It was, therefore, decided to develop a new approach based on the COMIFER model, that could be applied to France. This was a simplified approach, set up by a group of recognized experts, for plot-scale analyses that could be used on larger scales (regions, etc). This method took account of the main factors determining leaching and also had the advantage that it would be ready for use within a short space of time.

Orchards and grapevines, special French crops (including carrots and soilless crops)

The SQCB model (Faist *et al*, 2009) was selected for orchards, grapevines and special French crops. For vineyards with grass cover, leaching was considered for only 50% of the field. The effect of grass cover was not considered in orchards.

An exception was made for soilless crop production (shrubs, roses and tomatoes) with open or closed circuit fertigation: leaching was calculated on the basis of the waste water which was considered to be leached into the surface water or using a nutrition solution loss rate defined by expert opinion.

Grassland

Neither the modified COMIFER table (for annual crops) nor the SQCB model were able to meet the requirements for the various types of grassland (temporary, permanent, grazed grass). As the DEAC model was parameterized specifically for France and took account of the parameters for distinguishing between the different types of grassland, nitrate leaching from the grassland was calculated separately for the 17 grassland LCI data sets in AGRIBALYSE® using the DEAC model.

Outdoor runs

Estimates of nitrate losses from outdoor runs were based on Basset-Mens *et al* (2007). An emission factor of 17.5% of the nitrogen applied was used. This was applied to all outdoor runs, regardless of the type of animal.

Tropical crops

The IPCC (2006b) Tier 1 model was selected for tropical crops, given the lack of information required to implement other methods and to ensure methodological coherence between the different types of tropical crop. A specific model based on the nitrogen mass balance and water balance was selected for rice.

The models selected are given in **Table 20.**

Table 20: Models selected for each source of NO_3 emissions

Source of NO_3 emissions	Model selected
Annual French crops	**COMIFER 2001 adjusted (Tailleur *et al*, 2012)**
Special French crops	**SQCB (Faist *et al*, 2009)**
Special soilless crops	**This report:** Based on waste water / water losses
Grassland	**This report:** DEAC
Tropical crops (clementines, coffee)	**IPCC 2006b Tier 1**
Thai rice	**This report**: Based on water balance
Livestock production: Outdoor runs	**Basset-Mens *et al*, 2007**

d) Modifications

The COMIFER (2001) takes account of a "crop" risk (depending on the period able to absorb nitrogen without plant cover, the amount of nitrogen released by crop residues, the nitrogen absorption capacity of the following crop in the fall and the application of organic fertilizers in the fall) and a "condition" risk (depending on the quantity of water percolating through the soil (CORPEN, 1991) and the mineralization conditions). However, it did not originally take account of the quantity of fertilizer applied to the crop with respect to its nutritional requirements before the leaching period. This parameter was modified and added. An amount of nitrate leached was associated with each risk of leaching level based on experimental data or, when the experimental data was insufficient, estimated from the DEAC model (Cariolle, 2002; Jolivel, 2003).

B.3.5.8 Land occupation and transformation

A detailed description of the parameters for models for calculating land occupation and transformation is given in **Appendix D** – Datasheet 9.

a) Challenges and requirements

For LCA, land use, covers land occupation and land transformation from the point of view of economic competition of activities requiring land area. Land occupation is independent of changes in soil carbon stocks. It is concerned only with possible "loss" of land as a resource. A distinction is drawn between:

- Land occupation: the land is maintained in an unnatural state because of the way the land is used (Frischknecht *et al*, 2007).
- Land transformation: the changeover from one type of land occupation to another (Frischknecht *et al*, 2007).

b) Models selected and sources of emissions

The models selected for calculating this parameter are given in **Table 21**.

Table 21: Models selected for land occupation and land transformation

Type of resource consumption	Model selected
Land occupation	**ecoinvent® v2** (Frischknecht *et al*, 2007)
Land transformation	**ecoinvent® v2** (Frischknecht *et al*, 2007)

B.3.5.9 Calculating nitric oxide emissions (NO)

A detailed description of the parameters for calculating nitric oxide emissions is given in **Appendix D** – Datasheet 10.

a) Challenges and requirements

Nitrogen oxides are produced during the denitrification processes. In farming these emissions can increase significantly owing to the application of nitrogen in the form of mineral and organic fertilizers from animal excretion.

b) Available models

Several models were 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

c) Models selected and sources of emissions

The models selected are given in **Table 22.**

Table 22: Models selected for each source of NO emissions

Source of NO emissions	Model selected
Excretion in livestock building	**EMEP/EEA 2009, Tier 1**
Excretion during storage	**EMEP/EEA 2009, Tier 1**
Mineral and organic fertilization	**EMEP/EEA 2009, Tier 1**
Thai rice	**Yan *et al*, 2003b**

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

A single emission factor was used for mineral and organic fertilizers, regardless of the type of product.

B.3.5.10 Calculating phosphorus emissions (P/PO_4)

A detailed description of the parameters for models for calculating phosphorus emissions is given in **Appendix D** – Datasheet n°11.

a) Challenges and requirements

Given the importance of phosphorus in eutrophication, this flow was included in the AGRIBALYSE® LCI data sets. Phosphorus emissions are mainly flows (owing to fertilization) to “surface water” and “aquifer’ compartments.

b) Available models

The models were identified in the literature:

- **SALCA-P/ecoinvent®**: Method applied for calculating phosphorus emissions in the ecoinvent® LCIA documented in Nemecek and Kägi (2007) and Prasuhn *et al* (2006).

- **Application of fixed factors** (eg. 0.69% of P applied), from experimental results in several French drainage basins (Castillon and Lesouder, 2010).
- **ECODEFI**: A methodological approach based on the results of the ECODEFI project which focused on runoff (Pradel *et al*, 2011)

c) Models selected and sources of emissions

Few projects have been undertaken in France on a scale as large as that in the AGRIBALYSE® program (Thomas NESME, ENITA Bordeaux, personal communication 2011). The ECODEFI project and "application of fixed factors" were based on French data. However, they were not selected as they were considered too specific. The SALCA-P model was selected because it had a more generic scope and was valid for all the sources of emissions, for major crops as well as for grassland. It should, however, be noted that it was validated for Switzerland and not for France. The following sources of emissions are given in **Table 23**.

Table 23: Models selected for each source of phosphorus emissions

Source of phosphorus emissions	Model selected
Emissions by leaching	**SALCA-P** (Nemecek and Kägi, 2007 and Prasuhn *et al*, 2006)
Emissions by run-off	
Emissions from soil loss	
Tropical crops (clementines, coffee)	
Thai rice	**This report**: based on water balance
Special soilless crops	**This report:** based on waste water / water losses
Emissions from storage of manure	**Not considered**

d) Modifications

The phosphorus content of organic manure and sludge was adjusted for French conditions. The following three parameters could not be modified as there was a lack of available data (**Appendix D**, datasheet 11):

- Average quantities of phosphorus lost by leaching
- Average quantities of phosphorus lost by runoff
- Average phosphorus soil content

Default values from SALCA-P models were used for these parameters.

e) Calculating phosphorus emissions by soil loss: calculating the amount of soil lost

The calculations for phosphorus emissions due to soil loss were based on the model for calculating the amount of soil lost (see B.2.4.4.e).

B.3.5.11 Calculating pesticide emissions

A detailed description of the parameters for models for calculating pesticide emissions is given in **Appendix D** – Datasheet 12.

a) Challenges and requirements

Apart from its initial aim, to protect plants against harmful organisms, the application of pesticides causes emissions of active substances to the water, air and soil compartments with the risk of toxicity for organisms not targeted by these products.

b) Available models

The following five models were studied:

- Audsley *et al* (2003), who proposed dividing pesticide emissions between soil (88.4%), crop (8%), air (2%) and water (1.6%) compartments
- Anton *et al* (2004), who developed a dynamic model targeted at the application of pesticides in greenhouses taking account of factors such as drift, canopy, vapor pressure, etc.
- ecoinvent® v2.0 (Nemecek and Kägi, 2007), according to which 100% of pesticides applied are emitted into the soil compartment
- EMEP (EMEP/EEA, 2009), part 4G – tier I - which proposed five emission factors into the air compartment, depending on the saturated vapor pressure of the active substance (between 1% and 95%)
- PestLCI 1.1 (Birkved and Hauschild, 2003) who calculated the emissions and their fate on the basis of the time lapsed since the application, using a dynamic model which requires considerable input data

c) Modification

None of the models identified was considered appropriate for the purposes of AGRIBALYSE®. Work began on the development of a simplified approach which took account of two parameters (vapor pressure and canopy). After discussion with an expert (P. Roux, IRSTEA), this was abandoned because it could not cover several types of application method (fumigation, injection, etc.).

The ecoinvent® v2.0 model, which assumes that 100% of the quantities applied are emitted into the soil compartment, was selected as it is commonly used for producing LCA. Direct emissions from the application of pesticides are potential maximum emissions. In the absence of reliable data, the assumption “100% to the soil” was also applied for growing crops under cover (eg. plastic film, in greenhouses or tunnels) and even for soilless crops.

An exception was made for rice which is grown in fields that are flooded for all or part of the growing period. For rice, it was assumed that pesticides were emitted in equal parts into the water and soil compartments.

d) Models selected and sources of emissions

The models selected are given in **Table 24**.

Table 24: Models selected for sources of pesticide emissions

Source of pesticide emissions	Model selected
All crops (except rice)	**ecoinvent® v2** (Nemecek and Kägi, 2007)
Thai rice	**This report (50% soil/50% water)**
Soilless crops or crops grown under plastic	**ecoinvent® v2** (Nemecek and Kägi, 2007)

film	

B.3.5.12 Calculating dinitrogen oxide emissions (N_2O)

The emissions of N_2O from agriculture are mainly due to the use of mineral and organic nitrogen amendments and the management of manure and slurry. The N_2O emitted comes from the nitrification - denitrification process and is a major contributor to global warming. A detailed description of the parameters for models for calculating N_2O emissions is given in **Appendix D** – Datasheet 13.

a) A) Challenges and requirements

In farming, N_2O emissions mainly come from mineral and organic fertilizers and management of animal excretions.

b) Available models

Several models were identified in the literature:

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

c) Models selected and sources of emissions

The model selected for dinitrogen oxide emissions was that proposed by IPCC (2006b) which is internationally recognized by scientists. When Tier 2 emission factors were available they were used but, for several cases, Tier 1 had to be used.

The models and sources of emissions for calculating N_2O emissions are given in **Table 25**.

Table 25: Models selected for each source of N_2O emissions

Source of N_2O emissions	Model selected
Arable / horticultural production (agricultural soils)	**IPCC 2006b, Tier 1** (for emission factors)[1)]
Special French crops	**IPCC 2006b, Tier 1** (for emission factors)[1)]
Tropical crops (clementines, coffee)	**IPCC 2006b, Tier 1**
Thai rice	**IPCC 2006b, Tier 2** based on **Yan *et al*, 2003b**
Grazing	**IPCC 2006b, Tier 1**
Excretions in buildings/storage	**CORPEN 2006, 2003, 2001, 1999a and 1999b:** for calculating the amount of nitrogen excreted by the animals
	IPCC 2006b, Tier 2 for emission factors (and the fraction leached):
Excretions in outdoor runs	**IPCC 2006b, Tier 2** for emission factors (and the fraction leached)

1) Indirect N_2O emissions were not calculated using the default leached and volatilized fractions in IPCC but by calculating the quantities leached and volatilized using nitrate and ammonia models.

Daum and Schenck (1996) analyzed the volatilization of N_2O for soilless crops. As the emission factor they proposed was close to that of IPCC (2006b) and it has large uncertainties, the N_2O flow estimation method used for agricultural soils was finally selected.

B.3.5.13 Water usage

For producing an LCA, water has until now been considered as a potential receptor of polluting emissions. The quality of the water is taken into account, in particular with categories of impact on eutrophication, acidification and ecotoxicity.

However, water has not as yet been taken into account as a resource. Recent methodological developments are able to take account of the impact of water consumption.

A bibliographic study carried out by CIRAD identified the method developed by Pfister *et al* (2009) as currently the most efficient (**Appendix F**).

The data required to implement this method is the amount of water consumed by the production processes. However, as this information was not available from the various data sets used for the AGRIBALYSE® product inventory, the method developed by Pfister *et al* (2009) could not be used.

B.3.5.14 Calculating emissions of phosphorus , nitrogen and total suspended solids from fish farms

A detailed description of the parameters for calculating N, P and TSS emissions from fish farms is given in **Appendix D** – Datasheet 14.

a) Challenges and requirements

Given the special nature of the farming methods, fish farms have a potentially significant impact on the environment, in particular for eutrophication. A more accurate estimate is, therefore, required of the TTS, nitrogen and phosphorus emissions in dissolved and particulate form, using specific models.

b) Models selected and sources of emissions

Models of phosphorus, nitrogen and TSS emissions have been developed specifically for French fish farms (Papatryphon *et al*, 2005). The models selected for calculating this parameter are given in **Table 26**.

Table 26: Models selected for each substance emitted by fish farms

Source of emissions	Model selected
Nitrogen	**Papatryphon *et al*, 2005**
Phosphorus	
Total suspended solids (TSS)	

The model selected is based on the principle of a balance between inputs and outputs required a knowledge of the composition of the food rations distributed to the fish, the composition of the fish (the trace elements in each tissue) and the quantity of undigested nutrients.

B.4 *Allocation of flows and emissions*

B.4.1 Allocation of shared inputs: infrastructure

The infrastructure requirements for farming were taken into account by allocating the impacts of the infrastructure pro rata for the operation time (for arable / horticultural agricultural processes) or pro rata for the time the area required is occupied (for buildings). The operation time covers the time required to do the work and the preparation. This is a standard approach for agricultural product LCAs (Nemecek and Kägi, 2007; Gac *et al*, 2010).

B.4.2 Allocation to co-products

AGRIBALYSE® is limited to agricultural production. With the exception of certain processes carried out on the farm (eg: haylage, silage, etc), processing "on the farm" and "post farm" is not considered. Co-products such as press cake, from post farm processing, are not within the scope of AGRIBALYSE®. Certain co-products were, however, evaluated using existing studies for the whole of the processing stage but only where the co-products were used for animal feed **(Appendix L)**.

B.4.2.1 Definition of "co-product"

Agricultural production systems are often used for several purposes and a single production system may provide several co-products. The "main product" is defined in AGRIBALYSE® as the output from the main production of the system considered. All other outputs produced by the system were defined as co-products.

B.4.2.2 Principles and choices

a) Basic rule

As a general rule, AGRIBALYSE® complies with international standards. Whatever the allocation rule selected, it must apply equally to the main product and to co-products. In all cases, the allocation procedure is described in detail.

b) Hierarchy

The allocation rules are based on the recommendations in the interpretation note (guide de lecture) for the methodology appendix of the BPX 30-323 manual (AFNOR, 2011). In accordance with ISO 14044 (ISO, 2006b), in AGRIBALYSE® the following general hierarchy is used for the allocation methods:

- **Option 1: Wherever possible, allocation should be avoided by**:
  - ✓ dividing the unit process to be allocated into two or more subprocesses and collecting the input and output data related to these sub-processes, or
  - ✓ By expanding the product system to include the additional functions related to the co-products, taking into account of the requirements of 4.2.3.3 of ISO 14044 (ISO, 2006b). This is not an option for attributional LCI databases such as AGRIBALYSE®.
- **Option 2. Physical allocation.** The inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them, i.e. they should reflect the way in

which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system.

- **Option 3. Economic allocation.** The economic value of the co-products (eg. the market value) represents the production goal. This allocation method is commonly used in LCA when there is no physical criterion that is relevant for the product or for the co-products. The disadvantage of this allocation method is that the impact of the products depends on the market and may vary significantly from year to year even though the production system remains the same.
- To overcome this problem, the values are smoothed over 5 years excluding the highest and lowest values (Olympic average). This method gives the value of a product and how the market value changes excluding major price swings.

c) AGRIBALYSE® products / co-products

Table 27 gives an overview of the products / co-products for each product type and the methods for allocating the flows between product and co-products. These methods are described in the following chapters (B.3.2.3 to B.3.2.5).

Table 27: Products / co-products generated in AGRIBALYSE® – Method selected for handling co-products

	Product type	Product / Co-product	Method selected for handling co-products
Arable / horticultural	Cereals / protein crops	Grain straw	Economic
	Carrots	Marketable carrots Waste	100% Not considered
	Orchards / Grapevines	Fruit Prunings	100% Not considered
	Grassland	Grazed grass Hay	Weight
	Clementines	Clementines, export Clementines, local	Economic
	Coffee	Green coffee seed (main product) Pulp (composted on plantation)	Economic 96% 4%
Livestock	Suckling beef	Young bulls / heifers Cull cows	Bio-physical
	Dairy cattle	Milk Cull cows Calves	Bio-physical
	Sheep (meat)	Lambs Wool Cull sheep	Bio-physical
	Sheep (milk)	Milk Lambs Wool Cull sheep	Bio-physical
	Goats (milk)	Milk Cull goats	Bio-physical
	Layers	Eggs Cull poultry	Bio-physical
	Pigs	Pork Cull sows	Bio-physical

B.4.2.3 French crops

a) Grain / straw (cereals, protein crops)

It was decided to use economic allocation for straw as a co-product of grain. However, as the straw market is currently not very structured, the data on the economic value of this co-product is not very reliable. Consequently, no value was allocated to the straw and 100% of the impact was allocated to the grain. An exception was done concerning biogenic CO2, a mass allocation was performed to account for the real carbon flow.
Note: The straw market may one day become more structured or more reliable, representative data may become available. Selecting economic allocation makes it possible to take account of this data in an update to the AGRIBALYSE® database.

b) Marketable carrots – Carrot waste

In accordance with the allocation rules for the other products, no allocation was made for waste. The carrot yield included top grade carrots (for the fresh vegetable market) and second grade carrots (for industrial processing). Not distinguishing between these two outputs is equivalent to mass allocation, i.e. the two types of carrot have the same impact.

c) Peaches/nectarines, apples / cider apples – wood; grapes for wine - wood

As the wood and prunings from orchards are usually burned in the field, the wood is not considered as a co-product leaving the field and so no allocation is required.
As for carrots, the yield from apples includes second grade apples for industrial processing.

d) Grass for hay / silage and grazed grass

The grassland LCI data sets include five LCI data sets for grass grazed by cattle and twelve cut grass LCI data sets with both cutting and grazing. Some of the grass is stored (hay, haylage, silage) and considered to be the main product of the LCI. The other part is grazed for the period of the inventory and considered as a co-product. Mass allocation was used for the flows related to pasture seeding and fertilizing, on the basis that the protein and energy content of the grass was roughly the same whether the grass was grazed or harvested to be preserved. Flows due to harvesting were fully allocated to stored grass.The “grazed grass” co-products were not included in the AGRIBALYSE® database as there were five LCI data sets for full grazing (cattle) and no use of these co-product data sets was envisaged.

B.4.2.4 Tropical crops

a) Export grade clementines – Local market grade clementines

Economic allocation was used between local market grade clementines and export grade clementines.
Wood from prunings in Moroccan clementine orchards was not considered as a co-product leaving the plot. This wood was generally shredded and spread on the ground between rows and so no allocation was required.

b) Coffee – wood

Some of the wood from pruning in coffee plantations is left in situ and some is used for heating. As this wood has no market value, no impacts were allocated to it.

B.4.2.5 Livestock production

For livestock production, the impacts were allocated to the related products using a "bio-physical" model (**Figure 14**). Initially, allocation was avoided by dividing the process into several unit processes, breaking the life of the animal down into characteristic development stages. For certain stages, there were always several products, and so an allocation had to be made, for example for the milk production phase for cattle. An allocation for milk/calves had to be made. This was done pro rata for the energy required for the various physiological functions of the animal and to produce the product and co-products. Five functions were defined: maintenance, activity, growth, lactation and gestation. LCI « Animal of 0 day » (ex : "Calf of 0 day") correspond to phases required to build « young animals for meat » LCIs and replacing animals. These LCIS are not final product at farm gate (unlike "Calf, conventional […]/FR") and can't be used as such.

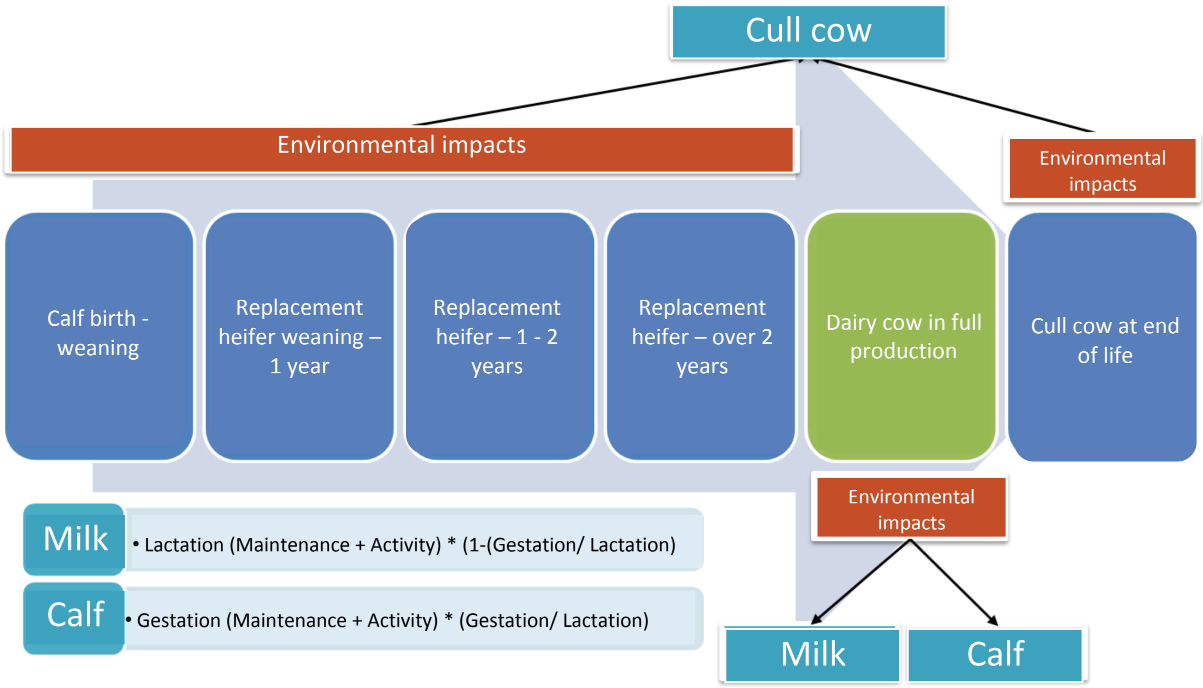


Figure 14: Allocation of impacts to co-products using a "bio-physical" model for a dairy farm: blue is the development stages for which the impacts are allocated to the cull cow and green for the stages for which the impacts are allocated to milk and calves. The impacts between milk and calves are allocated pro rata to the energy required to produce these two products.

Appendix M gives the allocation factors used in AGRIBALYSE®.

a) Dairy cattle

Table 28: Development stages, output products and physiological functions of dairy cattle, for allocating environmental impacts depending on the energy required for these functions

Stage	Output products	Maintenance	Activity	Growth	Lactation	Gestation	Comments
Calf 0-weaning	Cull cow	X	X	X			Mass allocation, pro rata to live weight of product
	Calf (b)	X	X	X			
Heifer Weaning-1 yr	Cull cow	X	X	X			
Heifer 1-2 yrs	Cull cow	X	X	X			
Heifer + 2 yrs	Cull cow	X	X	X			
Dairy cow in production	Milk	X	X		X		$Lactation + (Maintenance + Activity) * \left(1 - \frac{Gestation}{Lactation}\right)$
	Calf at birth	X	X			X	$Gestation + (Maintenance + Activity) * \frac{Gestation}{Lactation}$
	Cull cow						
Cull cow at end of life	Cull cow	X	X	X			

X is the functions concerned for each development stage.

It was assumed that the weight gain for the animal in the dairy cow in production stage was negligible. Consequently, all the impacts were allocated between the calves and the milk **(Table 28)**.

b) Beef cattle -Sucklers

Table 29: Development stages, output products and functions of suckler cows for allocating impacts depending on the energy required for these functions

Stage	Output products	Maintenance	Activity	Growth	Lactation	Gestation
Calf 0-1 year	Heifer and beef	X	X	X		
Replacement heifer 0-1 yr	Cull cow	X	X	X		
Replacement heifer 1-2 yrs	Cull cow	X	X	X		
Replacement heifer +2 yrs	Cull cow	X	X	X		
Suckler cow	Calf at birth	x	x	x	X	X
Cull cow at end of life	Cull cow	X	X	X		
Genitor	Cull cow	X	X	X		

X is the functions concerned for each development stage

During the suckler cow in production stage, the weight gain of the animal is not negligible and so the impacts were allocated between the cull cow and the heifers (**Table 29**).

c) Beef cattle - Fattening

The impacts of all classes of animals were allocated to the fattened steer.

d) Milk goats

Table 30: Development stages, output products and functions of milk goats for allocating impacts depending on the energy required for these functions

Stage	Output products	Maintenance	Activity	Growth	Lactation	Gestation	Comments
Kid (0 - 8 days)	Cull goat	X	X	X			
Replacement kid 0-1 yr	Cull goat	X	X	X			
Goat in production	Cull goat						
	Kid	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 is the functions concerned for each development stage

During the milk goat in production stage, it was assumed that the weight gain of the animal was negligible and so all the impacts were allocated to the kids and the milk (**Table 30**).

e) Sheep for meat

Cull sheep, lambs and wool were defined as co-products. The impacts were allocated as shown in **Table 31**.

Table 31: Development stages, output products and functions of sheep for meat for allocating impacts depending on the energy required for these functions

Stage	Output products	Maintenance	Activity	Growth	Lactation	Gestation	Wool production
Lamb 0-weaning	Cull ewe	X	X	X			
Replacement gimmer weaning-1 yr	Cull ewe	X	X	X			
	Wool						X
Weaned lamb for sale	Lambs	X	X	X			X
Replacement gimmer 1-2 yrs	Cull ewe	X	X	X			
	Wool						X
Ewe in production	Cull ewe	X	X	X			
	Lambs				X	X	
	Wool						X

X is the functions concerned for each development stage

During the ewe in production stage, the weight gain of the animal is not negligible and so the impacts were allocated to the cull ewes and the lambs.

f) Sheep for milk

Milk, cull ewes, lambs and wool were identified as co-products. The impacts were allocated as shown in **Table 33**.

Table 32: Development stages, output products and functions of milk sheep for allocating impacts depending on the energy required for these functions

Stage	Output products	Maintenance	Activity	Growth	Lactation	Gestation	Wool production	Comments
Lamb (0-weaning)	Cull ewe	X	X	X				
Replacement gimmer 0-1 yr	Cull ewe	X	X	X				
	Wool						X	
Replacement gimmer 1-2 yrs	Cull ewe	X	X	X				
	Wool						X	
Ewe in production	Cull ewe							
	Lamb	X	X			X		$Gestation + (Maintenance + Activity) * \frac{Gestation}{Lactation}$
	Milk	X	X		X			$Lactation + (Maintenance + Activity) * \left(1 - \frac{Gestation}{Lactation}\right)$
	Wool						X	

X is the functions concerned for each development stage

For the milk ewe phase, it was assumed that the weight gain of the animal was negligible and so all the impacts were allocated to the lambs and the milk.

g) Layers

Table 33: Development stage, output and percentage of impact of stage allocated to each product for layers

Stage	Output	Percentage of impacts allocated to product
Chick - For reproduction	Cull hen	100
Hen - Reproduction	Cull hen	100
Chicken	Cull hen	100
Layer	Cull hen	0
	egg	100

For layers, it was assumed that the weight gain of the animal was negligible. The environmental impacts were allocated to the eggs (**Table 33**).

h) Rabbits

Table 34: Development stages, output products and physiological functions of rabbits for allocating environmental impacts depending on the energy required for these functions

Stage	Output products	Maintenance	Activity	Growth	Lactation	Gestation
Rabbit - Doe	Cull rabbit	X	X	X		

	Rabbit (kit)				X	X
Rabbit - Fattening	Rabbit	X	X	X		

i) Pigs

For pig production, the impacts were allocated to the piglets and the cull sows depending on the amount of feed used (**Table 35**).

Table 35: Development stage, product and allocation of the environmental impacts for pigs

Stage	Output	Allocation of impacts
Pig - Sows	Cull sows	0.75*Qty feed sow in gestation + 0.4*Qty feed sow suckling + 1*Qty feed gilt
	Pig for pork (piglets)	0.25*Qty feed sow in gestation + 0.6*Qty feed sow suckling
Pig - Post weaning	Pig for pork	100% for pig for pork
Pig - Fattening	Pig for pork	100% for pig for pork

Note: Qty = Quantity

B.4.3 Allocation of processes, inputs and outputs for cropping sequences

B.4.3.1 Principles and allocations for cropping sequences in the AGRIBALYSE database®

It is difficult to allocate the impacts of a production system to each crop in a cropping sequence because:

- Certain practices may involve several crops in the rotation system,
- Certain emissions depend on the practices and characteristics associated with a crop as well as on the practices and characteristics associated with previous or following crops.

The ILCD Handbook recommends taking account of the nutrients remaining in the system after a crop has been harvested as a co-product of this crop and continue by extending the system or by allocation. The allocation rules used for AGRIBALYSE® are given below.

Table 36: Allocation rules used for cropping sequences

Element	Comments	Allocation rule
Phosphorus (P) and potassium (K)	These are immobile in the soil. Some farmers use residual nutrients by applying P and K fertilizers to one crop only in quantities sufficient to supply the needs of following crops.	The impacts associated with the production of these inputs and emissions (P, PO4, ETM) related to their application are allocated to each crop pro rata for the exports. Sources: COMIFER farming practice survey and export tables
Organic nitrogen	Only a fraction is directly available to the crop to which the organic nitrogen is applied. The rest contributes towards a stock of organic matter, which could benefit all crops in the rotation.	The nitrogen available for the crop to which the fertilizer is applied (PAN) is allocated to that crop. The rest is allocated to all the crops in the rotation. Sources: Farming practices and the mineralization dynamics of organic fertilizers from the CASDAR project "Sustainable soil management"
Mineral nitrogen	The amounts of nitrogen applied in mineral form are directly available for the crop to which the fertilizer is applied.	The impact of production and the emissions of the nitrogen applied to a crop in mineral form are allocated in full to the crop.
Nitrate between crops	Residual nitrates remain after a crop has been harvested. These may be used by the following crop but a fraction may also be leached.	The impact of nitrate production and emissions between crops are allocated to the previous crop.
Nitrogen from crop residues	Crop residues may constitute a source of nitrogen for the following crop(s). They may also produce N_2O emissions evaluated using the methodology of IPCC Tier 1.	The impact of nitrogen produced by crop residues and N_2O emissions from these residues are allocated to the crop which produced these residues.

B.4.3.2 Allocation of organic N, P and K inputs on the basis of the 2006 Agreste farming practices survey

Organic N, P and K inputs were allocated to all crops in a cropping sequence. This type of allocation required a detailed knowledge of the fertilizers applied and the yield for each of crops in the rotation system. There was little statistical data for cropping sequences and what information was available did not cover the production of all the crops studied in AGRIBALYSE®. The 2006 Agreste farming practices survey covered crops and not cropping sequences. However, it had the advantage of covering most of the main production regions for about ten major crops. It also gave information on the history for each plot and in particular details of previous crops. The year 2006 was considered representative of fertilizer applications during the reference period 2001-2005.

The succession of crops grown in the 14,000 plots studied was known for the period 2001 to 2005. An analysis of this data showed nearly 4,000 different cropping sequences. This diversity and the size of the samples did not make it possible to reconstitute fertilization practices for each type of cropping sequence. To take account of this diversity, these rotation systems were grouped together as "cropping sequence groups" using appropriate statistical optimal matching methods (Gabadinho *et al*, 2011). The 4,000 rotation systems were grouped into 34 major cropping sequence groups, depending on the dominant crops and production region (Jouy and Wissocq, 2011). This made it possible to take account of the differences in the application of fertilizers for a given crop depending on the rotation system and region, based on Agreste 2006 data. After allocation according to the rules in **Table 36** for each crop within the cropping sequence groups, a French average was calculated.

The implementation of this approach in the LCI data sets is given in **Appendix D** – Datasheet 16.

Part C – Impact assessment

AGRIBALYSE did not work on developping caracterization methods.

Following update v1.2, it was decided not to provide any specific caracterisation method along with AGRIBALYSE. This will enable users to choose the caracterisation method most suitable for there needs and most up to date. However users should always check that all the flows provided by AGRIBALYSE are characterized in the method they use.

In order to provide impact indicators to users without LCA softwares, most common ILCD mid point indicators were selected for the excel file, with seven extra common indicators related to energy/resource use. For "water resource depletion" and "particule matter", direct emissions are not accounted for in AGRIBALYSE.

Tableau 37 : Impact categories in the Excel summary files. Categories identified by * means that not all flows are not considered for these categories, thus these indicators should not be analyzed.(Table based on the description of characterization methods in SimaPro 8.03)

Catégorie d'impacts selon ILCD	Unité	Description	Source
Climate change	kg CO2 eq	Global Warming Potential calculating the radiative forcing over a time horizon of 100 years	IPCC 2007
Ozone depletion	kg CFC-11 eq	Calculating the destructive effects on the stratospheric ozone layer over a time horizon of 100 years.	World Meteorological Organization (WMO) 1999.
Human toxicity, cancer effects	CTUh	expressing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kilogramme). Specific groups of chemicals requires further works.	USEtox
Human toxicity, non-cancer effects	CTUh	expressing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kilogramme). Specific groups of chemicals requires further works	USEtox

Particulate matter*	kg PM2.5 eq	Quantification of the impact of premature death or disability that particulates/respiratory inorganics have on the population, in comparison to PM2.5. It includes the assessment of primary (PM10 and PM2.5) and secondary PM (incl. creation of secondary PM due to SOx, NOx and NH3 emissions) and CO.	Rabl and Spadaro 2004
Ionizing radiation HH	kBq U235 eq	Quantification of the impact of ionizing radiation on the population, in comparison to Uranium 235.	Frischknecht et al. 2000
Ionizing radiation E (interim)	CTUe	Expressing an estimate of the potentially affected fraction of species (PAF) integrated over time and volume per unit mass of a radionucleide emitted (PAF m3 day/kg). Fate of radionucleide based on USEtox consensus model (multimedia model). Relevant for freshwater ecosystems.	Garnier-Laplace et al. 2008
Photochemical ozone formation	kg NMVOC eq	Expression of the potential contribution to photochemical ozone formation. Only for Europe. It includes spatial differentiation	van Zelm et al. 2008
Acidification	molc H+ eq	characterizing the change in critical load exceedance of the sensitive area in terrestrial and main freshwater ecosystems, to which acidifying substances deposit. European-country dependent	Seppälä et al. 2006 and Posch et al. 2008
Terrestrial eutrophication	molc N eq	characterizing the change in critical load exceedance of the sensitive area, to which eutrophying substances deposit. European-country	Seppälä et al. 2006 and Posch et al. 2008.

		dependent	
Freshwater eutrophication	kg P eq	Expression of the degree to which the emitted nutrients reaches the freshwater end compartment (phosphorus considered as limiting factor in freshwater). European validity. Averaged characterization factors from country dependent characterization factors.	ReCiPe version 1.05.
Marine eutrophication	kg N eq	Expression of the degree to which the emitted nutrients reaches the marine end compartment (nitrogen considered as limiting factor in marine water). European validity. Averaged characterization factors from country dependent characterization factors.	ReCiPe version 1.05
Freshwater ecotoxicity	CTUe	Comparative Toxic Unit for ecosystems (CTUe) expressing an estimate of the potentially affected fraction of species (PAF) integrated over time and volume per unit mass of a chemical emitted (PAF m3 day/kg). Specific groups of chemicals requires further works	USEtox
Land use	kg C deficit	based on changes in SOM, measured in (kg C/m2/a). Biodiversity impacts not covered by the data set.	Mila i Canals et al. 2007.
Water resource depletion*	m3 water eq	Water resource depletion: Freshwater scarcity: Scarcity-adjusted amount of water used.	Swiss Ecoscarcity 2006
Mineral, fossil & ren resource depletion	kg Sb eq	Scarcity of mineral resource with the scarcity calculated as 'Reserve base'. It refers to identified resources that meets specified minimum physical and chemical criteria related to current mining	van Oers et al. 2002

		practice. The reserve base may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics.	
Extra indicators (non ILCD)			
Non renewable, fossil	MJ	Cumulative Energy Demand (CED) required to produce the good/service.	CED 1.8
Non renewable nuclear	MJ	Cumulative Energy Demand (CED) required to produce the good/service.	CED 1.8
Non-renewable, biomass	MJ	Cumulative Energy Demand (CED) required to produce the good/service.	CED 1.8
Renewable, biomass	MJ	Cumulative Energy Demand (CED) required to produce the good/service.	CED 1.8
Renewable, wind, solar, geothe	MJ	Cumulative Energy Demand (CED) required to produce the good/service.	CED 1.8
Renewable water	MJ	Cumulative Energy Demand (CED) required to produce the good/service.	CED 1.8
Land competition	M2	Land area required to produce the good/service. Permet de connaitre la quantité d'espace necessaire à la production du bie/service.	CML 2001

Part D – **Conclusion**

This report sets out all the choices made for building the AGRIBALYSE® LCI data sets. It explains how the data was obtained, simplifies the production of LCI data sets similar to those in AGRIBALYSE® and helps to interpret the results. It is not intended to be a guide although it may help to harmonize the selection of methodologies for LCA of agricultural products in France or abroad. New versions of this report may be issued depending on how the AGRIBALYSE® database develops.

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Glossary

To understand this report, the definitions of certain terms are given below, with the source if the definition is taken from the literature. These definitions are given for information and apply to this report for which they were drawn up.

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

The terms defined specifically for, or which have a particular meaning within, the AGRIBALYSE® program are **in green**. The definitions of expressions marked with an * are taken from ISO 14044 (ISO, 2006b).

Active substance

Material within a pesticide responsible for all or part of its effectiveness against pests.

ADEME-AFNOR platform

Methodology platform managed by ADEME and supervised by AFNOR, set up to meet the goals of the Grenelle de l'Environnement on environmental labeling. Its aims are to harmonize LCA methods and minimize costs for developing new methodologies, to meet the current goal of environmental labeling for food products.

AGRIBALYSE® database

Database of agricultural product LCI data sets (mainly products grown in France with some imported products) at the farm gate in the form of unit processes. This report describes how these data sets were built.

*Allocation

Allocation method used to partition the inputs or outputs of a product system between the product system studied and one or several other product systems.

Animal class

Component of livestock production systems, used for data collection in the AGRIBALYSE® data collection module. Each class of animals represents a group of animals processed with the same input parameters (feed, use of space in the buildings, excretions and technical data). For livestock production, most of the LCI data sets comprise several "classes".

Example the dairy cow data sets have six classes:

- Calf (birth -"1 week")
- Calf ("1 week" - weaning)
- Dairy cow replacement heifers weaning-1 year
- Dairy cow replacement heifers 1-2 years
- Dairy cow replacement heifers +2 years
- Dairy cows in production

Arithmetic mean

The arithmetic mean is the "ordinary" average, the value obtained by dividing the sum of a set of quantities by the number of quantities in the set.

Basic feed

Raw material or forage fed directly to the animals. In theory, only food rations for herbivores (cattle, sheep and goats) can contain basic feed. For other livestock production, only feed mixes are used (exception: pigs, ducks and geese which may be fed on moist maize grain fed directly).

Batch

Group of animals at the same development stage raised in a similar way. Several batches may be raised in the same livestock building during a given year.

Biogenic carbon

Carbon stored or released by natural sources (short cycle), i.e. not from the use of fossil fuel sources.

Carbon database

Database developed by ADEME additional to the IMPACTS® database. It contains only information on greenhouse gas emissions.

Case

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

***Category endpoint**

Attribute or aspect of natural environment, human health, or resources identifying an environmental issue giving cause for concern.

***Characterization factor**

Factor derived from a characterization model which is used to convert an assigned life cycle inventory analysis result to the common unit of the category indicator.

NOTE: The common unit allows calculation of the category indicator result.

Characterization model

Mathematical model for defining characterization factors. These factors are then used to characterize the system inputs and outputs, *i.e.* converting the life cycle inventory results into impact indicators, based on the extent to which they contribute to the impacts modeled.

***Consistency check**

Process of verifying that the assumptions, methods and data are consistently applied throughout the study and are in accordance with the goal and scope definition performed before conclusions are reached. This approach also aims to compare the results from the AGRIBALYSE® program with the references in the bibliography.

***Co-product**

Any of two or more products coming from the same unit process or product system.

***Critical review**

Process intended to ensure consistency between a life cycle assessment and the principles and requirements of the international standards on life cycle assessment

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

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

***Cut-off criteria**

Specification of the amount of material or energy flow or the level of environmental significance associated with unit processes or product system to be excluded from a study.

Data collection guide

Guide (Biard *et al*, 2011a) drawn up for the AGRIBALYSE® program to describe how data should be collected, explain "good modeling practices" for the systems and ensure that the data sets could be compared.

Data collection module

The data collection module developed by AGRIBALYSE® is used to input the data for setting up the LCI data sets.

Data collection units

Units used to simplify data collection. They can also be used to express the reference flow.

Direct emissions (foreground)

Flows of potentially polluting substances to the environment, directly associated with livestock and arable/horticultural production on the production site considered.

Ecospold

XML data transfer format frequently used for life cycle data sets.

***Evaluation**

Element within the life cycle interpretation phase intended to establish confidence in the results of the life cycle assessment.

NOTE: Evaluation includes completeness check, sensitivity check, consistency check, and any other validation that may be required according to the goal and scope definition of the study.

Feed mix

Feed composed of several raw or processed materials, bought in or fabricated by the farmer and distributed to the animals. Six feed mixes can be defined for each class of animal.

Fertigation

A technique which couples irrigation (provision of water) with the application of soluble fertilizers.

***Functional unit**

Quantified performance of a product system for use as a reference unit.

***Impact category**

Class representing environmental issues of concern to which LCI results may be assigned.

***Impact category indicator**

Quantifiable representation of an impact category

IMPACTS® database

Public LCI database developed by ADEME in the form of system processes to provide data for environmental labeling of major food products. This database contains generic data.

Indirect emissions (background)

Flows of potentially polluting substances to the environment associated with the production of inputs used on the production site considered. These flows are proportional to the quantity of input used. These emissions are calculated based on background processes in the database.

***Input**

Product, material or energy flow that enters a unit process.

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

Intercropping period

Period between two main crops. It begins at the harvest of the previous crop and ends when the following crop is sown.

Intermediate crop

Catch crop grown to provide plant cover for a plot between crops. As intermediate crops are often not harvested, they have no economic role. In the AGRIBALYSE® program, an intermediate crop not grown for sale before the crop inventoried is included in the production system. When it is harvested or when it is grown for sale, it is considered as such and not as an intermediate crop.

Intermediate product

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

Inventory data processing system (IDPS)

Data processing system initially based on SALCA, a Swiss calculation tool and database for life cycle assessments, modified to meet the requirements of AGRIBALYSE® for calculating LCI data sets. It comprises:

- the data collection module (see elsewhere)
- the direct emissions calculation models
- the data conversion module for merging the results from the data collection module and direct emissions calculation models and adding the results of transport models for inputs

These modules operate in series to convert the data collected for the unit processes to ecospold format.

***Life cycle**

Consecutive and interlinked stages of a product system, from raw material acquisition to final disposal.

***Life Cycle Assessment (LCA)**

Compilation and assessment of inputs, inputs and possible environmental impacts of a product system during its life cycle.

***Life Cycle Impact Assessment (LCIA)**

Phase of life cycle assessment method aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system throughout its life cycle.

***Life cycle inventory analysis (LCI)**

Phase of life cycle assessment including the compilation and quantification of inputs and outputs for a product throughout its life cycle.

***Life cycle inventory analysis result**

Outcome of a life cycle inventory analysis that catalogues the flows crossing the system boundary and provides the starting point for life cycle impact assessment.

Life cycle inventory data set classification

The AGRIBALYSE® life cycle inventory datasets are classified according to their availability:

- Interne (Internal): unpublished confidential information
- AGRIBALYSE®: information in the AGRIBALYSE® database accessible to the public
- Affichage (Labeling): information made available for integration in the IMPACTS® database for environmental labeling

Livestock / arable or horticultural farm?

Type of farm dedicated to one type of production. For AGRIBALYSE®, a distinction was drawn between arable / horticultural farms and livestock farms. For livestock production, the farm does not refer to all farming activities for raising animals. The forage and feed produced on the farm, particularly for mixed arable/livestock farms, are not considered.

Median

The median is the value in a set of ordered values that separates the data set into two equal sized groups (each group contains 50% of the elements).

Metadata

Additional information on the data input.

National LCI data set

Inventory that is representative at national scale, inventory with national scope = “national inventory”. This representativeness was achieved by including farming practices for different production systems, either by entering data directly into a single data set, indicating the frequency of each production practice (using the “area concerned”) or by averaging several data sets.

Olympic average

The arithmetic mean of a list of values after removing the highest and lowest values.

Optimal matching

Optimal matching is a statistical method based on measuring the similarity or dissimilarity between sequences. It calculates the distances between the sequences and then classifies them into groups. This method can be used to construct classifications.

***Output**

Product, material or energy flow that leaves a unit process.

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

Phantom LCI data set

A life cycle data set that does not contain any inputs or outputs. It is an "aide-mémoire" to help to give a better understanding of mass and energy flows.

Foreground data

Data set data in publicly available databases that are included in AGRIBALYSE® data sets.

***Process**

Set of interrelated or interacting activities that transforms inputs into outputs.

***Product**

Any goods or service.

NOTE 1: The product can be categorized as follows:

- services (eg transport)
- software (eg computer program, dictionary)
- hardware (eg engine mechanical part)
- processed materials (eg lubricant)

NOTE 2: Services have tangible and intangible elements. Provision of a service can include, for example, the following:

- an activity performed on a customer-supplied tangible product (eg automobile to be repaired)
- an activity performed on a customer-supplied intangible product (eg the income statement needed to prepare a tax return)
- the delivery of an intangible product (eg the delivery of information in the context of knowledge transmission)
- the creation of ambience for the customer (eg in hotels and restaurants)

Software consists of information and is generally intangible and can be in the form of approaches, transactions or procedures.

Hardware is generally tangible and its amount is a countable quantity.

Processed materials are generally tangible and their amount is a continuous quantity.

Product variant

Special form of a production system which is distinguished by particular parameters (eg: production region, production system, etc). Products from several variants of a production system form a product group.

***Product flow**

Products entering from or leaving to another product system.

Product group

Group bringing together comparable products based on the concept of product variants.

*Product system

Collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product.

Production system

A production system is a combination of sequential, ordered farming techniques used on a plot which, by controlling the environment, achieves a given production goal, in quantity and quality (Sebillotte, 1974).

Proxy

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

Ration

The ration in AGRIBALYSE® denotes a feed regime (feed mix + basic fodder) for the animals in a class. Six types of ration can be defined for each class of animals. The composition of the ration is defined by selecting from the six feed mixes and all the types of basic fodder.

The sum of all the rations is the annual ration, i.e. all the feed distributed to this class of animal over one year.

*Reference flow

Measure of the outputs from processes in a given product system required to fulfill the function expressed by the functional unit.

Reference period

Period covered by life cycle inventories in terms of representativeness of data. It was defined as needing to be recent at the time data was collected (to that the LCI data sets represent current farming practices) and to cover several years (to prevent any bias in the results of the LCI data sets owing to an exceptional year). All the data collected for AGRIBALYSE® refers to this period (2005 – 2009).

Second grade product

Product that is damaged or does not conform to the commercial standard. These products are not necessary unsuitable for consumption and may be used for other outlets with lower added value.

Shrub

Ornamental woody plant in a container.

System boundary

Set of criteria specifying which unit processes are part of a product system. To ensure that different products can be compared, AGRIBALYSE® took particular care in defining the boundaries common to the system studied:

- The "cradle to gate" system boundaries were selected for plant production and up to the farm gate for livestock production.
- The assessment period for plant production systems was "harvest to harvest", with the exception of short cycle and permanent crops for which the period was from January 1st to December 31st. For livestock production, the period was from January 1st to December 31st.

System process

The system process is an abstract concept in LCA software. A system process contains the aggregated results from calculating the life cycle of a unit process. A system process is a black box.

Typical case

Description, using a set of technical and economic or environmental indicators of the coherent normal operation of a farm, for a given system and conditions. A typical case illustrated the operation and performance of a typical production system.

***Unit process**

Smallest element considered in the life cycle inventory analysis for which input and output data are quantified. When producing a LCA, the concept of "unit process" covers two situations:

- processes that are not really divisible from a technical / physical point of view
- divisible processes that are handled as "black box" (JRC and IES, 2010a).

***Waste**

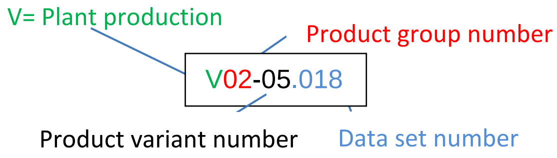
Substances or objects that the holder intends or is required to dispose of.

AGRIBALYSE: METHODOLOGY

APPENDICES

Appendices

Appendix A: Product groups and variants in the AGRIBALYSE program



PLANT PRODUCTION – FRANCE

Nb de groupe de produits : 22.
Nb de déclinaisions/produits : 63.
Nb totale des inventaires (y compris les inventaires internes et les phases de production) : 133.

Un astérisque indique que c'est un inventaire Phase de production

N°	Nom de l'inventaire (interne au programme)	Classement	Institut	English Name
V01-01.001*	Tomate, pépinière (phase), conventionnelle, en sol, sortie serre	interne (phase)	Ctifl	Tomato, seedling (phase), conventional, soil based production, at greenhouse
V01-01.002*	Tomate, culture (phase), conventionnelle, en sol, sous abri froid, sortie serre	interne (phase)	Ctifl	Tomato, cultivation (phase), conventional, soil based, non-heated greenhouse production, at greenhouse
V01-01.003	Tomate pour la consommation en frais, conventionnelle, sous abri froid, sortie serre	affichage	Ctifl	Tomato, conventional, soil based, non-heated greenhouse, at greenhouse
V01-02.004*	Tomate, pépinière (phase), conventionnelle, hors sol, sortie serre	interne (phase)	Ctifl	Tomato, seedling (phase), conventional, soilless production, at greenhouse
V01-02.005*	Tomate, culture (phase), conventionnelle, hors sol, sous abri chauffé, sortie serre	interne (phase)	Ctifl	Tomato, cultivation (phase), conventional, soilless, heated greenhouse production, at greenhouse
V01-02.006	Tomate pour la consommation en frais, conventionnelle, sous abri chauffé – Moyenne France	interne	Ctifl	Tomato, conventional, soilless, heated greenhouse production, at greenhouse
V01-02.007	Tomate pour la consommation en frais, conventionnelle, sous abri – Moyenne nationale (France), sortie serre	affichage	Ctifl	Tomato, conventional, greenhouse production, national average, at greenhouse
V01-03.008*	Tomate, pépinière (phase), biologique, en sol, sortie serre	interne (phase)	Ctifl	Tomato, seedling (phase), organic, soil based production, at greenhouse
V01-03.009*	Tomate, culture (phase), biologique, en sol, sous abri froid, sortie serre	interne (phase)	Ctifl	Tomato, cultivation (phase), organic, soil based, non-heated greenhouse production, at greenhouse
V01-03.010	Tomate pour la consommation en frais, biologique, sous abri – Moyenne nationale (France), sortie serre	affichage	Ctifl	Tomato, organic, greenhouse production, national average, at greenhouse
V01-04.011	Tomate pour la consommation en frais, sous abri – Moyenne nationale (France), sortie serre	affichage	Ctifl	Tomato, production mix, greenhouse production, national average, at greenhouse
V02-05.012	Carotte d'automne, conventionnelle, premier et deuxième choix, Val de Saire, sortie champ	interne	Ctifl	Carrot, fall, conventional, Val de Saire, at farm gate
V02-05.013	Carotte d'hiver, conventionnelle, premier et deuxième choix, Val de Saire, sortie champ	interne	Ctifl	Carrot, winter, conventional, Val de Saire, at farm gate

N°	Nom de l'inventaire (interne au programme)	Classement	Institut	English Name
V02-05.014	Carotte d'automne, conventionnelle, premier et deuxième choix, Mont St Michel, sortie champ	interne	Ctifl	Carrot, fall, conventional, Mont Saint-Michel, at farm gate
V02-05.015	Carotte d'hiver, conventionnelle, premier et deuxième choix, Mont St Michel, sortie champ	interne	Ctifl	Carrot, winter, conventional, Mont Saint-Michel, at farm gate
V02-05.016	Carotte d'automne, conventionnelle, premier et deuxième choix, Créances, sortie champ	interne	Ctifl	Carrot, fall, conventional, Créances, at farm gate
V02-05.017	Carotte d'hiver, conventionnelle, premier et deuxième choix, Créances, sortie champ	interne	Ctifl	Carrot, winter, conventional, Créances, at farm gate
V02-05.018	Carotte, conventionnelle, premier et deuxième choix – Moyenne Basse Normandie, sortie champ	interne	Ctifl	Carrot, conventional, Lower Normandy, at farm gate
V02-05.019	Carotte primeur, conventionnelle, premier et deuxième choix, Aquitaine, sortie champ	interne	Ctifl	Carrot, early, conventional, Aquitaine, at farm gate
V02-05.020	Carotte de saison, conventionnelle, premier et deuxième choix, Aquitaine, sortie champ	interne	Ctifl	Carrot, main season, conventional, Aquitaine, at farm gate
V02-05.021	Carotte d'hiver, conventionnelle, premier et deuxième choix, Aquitaine, sortie champ	interne	Ctifl	Carrot, winter, conventional, Aquitaine, at farm gate
V02-05.022	Carotte, conventionnelle, premier et deuxième choix – Moyenne Aquitaine, sortie champ	interne	Ctifl	Carrot, conventional, Aquitaine, at farm gate
V02-05.023	Carotte, conventionnelle, premier et deuxième choix – Moyenne nationale (France), sortie champ	affichage	Ctifl	Carrot, conventional, national average, at farm gate
V02-06.024	Carotte, biologique, premier et deuxième choix, Basse Normandie, sortie champ	affichage	Ctifl	Carrot, organic, Lower Normandy, at farm gate
V03-07.025*	Pêche, pépinière commune au conventionnel et au bio (phase), sortie pépinière	AGRIBALYSE	Ctifl	Peach, tree seedling, conventional and organic, at tree nursery
V03-07.026*	Pêche, conventionnelle, plantation, années sans production et arrachage (phase), en verger	AGRIBALYSE	Ctifl	Peach, plantation and destruction, conventional (phase), at orchard
V03-07.027*	Pêche, conventionnelle, début production (phase), en verger	AGRIBALYSE	Ctifl	Peach, first production years, conventional (phase), at orchard
V03-07.028*	Pêche, conventionnelle, pleine production (phase), en verger	AGRIBALYSE	Ctifl	Peach, full production years, conventional (phase), at orchard
V03-07.029	Pêche, conventionnelle – Moyenne nationale (France), sortie verger	affichage	Ctifl	Peach, conventional, national average, at orchard
V03-08.030*	Pêche, biologique, plantation, années sans production et arrachage (phase), en verger	AGRIBALYSE	Ctifl	Peach, plantation and destruction, organic (phase), at orchard
V03-08.031*	Pêche, biologique, début production (phase), en verger	AGRIBALYSE	Ctifl	Peach, first production years, organic (phase), at orchard
V03-08.032*	Pêche, biologique, pleine production (phase), en verger	AGRIBALYSE	Ctifl	Peach, full production years, organic (phase), at orchard
V03-08.033	Pêche, biologique – Moyenne nationale (France), sortie verger	affichage	Ctifl	Peach, organic, national average, at orchard
V03-09.034	Pêche, mix de production (conventionnelle et biologique) – Moyenne nationale (France), sortie verger	affichage	Ctifl	Peach, production mix, national average, at orchard
V04-10.035*	Pomme, pépinière commune au conventionnel et au bio (phase), sortie pépinière	AGRIBALYSE	Ctifl	Apple, tree seedling, production mix (phase), at tree nursery

N°	Nom de l'inventaire (interne au programme)	Classement	Institut	English Name
V04-10.036*	Pomme non tolérante à la tavelure, conventionnelle, plantation, années sans production et arrachage (phase), en verger	AGRIBALYSE	Ctifl	Apple non scab-resistent, plantation and destruction, conventional (phase), at orchard
V04-10.037*	Pomme non tolérante à la tavelure, conventionnelle, début production (phase), en verger	AGRIBALYSE	Ctifl	Apple non scab-resistent, first production years, conventional (phase), at orchard
V04-10.038*	Pomme non tolérante à la tavelure, conventionnelle, pleine production (phase), en verger	AGRIBALYSE	Ctifl	Apple non scab-resistent, full production years, conventional (phase), at orchard
V04-10.039	Pomme non tolérante à la tavelure, conventionnelle – Moyenne nationale (France), sortie verger	affichage	Ctifl	Apple non scab-resistent, conventional, national average, at orchard
V04-11.040*	Pomme tolérante à la tavelure, conventionnelle, plantation, années sans production et arrachage (phase), en verger	AGRIBALYSE	Ctifl	Apple scab-tolerant, plantation and destruction, conventional (phase), at orchard
V04-11.041*	Pomme tolérante à la tavelure, conventionnelle, début production (phase), en verger	AGRIBALYSE	Ctifl	Apple scab-tolerant, first production years, conventional (phase), at orchard
V04-11.042*	Pomme tolérante à la tavelure, conventionnelle, pleine production (phase), en verger	AGRIBALYSE	Ctifl	Apple scab-tolerant, full production years, conventional (phase), at orchard
V04-11.043	Pomme tolérante à la tavelure, conventionnelle – Moyenne nationale (France), sortie verger	affichage	Ctifl	Apple scab-tolerant, conventional, national average, at orchard
V04-11.044	Pomme de table, conventionnelle – Moyenne nationale (France), sortie verger	affichage	Ctifl	Apple, conventional, national average, at orchard
V04-12.045*	Pomme, biologique, plantation, années sans production et arrachage (phase), en verger	AGRIBALYSE	Ctifl	Apple, plantation and destruction, organic (phase), at orchard
V04-12.046*	Pomme, biologique, début production (phase), en verger	AGRIBALYSE	Ctifl	Apple, first production years, organic (phase), at orchard
V04-12.047*	Pomme, biologique, pleine production (phase), en verger	AGRIBALYSE	Ctifl	Apple, full production years, organic (phase), at orchard
V04-12.048	Pomme de table, biologique – Moyenne nationale (France), sortie verger	affichage	Ctifl	Apple, organic, national average, at orchard
V04-13.049	Pomme de table, mix de production (conventionnelle et biologique) – Moyenne nationale (France), sortie verger	affichage	Ctifl	Apple, production mix, national average, at orchard
V05-14.051	Colza, conventionnel, 9% humidité – Moyenne nationale (France), sortie champ	affichage	TERRES INOVIA	Rapeseed, conventional, 9% moisture, national average, at farm gate
V06-15.053	Tournesol, conventionnel, 9% humidité – Moyenne nationale (France), sortie champ	affichage	TERRES INOVIA	Sunflower, conventional, 9% moisture, national average, at farm gate
V07-16.054	Blé tendre conventionnel, panifiable, 15% humidité, sortie champ	AGRIBALYSE	Arvalis	Soft wheat grain, conventional, breadmaking quality, 15% moisture, at farm gate
V07-17.055	Blé tendre conventionnel, améliorant, 15% humidité, sortie champ	AGRIBALYSE	Arvalis	Soft wheat grain, conventional, protein improved quality, 15% moisture, at farm gate
V07-18.056	Blé tendre biologique de luzerne (cas type), région Centre, sortie champ	AGRIBALYSE	Arvalis	Soft wheat grain, organic (model type), after Alfalfa, Central Region, at farm gate
V07-19.057	Blé tendre biologique de féverole (cas type), région Centre, sortie champ	AGRIBALYSE	Arvalis	Soft wheat grain, organic (model type), after fava beans, Central Region, at farm gate

N°	Nom de l'inventaire (interne au programme)	Classement	Institut	English Name
V07-20.058	Blé tendre, conventionnel – Moyenne nationale (France), sortie champ	affichage	Arvalis	Soft wheat grain, conventional, national average, at farm gate
V08-21.059	Blé dur, conventionnel – Moyenne nationale (France), sortie champ	affichage	Arvalis	Durum wheat grain, conventional, national average, at farm gate
V09-22.060	Orge de brasserie, de printemps, conventionnelle, sortie champ	interne	Arvalis	Spring barley, conventional, malting quality, at farm gate
V09-22.061	Orge de brasserie, d'hiver, conventionnelle, sortie champ	interne	Arvalis	Winter barley, conventional, malting quality, at farm gate
V09-22.062	Orge de brasserie, conventionnelle – Moyenne nationale (France), sortie champ	affichage	Arvalis	Barley, conventional, malting quality, national average, at farm gate
V10-23.063	Pomme de terre de consommation destinée à l'industrie, conventionnelle, sortie champ	AGRIBALYSE	Arvalis	Ware potato, conventional, for industrial use, at farm gate
V10-24.064	Pomme de terre destinée au marché du frais, chair ferme, conventionnelle, sortie champ	AGRIBALYSE	Arvalis	Ware potato, conventional, for fresh market, firm flesh varieties, at farm gate
V10-25.065	Pomme de terre destinée au marché du frais, autres variétés, conventionnelle, sortie champ	AGRIBALYSE	Arvalis	Ware potato, conventional, for fresh market, other varieties, at farm gate
V10-26.066	Pomme de terre, conventionnelle, mix de variétés – Moyenne nationale (France), sortie champ	Affichage	Arvalis	Ware potato, conventional, variety mix, national average, at farm gate
V10-27.067	Pomme de terre fécule, conventionnelle – Moyenne nationale (France), sortie champ	Affichage	Arvalis	Starch potato, conventional, national average, at farm gate
V11-28.069	Maïs grain humide, conventionnel, 28% humidité – Moyenne nationale (France), sortie champ	affichage	Arvalis	Grain maize, conventional, 28% moisture, national average, at farm gate
V12-29.070	Maïs ensilage, conventionnel – Moyenne nationale (France), sortie champ	Affichage	Arvalis	Silage maize, conventional, national average, at farm gate
V13-30.071	Herbe pâturée, prairie permanente, sans trèfle, Auvergne, sur prairie	interne	Arvalis	Grazed grass, permanent meadow, without clover, Auvergne, on field
V13-30.072	Herbe conservée, enrubannage, prairie permanente, sans trèfle, Auvergne, sortie champ	interne	Arvalis	Baled grass, permanent meadow, without clover, Auvergne, at farm
V13-30.073	Herbe conservée, ensilage, prairie permanente, sans trèfle, Auvergne, sortie champ	interne	Arvalis	Grass silage, horizontal silo, permanent meadow, without clover, Auvergne, at farm
V13-30.074	Herbe conservée, foin, prairie permanente, sans trèfle, Auvergne, sortie champ	interne	Arvalis	Baled hay, permanent meadow, without clover, Auvergne, at farm
V13-30.075	Herbe pâturée, prairie permanente, sans trèfle, Nord-Ouest, sur prairie	interne	Arvalis	Grazed grass, permanent meadow, without clover, Northwestern region, on field
V13-31.076	Herbe conservée, enrubannage, prairie permanente, sans trèfle, Nord-Ouest, sortie champ	interne	Arvalis	Baled grass, permanent meadow, without clover, Northwestern region, at farm
V13-32.077	Herbe conservée, foin, prairie permanente, sans trèfle, Nord-Ouest, sortie champ	interne	Arvalis	Baled hay, permanent meadow, without clover, Northwestern region, at farm
V13-33.078	Herbe pâturée, prairie temporaire, sans trèfle, Nord-Ouest, sur prairie	interne	Arvalis	Grazed grass, temporary meadow, without clover, Northwestern region, on field

N°	Nom de l'inventaire (interne au programme)	Classement	Institut	English Name
V13-34.079	Herbe conservée, enrubannage, prairie temporaire, sans trèfle, Nord-Ouest, sortie champ	interne	Arvalis	Baled grass, temporary meadow, without clover, Northwestern region, at farm
V13-35.080	Herbe conservée, foin, prairie temporaire, sans trèfle, Nord-Ouest, sortie champ	interne	Arvalis	Baled hay, temporary meadow, without clover, Northwestern region, at farm
V13-36.081	Herbe pâturée, prairie permanente, avec trèfle, Nord-Ouest, sur prairie	interne	Arvalis	Grazed grass, permanent meadow, with clover, Northwestern region, on field
V13-37.082	Herbe conservée, enrubannage, prairie permanente, avec trèfle, Nord-Ouest, sortie champ	interne	Arvalis	Baled grass, permanent meadow, with clover, Northwestern region, at farm
V13-38.083	Herbe conservée, foin, prairie permanente, avec trèfle, Nord-Ouest, sortie champ	interne	Arvalis	Baled hay, permanent meadow, with clover, Northwestern region, at farm
V13-39.084	Herbe pâturée, prairie temporaire, avec trèfle, Nord-Ouest, sur prairie	interne	Arvalis	Grazed grass, temporary meadow, with clover, Northwestern region, on field
V13-40.085	Herbe conservée, enrubannage, prairie temporaire, avec trèfle, Nord-Ouest, sortie champ	interne	Arvalis	Baled grass, temporary meadow, with clover, Northwestern region, at farm
V13-41.086	Herbe conservée, ensilage, prairie temporaire, avec trèfle, Nord-Ouest, sortie champ	interne	Arvalis	Grass silage, horizontal silo, temporary meadow, with clover, Northwestern region, at farm
V13-42.087	Herbe conservée, foin, prairie temporaire, avec trèfle, Nord-Ouest, sortie champ	interne	Arvalis	Baled hay, temporary meadow, with clover, Northwestern region, at farm
V14-43.088	Luzerne, conventionnelle, pour la déshydratation, sortie champ	AGRIBALYSE	Arvalis	Alfalfa, conventional, for deshydration, at farm gate
V14-44.089	Luzerne, conventionnelle, pour l'alimentation animale (en exploitation avec élevage), sortie champ	AGRIBALYSE	Arvalis	Alfalfa, conventional, for animal feeding, at farm gate
V14-45.090	Luzerne, conventionnelle – Moyenne nationale (France), sortie champ	Affichage	Arvalis	Alfalfa, conventional, national average, at farm gate
V15-46.091	Triticale, conventionnelle – Moyenne nationale (France), sortie champ	affichage	Arvalis	Triticale grain, conventional, national average, at farm gate
V15-47.092	Triticale, biologique (cas type), région Centre, sortie champ	AGRIBALYSE	Arvalis	Triticale grain, organic (model type), Central region, at farm gate
V09-48.093	Orge de printemps, conventionnelle, déclassée, sortie champ	interne	Arvalis	Spring barley, conventional, downgraded quality, at farm gate
V09-48.094	Orge fourragère, d'hiver, conventionnelle, sortie champ	interne	Arvalis	Winter forage barley, conventional, at farm gate
V09-48.095	Orge fourragère, conventionnelle – Moyenne nationale (France), sortie champ	affichage	Arvalis	Forage barley, conventional, national average, at farm gate
V16-49.096	Betterave sucrière, conventionnelle, année de production 2005, sortie champ	interne	ITB	Sugar beet root, conventional, production year 2005, at farm gate
V16-49.097	Betterave sucrière, conventionnelle, année de production 2006, sortie champ	interne	ITB	Sugar beet root, conventional, production year 2006, at farm gate
V16-49.098	Betterave sucrière, conventionnelle, année de production 2007, sortie champ	interne	ITB	Sugar beet root, conventional, production year 2007, at farm gate
V16-49.099	Betterave sucrière, conventionnelle, année de production 2008, sortie champ	interne	ITB	Sugar beet root, conventional, production year 2008, at farm gate

N°	Nom de l'inventaire (interne au programme)	Classement	Institut	English Name
V16-49.100	Betterave sucrière, conventionnelle, année de production 2009, sortie champ	interne	ITB	Sugar beet root, conventional, production year 2009, at farm gate
V16-49.101	Betterave sucrière, conventionnelle – Moyenne nationale (France), sortie champ	affichage	ITB	Sugar beet roots, conventional, national average, at farm gate
V17-50.102*	Pomme à cidre, pépinière, conventionnelle sortie pépinière	AGRIBALYSE	Astredhor	Cider apple, tree seedling, conventional (phase), at tree nursery
V17-50.103*	Pomme à cidre, plantation et arrachage, conventionnelle (phase), sortie verger	AGRIBALYSE	Astredhor	Cider apple, plantation and destruction, conventional (phase), at orchard
V17-50.104*	Pomme à cidre, années sans production, conventionnelle (phase), sortie verger	AGRIBALYSE	Astredhor	Cider apple, period without yield, conventional (phase), at orchard
V17-50.105*	Pomme à cidre, années de basse production, conventionnelle (phase), sortie verger	AGRIBALYSE	Astredhor	Cider apple, low yield production period, conventional (phase), at orchard
V17-50.106*	Pomme à cidre, années de pleine production, conventionnelle (phase), sortie verger	AGRIBALYSE	Astredhor	Cider apple, full production period, conventional (phase), at orchard
V17-50.107	Pomme à cidre, conventionnelle – Moyenne nationale (France), sortie verger	affichage	Astredhor	Cider apple, conventional, national average, at orchard
V18-51.109	Rose fleur coupée hors sol, lutte intégrée et chauffage faible, sortie serre	AGRIBALYSE	Astredhor	Rose (cut flower), soilless, low-heated, integrated pest management, at greenhouse
V18-51.110	Rose fleur coupée hors sol, lutte intégrée, chauffée (et éclairée), sortie serre	AGRIBALYSE	Astredhor	Rose (cut flower), soilless, heated and enlighted, integrated pest management, at greenhouse
V18-51.111	Rose fleur coupée hors sol, lutte conventionnelle et chauffage faible, sortie serre	AGRIBALYSE	Astredhor	Rose (cut flower), soilless, low-heated, conventional pest management, at greenhouse
V18-51.112	Rose fleur coupée hors sol, lutte conventionnelle, chauffée (et éclairée), sortie serre	AGRIBALYSE	Astredhor	Rose (cut flower), soilless, heated and enlighted, conventional pest management, at greenhouse
V18-51.113	Rose fleur coupée hors sol, mix de production (lutte conventionnelle et intégrée) – Moyenne nationale (France), sortie serre	affichage	Astredhor	Rose (cut flower), production mix, national average, at greenhouse
V19-52.115*	Arbuste en conteneur, période de production à forte densité (phase), hivernage, sortie serre	AGRIBALYSE	Astredhor	Potted shrub, wintering (phase), in greenhouse, high density, at production site
V19-52.116*	Arbuste en conteneur, période de production à faible densité (phase), extérieur, sortie serre	AGRIBALYSE	Astredhor	Potted shrub, growing period (phase), outdoor phase, low density, at production site
V19-52.117	Arbuste en conteneur – Moyenne nationale (France), sortie serre	affichage	Astredhor	Potted shrub, national average, at production site
V20-63.128	Féverole, conventionnelle – Moyenne nationale (France), sortie champ	affichage	TERRES INOVIA	Faba beans, conventional, national average, at farm gate
V20-64.129	Féverole, de printemps, conventionnelle, en conduite allégée, sortie champ	AGRIBALYSE	TERRES INOVIA	Spring faba beans, conventional, reduced protection, at farm gate
V20-65.130	Féverole, biologique en culture pure (cas type), région Centre, sortie champ	AGRIBALYSE	TERRES INOVIA	Faba beans, organic (model type), Central Region, at farm gate
V21-66.131	Pois d'hiver, conventionnel, 15% humidité, sortie champ	AGRIBALYSE	TERRES INOVIA	Winter pea, conventional, 15% moisture, at farm gate

N°	Nom de l'inventaire (interne au programme)	Classement	Institut	English Name
V21-67.132	Pois de printemps, conventionnel, 15% humidité, sortie champ	AGRIBALYSE	TERRES INOVIA	Spring pea, conventional, 15% moisture, at farm gate
V21-68.133	Pois, moyenne nationale (identique avec pois de printemps, V25-67.132)	affichage	TERRES INOVIA	(identique avec spring pea)
V22-53-134*	Plants de vigne, pépinière production plants greffés soudés (phase), site expérimental tous cépages confondus, sortie champ	AGRIBALYSE	IFV	Grafted vine plant, nursery, production and varieties mix, at tree nursery
V22-53-135*	Plants de vigne, plantation/arrachage conventionnel en Beaujolais Sud (phase), tous vins confondus, sortie champ	AGRIBALYSE	IFV	Grafted vine, plantation/destruction (phase), conventional, variety mix, Beaujolais, at vineyard
V22-53-136*	Plants de vigne, plantation/arrachage conventionnel en Languedoc Roussillon (phase), tous vins confondus, sortie champ	AGRIBALYSE	IFV	Grafted vine, plantation/destruction (phase), conventional, variety mix, Languedoc-Roussillon, at vineyard
V22-53-137*	Raisin, début de production (phase), raisonnée, Beaujolais Sud, vin appellation Beaujolais, sortie champ	AGRIBALYSE	IFV	Grape, early production (phase), integrated, AOC, Beaujolais, at vineyard
V22-53-138*	Raisin, début de production (phase), raisonnée, Languedoc Roussillon, tous vins confondus, sortie champ	AGRIBALYSE	IFV	Grape, early production (phase), integrated, variety mix, Languedoc-Roussillon, at vineyard
V22-53-139*	Raisin, début de production (phase), biologique, Maconnais, vin appellation, sortie champ	AGRIBALYSE	IFV	Grape, early production (phase), organic, AOC, Maconnais, at vineyard
V22-53-140*	Raisin, début de production (phase), biologique, Languedoc Roussillon, tous vins confondus, sortie champ	AGRIBALYSE	IFV	Grape, early production (phase), organic, variety mix, Languedoc-Roussillon, at vineyard
V22-53-141*	Raisin, pleine production (phase), raisonnée, Beaujolais Sud, vin appellation Beaujolais, sortie champ	AGRIBALYSE	IFV	Grape, full production (phase), integrated, AOC, Beaujolais, at vineyard
V22-53-142*	Raisin, pleine production (phase), raisonnée, Languedoc Roussillon, tous vins confondus, sortie champ	AGRIBALYSE	IFV	Grape, full production (phase), integrated, variety mix, Languedoc-Roussillon, at vineyard
V22-53-143*	Raisin, pleine production, biologique (phase), Maconnais, vin appellation, sortie champ	AGRIBALYSE	IFV	Grape, full production (phase), organic, AOC, Maconnais, at vineyard
V22-53-144*	Raisin, pleine production (phase), biologique, Languedoc Roussillon, tous vins confondus, sortie champ	AGRIBALYSE	IFV	Grape, full production (phase), organic, variety mix, Languedoc-Roussillon, at vineyard
V22-53-145	Raisin vigne, raisonnée, Beaujolais Sud, vin appellation Beaujolais, sortie champ	AGRIBALYSE	IFV	Grape, integrated, AOC, Beaujolais, at vineyard
V22-53-146	Raisin vigne, raisonnée, Languedoc Roussillon, tous vins confondus, sortie champ	AGRIBALYSE	IFV	Grape, integrated, variety mix, Languedoc-Roussillon, at vineyard
V22-53-147	Raisin vigne, biologique, Maconnais, vin appellation, sortie champ	AGRIBALYSE	IFV	Grape, organic, AOC, Maconnais, at vineyard
V22-53-148	Raisin vigne, biologique, Languedoc Roussillon, tous vins confondus, sortie champ	AGRIBALYSE	IFV	Grape, organic, variety mix, Languedoc-Roussillon, at vineyard

Tropical Products

Nb de groupe de produits : 6
Nb Déclinaisons /produits : 6
Nb totale des inventaires (y inclus les inventaires internes et les phases) : 27

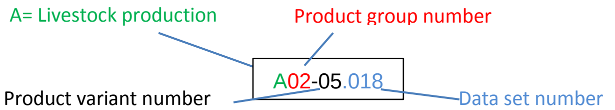
Un astérisque indique que c'est un inventaire Phase de production.

N°	Nom Produit (interne au programme)	Classement	Institut	English Name
T01-01.001	Riz jasmin, Nord-Est, système pluviale sans irrigation artificielle, sortie champ	interne	CIRAD	Jasmine rice, North East, Rainfed, Wet season, at farm gate
T01-01.002	Riz jasmin, Nord-Est, système pluviale avec irrigation artificielle, sortie champ	interne	CIRAD	Jasmine rice, North East, Irrigated, Wet season, at farm gate
T01-01.003	Riz jasmin, Nord-Est, système avec irrigation artificielle, sortie champ	interne	CIRAD	Jasmine rice, North East, Irrigated, Dry season, at farm gate
T01-01.004	Riz jasmin, Nord, système pluviale sans irrigation artificielle, sortie champ	interne	CIRAD	Jasmine rice, North, Rainfed, Wet season, at farm gate
T01-01.005	Riz jasmin, Nord, système pluviale avec irrigation artificielle, sortie champ	interne	CIRAD	Jasmine rice, North, Irrigated, Wet season, at farm gate
T01-01.006	Riz jasmin, Nord, système avec irrigation artificielle, sortie champ	interne	CIRAD	Jasmine rice, North, Irrigated, Dry season, at farm gate
T01-01.007	Riz Thaï (Riz jasmin), Moyenne nationale (Thaïlande), sortie champ	affichage	CIRAD	Jasmine rice, national average, at farm gate
T02-02.008*	Clémentine (Nour), pépinière (phase), Souss, sortie pépinière	interne (phase)	CIRAD	Clementine, tree seedling (phase), Souss, at tree nursery
T02-02.009*	Clémentine (Nour), période non productive (années 1 à 3) (phase), Souss, en verger	interne (phase)	CIRAD	Clementine, non productive period (phase), Souss, at orchard
T02-02.010*	Clémentine (Nour), début production (années 4 à 8) (phase), Souss, en verger	interne (phase)	CIRAD	Clementine, first production years (phase), Souss, at orchard
T02-02.011*	Clémentine (Nour), pleine production (années 9 à 25) (phase), Souss, en verger	interne (phase)	CIRAD	Clementine, full production period (phase), Souss, at orchard
T02-02.012	Clémentine (Nour), qualité export, Souss, sortie verger	affichage	CIRAD	Clementine, export quality, Souss, at orchard
T03-03.014*	Café (Robusta), plantation année 1 (phase), sortie champ	interne (phase)	CIRAD	Coffee bean (Robusta), first year, plantation (phase), Brazil, at farm gate
T03-03.015*	Café (Robusta), plantation année 2 (phase), sortie champ	interne (phase)	CIRAD	Coffee bean (Robusta), second year (phase), Brazil, at farm gate
T03-03.016*	Café (Robusta), plantation année 3 (phase), sortie champ	interne (phase)	CIRAD	Coffee bean (Robusta), third year (phase), Brazil, at farm gate
T03-03.017*	Café (Robusta), sans pulpe, plantation année 4-25 (phase), sortie champ	interne (phase)	CIRAD	Coffee bean (Robusta), depulped, full production period year (phase), Brazil, at farm gate
T03-03.018	Café du Brésil (Robusta), sans pulpe, Brésil, sortie champ	affichage	CIRAD	Coffee bean (Robusta), depulped, Brazil, at farm gate
T04-04.019*	Mangue, période non productive (années 1 à 3) (phase), en verger	interne (phase)	CIRAD	Mango, non productive period (phase), conventional, Brazil, at orchard
T04-04.020*	Mangue, début production (années 4 à 10) (phase), en verger	interne (phase)	CIRAD	Mango, first production years (phase), conventional, Brazil, at orchard

N°	Nom Produit (interne au programme)	Classement	Institut	English Name
T04-04.021*	Mangue, pleine production (années 11 à 25) (phase), en verger	interne (phase)	CIRAD	Mango, full production years (phase), conventional, Brazil, at orchard
T04-04.022	Mangue, conventionnelle, Val de San Francisco, Brésil, sortie verger	affichage	CIRAD	Mango, conventional, Val de San Francisco, Brazil, at orchard
T05-05.023*	Cacao pépinière (phase), Brésil, sortie pépinière	interne (phase)	CIRAD	Cocoa tree seedling (phase), Brazil, at tree nursery
T05-05.024*	Cacao, période non productive (phase), conventionnel, Cabruca, en verger	interne (phase)	CIRAD	Cocoa, non productive period (phase), conventional, Cabruca, at orchard
T05-05.025*	Cacao, pleine production (phase), conventionnel, Cabruca, en verger	interne (phase)	CIRAD	Cocoa, full production period years (phase), conventional, Cabruca, at orchard
T05-05.026	Cacao, conventionnel, Cabruca, sortie verger	affichage	CIRAD	Cocoa, conventional, Cabruca, at orchard
T06-06.027	Fruit du palmier à huile, conventionnel, Sumatra, , sortie plantation	affichage	CIRAD	Oil palm fruit, conventional, Sumatra, at farm gate

LIVESTOCK PRODUCTION – FRANCE

Number of product groups: **19**
Number of product variants: **48**



N°	Nom de l'inventaire	Classement	Institut	English Name
A101-101.101	Lait de vache, conventionnel, système spécialisé de plaine de l'ouest, maïs dominant (>30% maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Cow milk, conventional, lowland milk system, silage maize more than 30%, at farm gate
A101-102.102	Lait de vache, conventionnel, système spécialisé de plaine de l'ouest, herbe - maïs (10-30% de maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Cow milk, conventional, lowland milk system, silage maize 10 to 30%, at farm gate
A101-103.103	Lait de vache, conventionnel, système spécialisé de plaine, herbe (5 à 10% maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Cow milk, conventional, lowland milk system, silage maize 5 to 10%, at farm gate
A101-104.104	Lait de vache, biologique, système spécialisé de plaine de l'ouest, herbe (5 à 10% maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Cow milk, organic, lowland milk system, silage maize 5 to 10%, at farm gate
A101-105.105	Lait de vache, conventionnel, système spécialisé de montagne, Massif Central, herbe, sortie atelier	AGRIBALYSE	IDELE	Cow milk, conventional, highland milk system, grass fed, at farm gate
A101-xxx.106	Lait de vache, Moyenne nationale (France), sortie atelier	Affichage	IDELE	Cow milk, national average, at farm gate
A102-101.107	Vache laitière de réforme, conventionnel, système spécialisé de plaine de l'ouest, maïs dominant (>30% maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Cull cow, conventional, lowland milk system, silage maize more than 30%, at farm gate
A102-102.108	Vache laitière de réforme, conventionnel, système spécialisé de plaine de l'ouest, herbe - maïs (10-30% de maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Cull cow, conventional, lowland milk system, silage maize 10 to 30%, at farm gate
A102-103.109	Vache laitière de réforme, conventionnel, système spécialisé de plaine, herbe (5 à 10% maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Cull cow, conventional, lowland milk system, silage maize 5 to 10%, at farm gate
A102-104.110	Vache laitière de réforme, biologique, spécialisé de plaine de l'ouest, herbe (5 à 10% maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Cull cow, organic, lowland milk system, silage maize 5 to 10%, at farm gate
A102-105.111	Vache laitière de réforme, conventionnel, système spécialisé de montagne, Massif Central, herbe, sortie atelier	AGRIBALYSE	IDELE	Cull cow, conventional, highland milk system, grass fed, at farm gate
A102-106.112	Taurillon laitier, conventionnel, engraisseur spécialisé de taurillons laitiers, sortie atelier	AGRIBALYSE	IDELE	Young dairy bull, conventional, fattening system, at farm gate
A102-107.113	Vache de réforme d'origine allaitante, conventionnel, naisseur spécialisé, système charolais < 1,2 UGB/ha, sortie atelier	AGRIBALYSE	IDELE	Suckler cull cow, conventional, suckler cow system, less than 1.2 LU per ha, at farm gate

A102-108.114	Génisse race à viande, conventionnel, engraisseur de bœufs ou génisses de race à viande recevant des broutards issus du système naisseur charolais ≥ 1,2 UGB/ha, sortie atelier	AGRIBALYSE	IDELE	Suckler heifer, conventional, fattening system, more than 1.2 LU per ha, at farm gate
A102-109.115	Taurillon race à viande, conventionnel, engraisseur recevant des broutards issus du système naisseur charolais ≥ 1,2 UGB/ha, sortie atelier	AGRIBALYSE	IDELE	Young suckler bull, conventional, fattening system, more than 1.2 LU per ha, at farm gate
A102-110.116	Vache de réforme d'origine allaitante, conventionnel, naisseur spécialisé, système charolais ≥ 1,2 UGB/ha, sortie atelier	AGRIBALYSE	IDELE	Suckler cull cow, conventional, suckler cow system, more than 1.2 LU per ha, at farm gate
A102-111.117	Taurillon race à viande, conventionnel, engraisseur spécialisé recevant des broutards issus du système naisseur charolais < 1,2 UGB/ha, sortie atelier	AGRIBALYSE	IDELE	Young suckler bull, conventional, fattening system, less than 1.2 LU per ha, at farm gate
A102-xxx.118	Bovin viande, Moyenne nationale (France), sortie atelier	Affichage	IDELE	Beef cattle, national average, at farm gate
A103-112.119	Veau de boucherie, conventionnel, atelier d'engraissement recevant des veaux de 8 jours issus de systèmes laitiers de plaine, sortie atelier	Affichage	IDELE	Beef calf, conventional, fattening system, calves from lowland milk system, at farm gate
A104-113.120	Lait de brebis, conventionnel, système Roquefort, sortie atelier	AGRIBALYSE	IDELE	Sheep milk, conventional, Roquefort system, at farm gate
A105-114.121	Lait de chèvre, conventionnel, système zone fourragère intensive, centre ouest, sortie atelier	AGRIBALYSE	IDELE	Goat milk, conventional, intensive forage area, at farm gate
A106-115.122	Agneau, conventionnel, système spécialisé bergerie, sortie atelier	Affichage	IDELE	Lamb, conventional, indoor production system, at farm gate
A107-116.123	Œuf, biologique, sortie atelier (Bretagne)	AGRIBALYSE	ITAVI	Egg, organic, at farm gate
A107-117.124	Œuf, conventionnel, plein air, sortie atelier (Pays de la Loire, Sarthe)	AGRIBALYSE	ITAVI	Egg, conventional, outdoor system, at farm gate
A107-118.125	Œuf, conventionnel, en bâtiment, au sol, sortie atelier (Bretagne)	AGRIBALYSE	ITAVI	Egg, conventional, indoor system, non-cage, at farm gate
A107-119.126	Œuf, conventionnel, en bâtiment, en cage, sortie atelier (Bretagne, Côtes d'Armor)	AGRIBALYSE	ITAVI	Egg, conventional, indoor system, cage, at farm gate
A107-120.127	Œuf, conventionnel, en bâtiment, en cage, réglementation 2012, sortie atelier (Bretagne, Côtes d'Armor)	AGRIBALYSE	ITAVI	Egg, conventional, indoor production, cage 2012 rules, at farm gate
A107-xxx.128	Œuf, Moyenne nationale (France), sortie atelier	Affichage	ITAVI	Egg, national average, at farm gate
A108-121.129	Poulet de chair, conventionnel, sortie atelier	AGRIBALYSE	ITAVI	Broiler, conventional, at farm gate
A108-122.130	Poulet de chair, Label rouge, sortie atelier	AGRIBALYSE	ITAVI	Broiler, Label Rouge, at farm gate
A108-123.131	Poulet de chair, biologique, sortie atelier	AGRIBALYSE	ITAVI	Broiler, organic, at farm gate
A108-xxx.132	Poulet de chair, Moyenne nationale (France), sortie atelier	Affichage	ITAVI	Broiler, national average, at farm gate
A109-124.133	Dinde, conventionnel, sortie atelier (Bretagne, Morbihan)	AGRIBALYSE	ITAVI	Turkey, conventional, at farm gate

A109-125.134	Dinde, Label rouge, sortie atelier (Bretagne, Morbihan)	AGRIBALYSE	ITAVI	Turkey, Label Rouge, at farm gate
A109-xxx.135	Dinde, Moyenne nationale (France), sortie atelier	Affichage	ITAVI	Turkey, national average, at farm gate
A110-126.136	Palmipède gras , canard à gaver, conventionnel, sortie atelier (Aquitaine, Landes)	Affichage	ITAVI	Fattening duck, conventional, at farm gate
A111-127.137	Canard à rôtir, conventionnel (sur caillebotis), sortie atelier (Pays de la Loire, Vendée)	Affichage	ITAVI	Duck for roasting, conventional, at farm gate
A112-128.138	Truite portion, 250-350g, convenntionel, sortie atelier	Affichage	ITAVI	Small trout, 250-350g, conventional, at farm gate
A113-129.139	Grande truite, 2 à 4kg, conventionnel, sortie atelier	Affichage	ITAVI	Large trout, 2-4kg, conventional, at farm gate
A114-130.140	Bar ou dorade, 200 à 500g, conventionnel, en cage, sortie atelier (méditerranée)	Affichage	ITAVI	Sea bass or sea bream, 200-500g, conventional, in cage, at farm gate
A115-131.141	Lapin, conventionnel, en cage, sortie atelier (Pays de la Loire, Vendée)	Affichage	ITAVI	Rabbit, conventional, in cage, at farm gate
A116-132.142	Porc, conventionnel, alimentation à dominante colza, sortie atelier	AGRIBALYSE	IFIP	Pig, conventional, fed rapeseed meal, at farm gate
A116-133.143	Porc, conventionnel, alimentation à dominante soja, sortie atelier	AGRIBALYSE	IFIP	Pig, conventional, fed soybean meal, at farm gate
A116-134.144	Porc, conventionnel, d'exploitation céréales/porcs en approvisionnement local, sortie atelier (Pays de la Loire)	AGRIBALYSE	IFIP	Pig, conventional, on-farm feed supply, at farm gate
A116-135.145	Porc, conventionnel, standard d'élevage spécialisé avec traitement biologique des effluents - 100% achat, sortie atelier	AGRIBALYSE	IFIP	Pig, conventional, excess slurry treatment, at farm gate
A116-136.146	Porc, conventionnel, Moyenne nationale (France), sortie atelier	Affichage	IFIP	Pig, conventional, national average, at farm gate
A117-137.147	Porc, Label Rouge, bâtiment courette, sortie atelier	Affichage	IFIP	Pig, Label Rouge, pig with run system, at farm gate
A117-138.148	Porc, Label Rouge, plein air, sortie atelier	Affichage	IFIP	Pig, Label Rouge, outdoor system, at farm gate
A118-139.149	Porc, biologique, sortie atelier	Affichage	IFIP	Pig, organic, at farm gate
Axxx-101.150	Veau, conventionnel, système spécialisé de plaine de l'ouest, maïs dominant (>30% maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Calf, conventional, lowland milk system, silage maize more than 30%, at farm gate
Axxx-102.151	Veau, conventionnel, système spécialisé de plaine de l'ouest, herbe - maïs (10-30% de maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Calf, conventional, lowland milk system, silage maize 10 to 30%, at farm gate
Axxx-103.152	Veau, conventionnel, système spécialisé de plaine, herbe (5 à 10% maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Calf, conventional, lowland milk system, silage maize 5 to 10%, at farm gate
Axxx-104.153	Veau, biologique, système spécialisé de plaine de l'ouest, herbe (5 à 10% maïs / SFP), sortie atelier	AGRIBALYSE	IDELE	Calf, organic, lowland milk system, silage maize 5 to 10%, at farm gate
Axxx-105.154	Veau, conventionnel, système spécialisé de montagne, herbe, Massif Central, sortie atelier	AGRIBALYSE	IDELE	Calf, conventional, highland milk system, grass fed, at farm gate

Axxx-107.154	Broutard, conventionnel, naisseur spécialisé, système charolais < 1,2 UGB/ha, sortie atelier	AGRIBALYSE	IDELE	Cattle weaner, conventional, suckler cow system, less than 1.2 LU per ha, at farm gate
Axxx-110.156	Broutard, conventionnel, naisseur spécialisé, système charolais ≥ 1,2 UGB/ha, sortie atelier	AGRIBALYSE	IDELE	Cattle weaner, conventional, suckler cow system, more than 1.2 LU per ha, at farm gate
Axxx-113.157	Brebis laitière de réforme, conventionnel, système Roquefort, sortie atelier	Affichage	IDELE	Cull ewe, conventional, Roquefort system, at farm gate
Axxx-113.158	Agneau, conventionnel, système Roquefort, sortie atelier	Affichage	IDELE	Lamb, conventional, Roquefort system, at farm gate
Axxx-113.159	Laine, conventionnel, système Roquefort, sortie atelier	Affichage	IDELE	Wool, conventional, Roquefort system, at farm gate
Axxx-114.160	Chèvre de réforme, conventionnel, système zone fourragère intensive, centre ouest, sortie atelier	AGRIBALYSE	IDELE	Cull goat, conventional, intensive forage area, at farm gate
Axxx-114.161	Chevreau, conventionnel, système zone fourragère intensive, centre ouest, sortie atelier	Affichage	IDELE	Kid goat, conventional, intensive forage area, at farm gate
Axxx-115.162	Brebis allaitante de réforme, conventionnel, système spécialisé bergerie, sortie atelier	AGRIBALYSE	IDELE	Cull ewe, conventional, indoor production system, at farm gate
Axxx-115.163	Laine, conventionnel, système spécialisé bergerie, sortie atelier	AGRIBALYSE	IDELE	Wool, conventional, indoor production system, at farm gate
Axxx-116.164	Poule de réforme, biologique, sortie atelier (Bretagne)	AGRIBALYSE	ITAVI	Cull hen, organic, at farm gate
Axxx-117.165	Poule de réforme, conventionnel, plein air, sortie atelier (Pays de la Loire, Sarthe)	AGRIBALYSE	ITAVI	Cull hen, conventional, outdoor system, at farm gate
Axxx-118.166	Poule de réforme, conventionnel, en bâtiment, au sol, sortie atelier (Bretagne)	AGRIBALYSE	ITAVI	Cull hen, conventional, indoor system, non-cage, at farm gate
Axxx-119.167	Poule de réforme, conventionnel, en bâtiment, en cage, sortie atelier (Bretagne, Côtes d'Armor)	AGRIBALYSE	ITAVI	Cull hen, conventional, indoor system, cage, at farm gate
Axxx-120.168	Poule de réforme, conventionnel, en bâtiment, en cage, réglementation 2012, sortie atelier (Bretagne, Côtes d'Armor)	AGRIBALYSE	ITAVI	Cull hen, conventional, indoor production, cage 2012 rules, at farm gate
Axxx-xxx.169	Poule de reforme, Moyenne nationale (France), sortie atelier	Affichage	ITAVI	Cull hen, conventional, national average, at farm gate
Axxx-131.170	Lapine de reforme, conventionnel, en cage, sortie atelier	Affichage	ITAVI	Cull rabbit, conventional, in cage, at farm gate
Axxx-132.171	Truie de reforme, conventionnel, alimentation à dominante colza, sortie atelier	AGRIBALYSE	IFIP	Cull sow, conventional, fed rapeseed meal, at farm gate
Axxx-133.172	Truie de reforme, conventionnel, alimentation à dominante soja, sortie atelier	AGRIBALYSE	IFIP	Cull sow, conventional, fed soybean meal, at farm gate
Axxx-134.173	Truie de reforme, conventionnel, d'exploitation céréales/truies en approvisionnement local, sortie atelier (Pays de la Loire)	AGRIBALYSE	IFIP	Cull sow, conventional, on-farm feed supply, at farm gate
Axxx-135.174	Truie de réforme, conventionnel, standard d'élevage spécialisé avec traitement biologique des effluents - 100% achat, sortie atelier	AGRIBALYSE	IFIP	Cull sow, conventional, excess slurry treatment, at farm gate

Axxx-136.175	Truie de reforme, conventionnel, Moyenne nationale (France), sortie atelier	Affichage	IFIP	Cull sow, conventional, national average, at farm gate
Axxx-137.176	Truie de réforme, Label Rouge, bâtiment courette, sortie atelier	Affichage	IFIP	Cull sow, Label Rouge, pig with run system, at farm gate
Axxx-138.177	Truie de reforme, Label rouge, plein air, sortie atelier	Affichage	IFIP	Cull sow, Label Rouge, outdoor system, at farm gate
Axxx-139.178	Truie de reforme, biologique, sortie atelier	Affichage	IFIP	Cull sow, organic, at farm gate

Appendix B: Calculating national LCI data sets (French average)

Plant production

1. Carrot, conventional – French Average

Table 38: Composition of the national conventional carrot data set

Data set	Weighting in the national LCI data set (%)
Carrot, early, conventional, Aquitaine	27.4
Carrot, main season, conventional, Aquitaine	25.2
Carrot, winter, conventional, Aquitaine	15.4
Carrot, fall, conventional, Créances	7.7
Carrot, winter, conventional, , Créances	11.6
Carrot, fall, conventional, Val de Saire	1.8
Carrot, winter, conventional, Val de Saire	4.1
Carrot, fall, conventional, Mont St Michel	5.4
Carrot, winter, conventional, Mont St Michel	1.4

Data based on expert opinion when collecting data for the carrot data sets for the AGRIBALYSE program. The "Conventional carrot French average for sale as fresh produce" is the weighted mean of the basic data sets listed above. These nine regional data sets are classified "interne" and are not published in the AGRIBALYSE database.

2. Alfalfa, conventional – French Average

Table 39: Composition of the national conventional alfalfa data set

Data set	Weighting in the national LCI data set (%)
Alfalfa for dehydration	33
Alfalfa for animal feeding	77

Data based on expert opinion when collecting data for the alfalfa data sets for the AGRIBALYSE program. The "Conventional alfalfa French average" is the weighted mean of the two basic data sets listed above.

3. Conventional barley, malting quality – French Average

Table 40: Composition of the national data set for malting quality barley

Data set	Weighting in the national LCI data set (%)
Spring barley, conventional, malting quality	54
Winter barley, conventional, malting quality	46

Data based on expert opinion when collecting data for the barley data sets for the AGRIBALYSE program. The "Conventional malting quality barley French average" is the weighted mean of the two basic data sets listed above. These two data sets are classified "interne" and are not published in the AGRIBALYSE database.

4. **Forage barley, conventional – French Average**

Table 41: Composition of the national forage barley dataset

Data set	Weighting in the national LCI data set (%)
Spring barley, conventional, downgraded quality	15
Winter forage barley, conventional	66
Winter barley, conventional, malting quality	19

Data based on expert opinion when collecting data for the barley data sets for the AGRIBALYSE program. The "Conventional forage barley French Average" data set is the weighted mean of the basic data sets listed above. These nine regional data sets are classified "interne" and are not published in the AGRIBALYSE database.

5. **Peaches/nectarines – French average**

Table 42: Composition of the national peach/nectarine data set

Data set	Weighting in the national LCI data set (%)
Peach/nectarine, conventional – French average	98.5
Peach/nectarine, organic – French average	1.5

Data based on expert opinion when collecting data for the peach/nectarine data sets for the AGRIBALYSE program. The "Peach/nectarine French average" data set is the weighted mean of the basic data sets listed above. The two data sets are based on several growth phase data sets which are published in the AGRIBALYSE database.

6. **Eating apples, conventional – French average**

Table 43: Composition of the national conventional eating apple data set (scab-resistant and non scab-resistant varieties)

Data set	Weighting in the national LCI data set (%)
Apple non-scab resistant, conventional – French average	90
Apple scab resistant, conventional – French average	10

Data based on expert opinion when collecting data for the apple data sets for the AGRIBALYSE program. The "Conventional eating apple French average" data set is the weighted mean of the two basic data sets listed above. The two data sets are based on several growth phase data sets which are published in the AGRIBALYSE database.

7. Eating apples – French average

Table 44: Composition of the national eating apple data set

Data set	Weighting in the national LCI data set (%)
Eating apple, conventional – French average	98.5
Eating apple, organic – French average	1.5

Data based on expert opinion when collecting data for the apple data sets for the AGRIBALYSE program. The Eating apple French average data set data set is the weighted mean of the two basic data sets listed above.

8. Potato, conventional – French average

Table 45: Composition of the national potato dataset

Data set	Weighting in the national LCI data set (%)
Starch potato, conventional – French average	20
Potato for industrial use, conventional	28
Potato for fresh market, other varieties, conventional	52

Data based on expert opinion when collecting data for the potato data sets for the AGRIBALYSE program. The Potato French average data set is the weighted mean of the basic data sets listed above.

9. Rose (cut flower), soilless – French average

Table 46: Composition of the national rose (cut flower) soilless data set

Data set	Weighting in the national LCI data set (%)
Rose (cut flower) soilless, integrated pest management with low heating	12
Rose (cut flower) soilless, integrated pest management, with heating and lighting	53
Rose (cut flower) soilless, conventional pest management, with low heating	19
Rose (cut flower) soilless, conventional pest management, with heating and lighting	16

Data based on expert opinion when collecting data for the rose data sets for the AGRIBALYSE program. The Rose (cut flower) soilless, French average data set is the weighted mean of the basic data sets listed above.

10. Thai rice (Jasmine rice) – Thai average

Table 47: Composition of the national Thai rice data set

Data set	Weighting in the national LCI data set (%)
Thai rice (jasmine rice) North East, Rainfed, Wet Season	66.2
Thai rice (jasmine rice) North East, Irrigated, Wet Season	11.8
Thai rice (jasmine rice) North East, Irrigated, Dry Season	5.9

Thai rice (jasmine rice) North, Rainfed, Wet Season	1.9
Thai rice (jasmine rice) North, Irrigated, Wet Season	7.1
Thai rice (jasmine rice) North, Irrigated, Dry Season	7.1

Data from the national Thai rice production statistics. The "Thai rice, Thai average" data set is the weighted mean of the basic data sets listed above. These seven regional data sets are classified "interne" and are not published in the AGRIBALYSE database.

11. Tomato for the fresh market, conventional, greenhouse production – French average

Table 48: Composition of the national conventional tomato greenhouse production for the fresh market data set

Data set	Weighting in the national LCI data set (%)
Tomato for the fresh market, conventional, unheated greenhouse production - French average	13.7
Tomato for the fresh market, conventional, heated greenhouse production– French average	86.3

Data based on expert opinion when collecting data for the tomato data sets for the AGRIBALYSE program. The Tomato **for the fresh market,** conventional, greenhouse production data set is the weighted mean of the two basic data sets listed above. As the "Tomato, conventional, French average, heated greenhouse production" data set is classified "interne" it is not published in the AGRIBALYSE database.

12. Tomato for the fresh market, greenhouse production – French average

Table 49: Composition of the national tomato for the fresh market data set

Data set	Weighting in the national LCI data set (%)
Tomato for the fresh market, conventional, unheated greenhouse production - French average	13,5
Tomato for the fresh market, conventional, heated greenhouse production - French average	85
Tomato for the fresh market, organic, greenhouse production - French average	1,5

Data based on expert opinion while collecting data for the tomato data sets for the AGRIBALYSE program. The "Tomato **for the fresh market** French average" data set is the weighted mean of the basic data sets listed above. As the "Tomato conventional French average heated greenhouse production" data set is classified "interne" it is not published in the AGRIBALYSE database.

13. Sugar beet, conventional – French average

Table 50: Composition of the national conventional sugar beet data set

Data set	Weighting in the national LCI data set (%)
Sugar beet, conventional, production year 2005	20
Sugar beet, conventional, production 2006	20
Sugar beet, conventional, production 2007	20

Sugar beet, conventional, production 2008	20
Sugar beet, conventional, production 2009	20

Data based on national statistics (Agreste 2009). The “Sugar beet conventional French average” data set is the weighted mean of the basic data sets listed above. These five data sets are classified “interne” and are not published in the AGRIBALYSE database;

Livestock production

Table 51: Composition of the national cow's milk LCI data set

AGRIBALYSE Classification		Study by the Institut de l'Elevage Observatoire de l'Alimentation des Vaches Laitières, 2011						% of the AGRIBALYSE milk average
Data set	Classification	System N°	System name	Number of farms	Standard quantity of milk / farm	Total qty of system = number of farms x Qty milk per farm	% of total national production	
Cow's milk, conventional, lowland milk system, maize dominant (maize more than 30%), at farm gate	AGRIBALYSE	2	Specialist lowland > 30% w	9226	307 983	2 841 451 158	12.3%	**58.2%**
Cow's milk, conventional, lowland milk system, grass- maize (maize 10 to 30%), at farm gate	AGRIBALYSE	4	Specialist lowland 10-30% w	3536	251 236	888 370 496	3.8%	**18.2%**
Cow's milk, conventional, lowland milk system, silage maize 5 to 10%, at farm gate	AGRIBALYSE	5	Specialist lowland <10%	2615	200 801	525 094 615	2.3%	**10.8%**
Cow's milk, organic, lowland milk system, silage maize 5 to 10% , at farm gate	AGRIBALYSE							
Cow's milk, conventional, highland milk system, Massif Central, grass fed, at farm gate	AGRIBALYSE	8	Mountain grass – Massif Central	4003	156 694	627 246 082	2.7%	**12.8%**
Cow's milk, French average, at farm gate	Affichage (labeling)	TOTAL					21.1%	**100.0%**

Table 52: Composition of national beef cattle LCI data set

AGRIBALYSE Classification		Description	Proportion of meat production in France (large cattle)		% of AGRIBALYSE beef average
Data set	Classification		Key figures for 2010–Institut de l'Elevage, GEB	Extrapolation	
Cull cow, conventional, lowland milk system, silage maize more than 30% at farm gate	AGRIBALYSE	Cow - dairy	26%	26%*58,2% =15.132	**16.81%**
Cull cow, conventional, lowland milk system, silage maize 10-30% at farm gate	AGRIBALYSE			26%*18.2% =4.732%	**5.25%**
Cull cow, conventional and organic, lowland milk system, grass, at farm gate	AGRIBALYSE			26%*10.8% = 2.808%	**3.12%**
Cull cow, conventional , highland milk system, Massif Central, grass, at farm gate	AGRIBALYSE			26%*12.8%= 3.328%	**3.69%**
Young dairy bull, conventional, fattening system, at farm gate	AGRIBALYSE	Young bull - dairy	8%	8%	**8.88%**
Suckler cull cow, conventional, suckler cow system, less than 1.2 LU/ha, at farm gate	AGRIBALYSE	Cow - suckler	22%	22%*50% = 11%	**12.22%**
Suckler cull cow, conventional, suckler cow system, more than 1.2 LU/ha, at farm gate	AGRIBALYSE			22%*50% = 11%	**12.22%**
Suckler heifer, conventional, fattening system. more than 1.2 LU/ha, at farm gate	AGRIBALYSE	Heifer - suckler	10%	10%	**11.11%**
Young suckler bull, conventional, fattening system, more than 1.2 LU/ha, at farm gate	AGRIBALYSE	Young bull - suckler	24%	24%*50% = 12%	**13.33%**
Young suckler bull, conventional, fattening system, less than 1.2 LU/ha, at farm gate	AGRIBALYSE			24%*50% = 12%	**13.33%**
Beef cattle, French average, at farm gate	affichage			90%	**100%**

Table 53: Composition of national average egg LCI data set

Data set	Weighting in the national LCI data set (%)
Eggs, indoor system, cage	83
Eggs, indoor system, non cage	4.5
Eggs, outdoor system	9.5
Eggs, organic	3

Data taken from the AGRESTE poultry survey (2008).
The “Egg French average” data set is the weighted mean of the basic data sets listed above.

Table 54: Composition of the national average broiler data set

Data set	Weighting in the national LCI data set (%)
Broiler, conventional	87.5
Broiler, Label Rouge	12
Broiler, organic	0.5

Data taken from the AGRESTE poultry survey (2008).
The “Broiler French average” data set is the weighted mean of the basic data sets listed above.

Table 55: Composition of the national average turkey data set

Data set	Weighting in the national LCI data set (%)
Turkey, conventional	97
Turkey, Label Rouge	3

Data taken from the AGRESTE poultry survey AGRESTE (2008).
The “Turkey French average” data set is the weighted mean of the basic data sets listed above.

Appendix C: Specification for quality control of production system data collected for the AGRIBALYSE program

AGRIBALYSE

June 2011

Quality control of French production system data Specification

For AGRIBALYSE quality control experts

Authors

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AGRIBALYSE Program

Specification: Quality control of French production system data

Version 4, June 2011

1 Introduction – Purpose of the specification

This specification is intended to provide answers to questions on the methodology and practices that might be raised by the experts selected for the quality control phase of the data collected for the production systems describing the farming production processed in the AGRIBALYSE program. Its aim is to: i) help the experts carry out their quality control brief and ii) harmonize the data quality assessments produced by the various experts.

To achieve these aims, this specification defines:

- The scope of the data subject to quality control
- The assessment methods

Partners of the AGRIBALYSE program

2 Presentation of the quality control procedure for the AGRIBALYSE program

The credibility of the database built for the AGRIBALYSE program relies on strict quality control. There are three stages in the quality control process:

1. Verification, by the project leaders, of the data and information entered by the Technical Institutes
2. Quality control of the data describing the production systems of the French production process, carried out by organizations external to the program
3. Quality control of the LCI and LCIA results, undertaken by the Technical Institutes supporting the program

A working seminar will be organized at the end of the second and third phases. This document concerns the second quality control phase. This phase is divided into two stages. The first stage is quality control by the experts and the second stage is the assessment of their comments on checking the data at seminar N°3 (February 2012). This seminar will decide what action, if any, should be taken on the comments from the experts. The experts are invited to attend the seminar but this is not compulsory.

3 Quality control framework

For the AGRIBALYSE program, it was decided that each expert should check a group of similar agricultural production processes (eg all oleaginous plants), depending on his field of competence.

3.1 Scope of quality control

Comment

The AGRIBALYSE program was set up to build a database of LCI datasets for French agricultural production. The data was, therefore, collected for “French average” production, in most cases. One of the aims of the program is to ensure that the various products were handled uniformly.

These two requirements require a strict definition of the methodology to be used (system boundaries, functional units, allocation, etc.).

The quality control required here does not cover the methodological choices. Experts are required to check:

a) Compliance with the main recommendations defined in the Data Collection Guide for the AGRIBALYSE program
b) Data for French production systems

As most of the data is for “French average” production systems, experts are not required to give their opinion on the precision of the data entered for particular situations. They are asked to give their opinion on the **plausibility** of the data entered.

They are asked to fill in the “Evaluation” column on the forms with the following scores:

- ***Plausible data:*** the data entered conforms, in the AGRIBALYSE context, to current French agricultural production practices
- ***With reservations:*** the values entered are borderline for what is usually found but remain plausible. If possible, they should be verified to check that there are no errors. This score should be supported by a comment.
- ***Unacceptable :*** the values are unrealistic or suspect and need to be corrected. This score should be supported by a comment.
- ***No opinion:*** if the expert was not qualified to evaluate the data quality

Experts are also asked to comment on any omissions or incoherences in the data checked.

Note: Depending on his conclusion (“major modifications required, to be reviewed after modifications”), the expert may be asked to carry out a second review to verify the quality of the data that has been modified.

3.2 General section

The first part covers general points common to the livestock and plant production processes. The following points are evaluated.

(A) Correspondence between the name of the process and its content

- Does the name of the process correspond to the content?
- Is the name sufficiently explicit?

(B) Implementation of the principles in the Data Collection Guide

- Are the main recommendations set out in the Data Collection Guide correctly applied?

(C) Data quality: - Representativeness

- Technological
- Geographical
- Time-related: is the data representative of the reference period (2005-2009)?

(D) Documentation

- Are the data and calculations adequately documented?
- Are the documents cited available to the public?

3.3 Livestock production

The data to be checked is divided into various groups (see livestock production form). Different information is evaluated for each group.

Activity data

- Yields: weight of animals on output, quantities produced (eggs/milk)
- Time spent on the farm

- Specific technical data (eg: lean meat percentage for pigs)

Feed

- This section has two parts, one for the formulation of feed mixes and one defining the composition of rations. The following data should to be checked:
- Formulation of the feed mixes: list of raw materials and proportions
- Composition of the rations
- Distribution of rations for a given class of animals

Excretions

- Management in buildings, quantities, dry matter content, storage duration
- Management during storage: storage structure, duration, quantities managed

Dates

- Distribution of feed rations
- Turning ruminants out to grass

Buildings

- Type, area
- Time spent by animals in buildings

Power consumption

- Fossil fuel (natural gas, propane/butane, oil, electricity)
- Lubricants

3.4 Arable / horticultural production

The data to be checked is divided into various groups (see plant production form). Different information is evaluated for each group.

Yield and co-products

- Yield: suitability of the functional unit definition (in particular details of the product quality), quantities produced and variations.
- Permanent crops: duration of the process
- Co-products: quantities produced
- Plausibility of the yield of the main product

Management of intercrops

- Previous crop: date of harvest, distribution and quantity of crop residues
- Plausibility of the intercrop management (no intermediate crop, intermediate crop not sold, with intermediate crop sold)

Tilling and drilling (quantities and mechanization)

- Suitability of the production system for tilling
- Quantities of seed sown and proportion of farm seed

Fertilization (quantities and mechanization)

- Plausibility of fertilizers used
- Application methods (mechanization) and frequency (number of passes)
- Plausibility of quantities applied (and variation)

Pesticides (quantities and mechanization)

- Plausibility of active substances used
- Application methods (mechanization) and frequency (number of passes)
- Plausibility of quantities applied (and variation)

Sundry

- Irrigation (if appropriate): volume of water used for watering, amount of power used and type of power
- Suitability of the various inputs entered
- Travel of seasonal labor: distances and number of seasonal workers per data collection unit

Plausibility of the dates

- Dates for harvesting previous crops
- Dates for tilling
- Date for sowing main crop
- Dates of fertilization (if given)
- Dates for applying pesticides (if given)
- Date for harvesting main crop

3.5 Estimated time taken for each process

Estimated workload for each process

1.	Evaluation of the specific criteria:	2 to 5 minutes for each section	10 – 35 minutes
2.	Filling in the review form:		30 – 45 minutes
For each process			**40 – 80 minutes**

It is likely that the speed of evaluation will improve. The upper limit applies, therefore, to the first processes checked.

3.6 Reporting

The review forms should be returned to the project leaders. One review form should be returned for each production system reviewed.

4 Documents provided

Various documents are provided for the experts to make it easier to check the quality of the production system data.

4.1 Specification

This document. It provides the information required on the quality control aims and methods. It defines the quality control procedures: what data should be checked and how this should be done.
The specification also includes important information on the schedule, confidentiality, etc.

4.2 Production system data

When the expert has signed a confidentiality agreement, production system data will be sent in the form of EXCEL spreadsheets. These were prepared by the project leaders and extracted from the data collection module. They contain all the data to be checked.

4.3 Review forms

The review forms are designed i) to provide a checklist for the data to make it easier to check the data ii) to ensure that the data review is consistent. These review forms should be sent back to the project leaders.
One form should be filled in for each process checked.

The review forms have a formal part setting out the criteria to be evaluated. This part is the core element of the review process and should be filled in. The second part allows experts greater freedom to give a more general assessment of the quality of the data checked.

4.4 Main recommendations in the Data Collection Guide

An overview of the main recommendations in the Data Collection Guide for the AGRIBALYSE program is provided for the experts to make it easier for them to check that the data entered complies with these recommendations.

4.5 Confidentiality agreement

The confidentiality agreement ensures that the data sent for quality control will be kept confidential. This agreement must be signed before the start of the quality control procedure.

5 Schedule

The quality control procedure is scheduled to take place during fall 2011 and the phase for checking French production system data is scheduled to end with a working seminar in

February 2012. To make preparations for this phase, experts are asked to send their reports to the appropriate project leaders within at least four weeks after receiving the data to be checked.

6 Confidentiality

Experts are reminded that the data sent is confidential and must be treated as such. It may not be used outside the scope of the AGRIBALYSE program.

7 Main recommendations in the Data Collection Guide

Table 56 below lists the main recommendations to ensure that the data collected for the AGRIBALYSE program is consistent.

Table 56: Main recommendations in the AGRIBALYSE Data Collection Guide

<table>
<tr><th colspan="2">Recommendation N°</th><th>Recommendation</th></tr>
<tr><td colspan="2">R1</td><td>Functional unit
The functional unit must be a unit of mass or volume at the farm gate with a description. Reasons must be given for any exceptions.</td></tr>
<tr><td rowspan="2">R2</td><td>Arable/ horticultural</td><td>Time-related representativeness
The reference period is from 2005 to 2009.
Exception: the period may be extended to 2000-2009 …
… if insufficient data is available for the period 2005-2009
… for products with fluctuating yields.</td></tr>
<tr><td>Livestock</td><td>Time-related representativeness
The reference period is from 2005 to 2009.
Exception: the period may be extended to 2000-2009 …
… if insufficient data is available for the period 2005-2009.</td></tr>
<tr><td colspan="2">R3</td><td>System boundaries
The general boundary is cradle to gate. Post harvest processes (drying, etc) should be modeled in separate LCI data sets.</td></tr>
<tr><td rowspan="2">R4</td><td>Arable/ horticultural</td><td>Details of the system boundaries
Process that is within the boundary:
✓ production of seed and plants
✓ production and application of active substances in pesticides (herbicides, fungicides, insecticides, etc).
✓ production and application of mineral fertilizers
✓ application of organic fertilizers. If processing is required, this is taken into account (eg: composting, feather meal, bone meal, etc)
✓ equipment, materials and buildings used for arable / horticultural products (management of intercrops, tilling, drilling, application of pesticides and fertilizers, harvesting, transport, etc.), including the production of the machines and buildings, maintenance and the space for storing the equipment (shed/barn/garage)
✓ for tropical products, animal traction is taken into account and feed for the animals used for traction is considered as an input
✓ work by third parties
✓ irrigation
✓ travel of seasonal workers to the production zone if this is a significant work force.</td></tr>
<tr><td>Livestock</td><td>Details of the system boundaries
Process that is within the boundary:
✓ fabrication of feed (production of raw materials and processing) and bedding, as well as transporting them to the livestock building, whether they are produced on the farm or not
✓ drinking water for the animals
✓ breeding of genitors and production of animals for input and feed
✓ work by third parties
✓ machinery and livestock buildings (milking parlor, stabling, handling equipment, buildings, etc.), including the production of the machines and buildings, maintenance and the space for storing the equipment (shed/barn/garage)
✓ water for cleaning the equipment and buildings and cooling</td></tr>
</table>

Recommendation N°		*Recommendation*
		systems ✓ activity of animals (rumination) and excretions (grazing, buildings, storage).
R5	**Arable/ horticultural**	**Details of the assessment period for determining the start and end of the crop for cropping sequences** The assessment period for a crop goes from the harvest of the previous crop to the harvest of the crop considered in the data set.
	Livestock	**Assessment period for livestock production** January 1st to December 31st.
R6		**Inputs not considered / cut-off rule** In theory there is no cut-off rule. It is stated explicitly whether an input is excluded from the system.
R7		**Data quality** The data quality is evaluated using the name of the data source.

8 Contacts

Further information may be obtained from the project leaders of the AGRIBALYSE program.

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Review forms for livestock and plant productions attached to the specification

Livestock production review form

Process evaluated (name and number)		
Evaluation		
General analysis	**Evaluation**	**Comments**
(A) Correspondence between the process name and its content		
(B) Implementation of the Data Collection Guide principles		
(C) Data quality: - Technological representativeness	☐ *Plausible data* ☐ *With reservations* ☐ *Unacceptable* ☐ *No opinion*[5]	
- Geographical representativeness	☐ *Plausible data* ☐ *With reservations* ☐ *Unacceptable* ☐ *No opinion*[5]	
- Time-related representativeness	☐ *Plausible data* ☐ *With reservations* ☐ *Unacceptable* ☐ *No opinion*[5]	
- Documentation	☐ *Plausible data* ☐ *With reservations* ☐ *Unacceptable* ☐ *No opinion*[5]	
Quality control criteria	**Evaluation**	**Comments**
1. Activity data		
2. Feed: formulation of feed mixes and composition of rations		
4. Excretions: management in building, management during storage and treatment		

[5] *No opinion*: This box should only be checked if it is not possible to assess the criterion to be evaluated.

Quality control criteria	Evaluation	Comments
5. Dates		
6. Buildings		
6. Power consumption		

General evaluation and comments

Decision	
☐ *Accepted*	
☐ *Accepted with minor modifications*	
☐ *Major modifications required (to be reviewed after modifications)*	
Date checked	
Name and signature	

Plant production review form

Process reviewed *(name and number)*		
Evaluation		
General analysis	**Evaluation**	**Comments**
(A) Correspondence between the process name and its content		
(B) Implementation of the Data Collection Guide principles		
(C) Data quality: *- Technological representativeness*	☐ *Plausible data* ☐ *With reservations* ☐ *Unacceptable* ☐ *No opinion*[5]	
- Geographical representativeness	☐ *Plausible data* ☐ *With reservations* ☐ *Unacceptable* ☐ *No opinion*[5]	
- Time-related representativeness - Current	☐ *Plausible data* ☐ *With reservations* ☐ *Unacceptable* ☐ *No opinion*[5]	
- Documentation	☐ *Plausible data* ☐ *With reservations* ☐ *Unacceptable* ☐ *No opinion*[5]	
Quality control criteria	**Evaluation**	**Comments**
1. Yield and co-products		
2. Intercrop management		

Quality control criteria	**Evaluation**	**Comments**
3. Tilling and drilling (quantities and mechanization)		

4. Fertilization (quantities and mechanization)		
5. Pesticides (quantities and mechanization)		
6. Sundry		
7. Plausibility of dates		

General evaluation and comments

Decision
☐ *Accepted*
☐ *Accepted with minor modifications*
☐ *Major modifications required (to be reviewed after modifications)*

Date checked	
Name and signature	

Appendix D: Parameters for models for calculating direct emissions used in the AGRIBALYSE program

Datasheet 1: Ammonia (NH_3)

1 General information

Table 57: Models selected for each source of NH_3 emissions

Source of NH_3 emissions	Model selected
Excretions in buildings	**CORPEN 1999a-1999b-2001-2003-2006:** for calculating the amount of nitrogen excreted by the animals
	EMEP/EEA 2009 Tier 2: for emission factors
Excretions during storage	**EMEP/EEA 2009 Tier 2:** for emission factors
Organic fertilizers	**EMEP/EEA 2009 Tier 2**
Mineral fertilizers	**EMEP/CORINAIR 2006 Tier 2**
Thai rice	**IPCC 2006b Tier 2 based on Yan *et al*, 2003b**
Special crops	**EMEP/EEA 2009 Tier 2**

The amounts of nitrogen excreted must be calculated in order to calculate the emissions from livestock excretions. This was calculated using the CORPEN method (2006, 2003, 2001, 1999a and 1999b) described in datasheet 2.

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2 Parameters for livestock production: buildings, storage and outdoor runs

The method proposed by EMEP/EEA (2009) Tier 2 is based on monitoring flows of materials. This model is used to calculate the global emissions and the emissions for each source of emissions:

- In buildings
- During storage
- In the outdoor runs (yard)

The EMEP model covers Tier 2 emission factors for 12 types of animal (11 of which are included in AGRIBALYSE). The AGRIBALYSE program defined 23 types of animal and 40 classes of animal. These must be assigned to the EMEP categories (see **Table 58**).

As fish are not included in the EMEP guide this source of emissions was not considered even though aquaculture may be the source of significant NH3 emissions (Gross *et al,* 1999).

Table 58: Correspondence between AGRIBALYSE classes of animal and EMEP types of animal (na - not available)

AGRIBALYSE class of animal	EMEP type of animal (Table 3.8, EMEP)
Suckler cow - Replacement heifers +2 yrs	Other Cattle (young cattle, beef cattle and suckling cows)
Suckler cow - Replacement heifers 0-1 yr	Other Cattle (young cattle, beef cattle and suckling cows)
Suckler cow - Replacement heifers 1-2 yrs	Other Cattle (young cattle, beef cattle and suckling cows)
Suckler cow - Genitors	Other Cattle (young cattle, beef cattle and suckling cows)
Suckler cow - Suckler cows	Other Cattle (young cattle, beef cattle and suckling cows)
Suckler cow - Calf 0-1 yr	Other Cattle (young cattle, beef cattle and suckling cows)
Beef cattle - Fattened steer or heifer + 2 yrs	Other Cattle (young cattle, beef cattle and suckling cows)
Beef cattle - Fattened steer or heifer 1-2 yrs	Other Cattle (young cattle, beef cattle and suckling cows)
Beef cattle - Calf <1 yr	Other Cattle (young cattle, beef cattle and suckling cows)
Dairy cow - Replacement heifers +2 yrs	Other Cattle (young cattle, beef cattle and suckling cows)
Dairy cow - Replacement heifers 1-2 yrs	Other Cattle (young cattle, beef cattle and suckling cows)
Dairy cow - Replacement heifers weaning-1 yr	Other Cattle (young cattle, beef cattle and suckling cows)
Dairy cow - Dairy cow in production	Dairy cows
Dairy cow - Calf ("1 week" - weaning)	Other Cattle (young cattle, beef cattle and suckling cows)
Dairy cow - Calf (birth -"1 week")	Other Cattle (young cattle, beef cattle and suckling cows)
Milk goat - Goat in production	Sheep (and goats)
Milk goat - Replacement kids 0-1 yr	Sheep (and goats)
Milk goat - Replacement kids 1-2 yrs	Sheep (and goats)
Rabbit - Fattening	Fur animals

AGRIBALYSE class of animal	EMEP type of animal (Table 3.8, EMEP)
Rabbit - Breeding	Fur animals
Milk ewe - Replacement lambs (0-weaning)	Sheep (and goats)
Milk ewe - Replacement gimmer 0-1 yr	Sheep (and goats)
Milk ewe - Replacement gimmer 1-2 years	Sheep (and goats)
Milk ewe - Milk ewe in production	Sheep (and goats)
Lamb - Raising lambs	Sheep (and goats)
Fattening duck - force feeding	Other poultry (geese)
Fattening duck - before force feeding	Other poultry (geese)
Fish - Sea bass / sea bream hatchery	na
Fish - Trout hatchery	na
Fish - Sea bass / sea bream fattening	na
Fish - Trout fattening	na
Pig - Suckling	Sows (and piglets to 8 kg)
Pig - Fattening	Fattening pigs (8-110 kg)
Pig - Post weaning	Fattening pigs (8-110 kg)
Beef calf	Other Cattle (young cattle, beef cattle and suckling cows)
Poultry - Broiler	Broilers (broilers and parents)
Poultry - Replacement reproductive	Laying hens (laying hens and parents)
Poultry - Layers	Laying hens (laying hens and parents)
Poultry - Chickens	Broilers (broilers and parents)
Poultry - Reproductives	Laying hens (laying hens and parents)

NH_3 emission factors are applied to the total ammonia nitrogen content (TAN) of the animal excretion. These were calculated from the quantities of dung excreted and the following factors, proposed by EMEP/EEA, 2009 (**Table 59**).

Table 59: Percentage of TAN in excreta for each type of animal (EMEP/EEA, 2009)

EMEP type of animal	% TAN/total N mass
Broilers (broilers and parents)	70%
Dairy cows	50%
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)	0.6
Other poultry (ducks)	70%
Other poultry (geese)	70%
Other poultry (turkeys)	70%
Sheep (and goats)	50%
Sows (and piglets to 8 kg)	70%

The NH_3 emissions were then calculated for liquid and solid manure in buildings (EF_building), in outdoor runs (EF_yard)[6] and during storage (EF_storage). For missing values, average factors or default factors were used.
Poultry dung was considered as solid manure. **Table 60** gives the emissions factors used.

Table 60: NH_3 emission factors for buildings (EF_building), outdoor runs (EF_yard) and storage (EF_storage) used for AGRIBALYSE

EMEP type of animal	Type of excretion	Source of emissions	EF NH_3
Broilers (broilers and parents)		EF_pât	0,10
	liquid	EF_fertorg	0,55
	solid	EF_fertorg	0,79
Dairy cows		EF_pât	0,10
	liquid	EF_fertorg	0,55
	solid	EF_fertorg	0,79
Fattening pigs (8-110 kg)	liquid	EF_fertorg	0,40
	solid	EF_fertorg	0,81
Fur animals		EF_pât	
	liquid	EF_fertorg	
	solid	EF_fertorg	
Laying hens (laying hens and parents),	liquid	EF_fertorg	0,69
	solid	EF_fertorg	0,69

6 As only the quantities in buildings and the quantities stored are entered in the data collection module, the outdoor run emission factors are not used. However, they were included in the data collection module so that the model could be improved in a subsequent version.

EMEP type of animal	Type of excretion	Source of emissions	EF NH_3
Other Cattle (young cattle, beef cattle and suckling cows)		EF_pât	0,06
	liquide	EF_fertorg	0,55
	solide	EF_fertorg	0,79
Other poultry (ducks)		EF_pât	
	liquide	EF_fertorg	
	solide	EF_fertorg	0,54
Other poultry (geese)		EF_pât	
	liquide	EF_fertorg	
	solide	EF_fertorg	0,45
Other poultry (turkeys)		EF_pât	
	liquide	EF_fertorg	
	solide	EF_fertorg	0,54
Sheep (and goats)		EF_pât	0,09
	liquide	EF_fertorg	
	solide	EF_fertorg	0,90
Sows (and piglets to 8 kg)		EF_pât	
	liquide	EF_fertorg	0,29
	solide	EF_fertorg	0,81
Others	liquide	EF_fertorg	0,4
	solide	EF_fertorg	0,81
Facteur moyen		EF_pât	0,09
	liquide	EF_fertorg	0,51
	solide	EF_fertorg	0,71

3 Parameters for livestock and plant production: Organic fertilizer, grazing

The EMEP/EEA approach implies using different emission factors (EF) for calculating emissions during grazing or while spreading organic fertilizer. Different factors are used for grazing (EF_graze) and for spreading organic fertilizer (EF_orgfert). These factors apply to the quantity of Total Ammoniacal Nitrogen (TAN) and depend on the type of organic fertilizer used, whether it is liquid or solid, the source of emissions (grazing or not) and the form of application (see **Table 61**). No specific factor was available for organic fertilizers not derived from animal excreta and so an average emission factor was used. The percentage of TAN is given in **Appendix H** (column N-NH_4^+) for organic fertilizers derived from animal excreta and in **Table 62** for other organic fertlizers**.**

Table 61: Emission factors used in AGRIBALYSE for organic fertilizers

EMEP type of animal	Form of fertilizer	Source of emissions	EF NH_3
Broilers (broilers and parents)		EF_graze	0.10
	liquid	EF_orgfert	0.55
	solid	EF_orgfert	0.79
Dairy cows		EF_graze	0.10
	liquid	EF_orgfert	0.55
	solid	EF_orgfert	0.79
Fattening pigs (8-110 kg)	liquid	EF_orgfert	0.40
	solid	EF_orgfert	0.81
Fur animals		EF_graze	
	liquid	EF_orgfert	
	solid	EF_orgfert	
Laying hens (laying hens and parents),	liquid	EF_orgfert	0.69
	solid	EF_orgfert	0.69
Other Cattle (young cattle, beef cattle and suckling cows)		EF_graze	0.06
	liquid	EF_orgfert	0.55
	solid	EF_orgfert	0.79
Other poultry (ducks)		EF_graze	
	liquid	EF_orgfert	
	solid	EF_orgfert	0.54
Other poultry (geese)		EF_graze	
	liquid	EF_orgfert	
	solid	EF_orgfert	0.45
Other poultry (turkeys)		EF_graze	
	liquid	EF_orgfert	
	solid	EF_orgfert	0.54
Sheep (and goats)		EF_graze	0.09
	liquid	EF_orgfert	
	solid	EF_orgfert	0.90
Sows (and piglets to 8 kg)		EF_graze	
	liquid	EF_orgfert	0.29
	solid	EF_orgfert	0.81
Sundry	liquid	EF_orgfert	0.81
	solid	EF_orgfert	0.40
Average factor		EF_graze	0.09
	liquid	EF_orgfert	0.51

EMEP type of animal	Form of fertilizer	Source of emissions	EF NH_3
	solid	EF_orgfert	0.71

These emission factors can be adjusted using a correction factor depending on the application method. However, lack of data on the application methods for any of the fertilizers identified made it impossible to use correction factors.

Table 62: TAN content for organic fertilizers from outside the farm

Organic fertilizer not from the farm	kg TAN/t or m^3
Limed sewage sludge	5.32
Liquid sewage sludge	2.13
Semi-solid sewage sludge	3.20
Dried sewage sludge	1.,80
Manure / slurry compost	0.83
Household waste compost	0.62
Green waste compost	0.83
Sugar scum (alkaline amendment)	0.96
Feather meal	6.50
Vegethumus	0.92
Concentrated sugar beet vinasse	0.96
Distillery vinasse	0.96
Unspecified organic fertilizer (Mixtures of organic fertilizers) (t N)	50.00

4 Parameters for plant production: mineral fertilizers

The EMEP/CORINAIR (2006) methodology was used. The recommendations of the group of experts led by CITEPA were followed rather than those of EMEP/EEA (2009) for producing the national inventories to avoid methodological bias (Joya *et al*, 2012). Using the EMEP/EEA (2009) methodology, the emission factors are calculated depending on the form of mineral nitrogen fertilizer, the average spring temperature (spring starts when the sum of temperatures since January 1st reaches 400°C and lasts for 3 months) and possibly on an alkaline soil. The working group found a problem with respect to the definition of the average spring temperature: "… it can be seen that spring starts fairly late in cold regions but as these regions tend to be continental regions with markedly different seasons, the temperature in spring is higher than in warmer regions. The experts present agreed that taking account of temperature as suggested in the EMEP/EEA (2009) model was not representative of temperatures for spreading mineral fertilizers and that there seemed to be significant bias in the method proposed. Therefore, CITEPA decided to continue to use the methodology based on EMEP 2006 until a new methodology was available at national level."
The emission factors used by AGRIBALYSE are listed in **Table 63**. They apply to the total amount of nitrogen applied. For all applications of nitrogen when the form is not specified

(described as “N unspecified) a weighting factor was used (depending on the composition of the “French average fertilizer”, see Appendix I).

Table 63: Emission factors selected for mineral fertilizers

Type of fertilizer – EMEP name	Emission factor (%) kg NH_3-N/kg total N applied)
Anhydrous ammonia	4
Ammonium nitrate	2
Calcium ammonium nitrate	2
Di-ammonium phosphate	5
N fertilizer French average (weighting factor)	5.9
Di-ammonium fertilizer	5
Mono-ammonium phosphate, other NP, NK and NPK fertilizer	2
Urea ammonium nitrate solution	8
Ammonium sulfate	8
Urea	15

5 Parameters for Thai rice

Assumptions:
Rice-growing period = 120 days
In the production systems studied the rice was not transplanted. However, urea was applied one month after sowing, which corresponds to the transplantation period. This was the emission factor considered.

According to FAO statistics (2002) and in agreement with observations during the period 2010-2011 in the zones studied, urea and ammonia based fertilizers account for 85% of the total nitrogen fertilizers applied to paddy fields in northern and north-eastern Thailand.

The bibliographic study carried out by Yan *et al* (2003b) focused on NH_3 emissions from urea fertilization, the most commonly used form in south east Asia. The period and application method have a significant effect on the volatilization rate. Yan *et al* (2003b) proposed considering volatilization of 20% of the nitrogen applied when the fertilizer was incorporated while the plot was being prepared, 36% when the urea was applied after transplantation and 12% when the fertilizer was applied on formation of the panicle. Equation 5 was used to model the emissions. An average emission factor of 22% of the nitrogen applied can be calculated on the basis of the application of 30% of fertilizer while the plot was being prepared, 30% after planting and 40% on the formation of the panicle.

$N\text{-}NH_3\ kg.ha^{-1}\ urea = (U_{inc} \times 0.2) + (U_{trans} \times 0.36) + (U_{pan} \times 0.12) \times 0.46$ (Equation 1)

Where:

0.46 is the conversion factor for N-urea

U_{inc} is the amount of urea applied and incorporated into the soil while the plot is being prepared

U_{trans} is the amount of urea applied during transplantation, during the growing phase

U_{pan} is the amount of urea applied on formation of the panicle

The lack of experimental data made it impossible to define specific emission factors for the other forms of fertilizer. Based on EEA recommendations, Yan *et al* (2003b) suggested using the NH_3 emission factors given in **Table 64**. They also recommended considering a basic emissions of 1.5 kg $N\text{-}NH_3.ha^{-1}.year^{-1}$.

Table 64: Emission factors for mineral fertilizers applied to paddy fields

Type of fertilizer	Emission factor (%) kg NH_3-N/kg total N applied)
Ammonia bicarbonate	33
Ammonium sulfate	22
Ammonium phosphate	5
Other forms	2
Compound fertilizer (NPK)	2

The total NH_3 emissions can be calculated using Equation 2.

$$N\text{-}NH_3\ kg.ha^{-1} = [N\text{-}NH_3\ urea] + (N\text{-}AB \times 0.33) + (N\text{-}AS \times 0.22) + (N\text{-}AP \times 0.05) + (N\text{-}Other \times 0.02) + (1.5\ kg\ N\text{-}NH_3.ha^{-1}.year^{-1} * D/365) \quad \text{(Equation 2)}$$

Where:

$N\text{-}NH_3$ urea is the N emissions from urea (see Equation 1)

N-AB is the quantity of N in the form of ammonium bicarbonate ($kg.ha^{-1}$)

N-AS is the quantity of N in the form of ammonium sulfate ($kg.ha^{-1}$)

N-AP is the quantity of N in the form of ammonium phosphate ($kg.ha^{-1}$)

N-Other is the quantity of N in another form of nitrogen ($kg.ha^{-1}$)

D is the effective duration of the crop period

(1.5 kg $N\text{-}NH_3.ha^{-1}.year^{-1}$ * D/365): base emissions, adjusted for the period D

17/14 is the conversion factor between N- NH_3 and NH_3

Datasheet 2: Excretion of nitrogen by livestock

1 General information

Table 65: Models selected for each source of emissions

Source of emissions	Model selected
Dairy cows	**CORPEN 1999(a)**
Suckler beef, growing or fattening (suckler and dairy)	**CORPEN 2001**
Pigs	**CORPEN 2003**
Poultry	**CORPEN 2006**
Rabbits	**CORPEN 1999(b)**

Main principle of the models

CORPEN (1999a, 1999b, 2001, 2003, 2006) proposes a methodology for calculating the total nitrogen excreted by the animals using mass balance. The total nitrogen ingested by the animal is calculated and then the nitrogen fixed by the animals is determined. The total quantity of nitrogen excreted is the difference. Equation 1 of the nitrogen excretion calculation is:

$$N_{excreted} = N_{ingested} - N_{fixed} \qquad \text{(Equation 1)}$$

The quantities of nitrogen ingested per day per animal are calculated from the description of the feed mixes and rations distributed to the animals and the tables given by INRA (1988, 1989, 2007) and Sauvant *et al* (2004).

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2 Parameters for livestock production: cattle

The quantities of nitrogen fixed by the classes of cattle in the AGRIBALYSE database are given in **Table 66**.

Table 66: Nitrogen fixed by the various classes of cattle in the AGRIBALYSE database (CORPEN, 1999a)

Class of animal	N (g) fixed per kg of weight gain or kg of milk produced for dairy cows
Dairy cow - Replacement heifers +2 years	24
Dairy cow - Replacement heifers 1-2 years	24
Dairy cow - Replacement heifers weaning-1 year	24
Dairy cow - Cull cows at end of life	16
Dairy cow - Calf ("1 week" - weaning)	29
Dairy cow - Calf (birth -"1 week")	29
Suckler cow - Replacement heifers +2 years	29
Suckler cow - Replacement heifers 0-1 year	29
Suckler cow - Replacement heifers 1-2 years	29
Suckler cow - Genitor bulls	29
Suckler cow - Suckler cows	29
Suckler cow - Cull cows at end of life	16
Suckler cow - Heifer 0-1 year	18
Fattening - Steer or heifer + 2 years	18
Fattening - Steer or heifer 1-2 years	18
Fattening - Calf <1 year	29
Veal	29
Dairy cows - Dairy cows in production	5.1

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

3 Parameters for livestock production: pigs

The nitrogen retained in the body by pigs was calculated using equation 1:

$$N = \frac{e^{(-0.9385-0,0145*LMC)}\left(0.915LW^{1,1009}\right)^{(0,7364+0,0044*LMC)}}{6.25} \qquad \text{(Equation 1)}$$

Where:
N is the quantity of nitrogen fixed (kg)
LW is the live weight of the animal (kg)
LMC is the Lean Meat Content at the normal slaughter weight (%)

The following LMCs were considered (**Table 67)**.

Table 67: LMC of the various classes of pig in the AGRIBALYSE database (Source: personal communication by Sandrine Espagnol-IFIP, 12/07/2012)

Class of animal	LMC (%)
Sows and piglets	0.615
Sows	0.565
Pigs - Post weaning	0.615
Pigs - Fattening	0.615

4 Parameters for livestock production: poultry

The quantities of nitrogen fixed by the classes of poultry in the AGRIBALYSE database are given in **Table 68**.

Table 68: Nitrogen fixed by the various classes of poultry in the AGRIBALYSE database (CORPEN, 2006)

Type of animal	N (g) fixed per kg of live weight gain wrt. kg egg
Chicken	29.6
Turkey	35.2
Duck	29,6
Chicken organic	32.8
Chicken, Label	32.8
Turkey, Label	35.2
Fattened duck	33.2
Egg	17.4

5 Parameters for livestock production: rabbits

The quantities of nitrogen fixed by the classes of rabbit in the AGRIBALYSE database are given in **Table 69**.

Table 69: Nitrogen fixed by the various classes of rabbit in the AGRIBALYSE database (CORPEN, 1999b)

Type of animal	N (g) fixed per kg of live weight gain/kg of live weight
Doe	36.25
Kit	32.48
Fattened animals	29.05

6 Parameters for livestock production: sheep and goats

The quantities of nitrogen fixed by the animals in the AGRIBALYSE database are given in **Table 70**.

Table 70: Nitrogen fixed by the various classes of sheep and goats in the AGRIBALYSE database

Type of animal	N fixed	Units
Milk goat - Kids (0 - 1 week)	26	g/kg live meat
Milk goat - Replacement goats 0-1 year	26	g/kg live meat
Milk goat - Replacement goats 1-2 years	26	g/kg live meat
Milk ewe - Replacement lambs (0-weaning)	26	g/kg live meat
Milk ewe - Replacement gimmer 0-1 an	26	g/kg live meat
Milk ewe - Replacement gimmer 1-2 years	26	g/kg live meat
Lamb - Lambs 0-weaning	26	g/kg live meat
Lamb - Lambs weaning-sale	26	g/kg live meat
Lamb - Replacement gimmers 1 year-2 years	26	g/kg live meat
Lamb - Replacement gimmers weaning-1 year	26	g/kg live meat
Lamb - Ewe in production	26	g/kg live meat
Lamb - Suckling lamb	26	g/kg live meat
Milk goat - Goats in production	5	g/l milk
Milk ewe - Ewe in production	8.5	g/l milk

The nitrogen fixed by sheep and goats in production (bone, meat, hair, etc) was neglected. Only the nitrogen exported in the milk was taken into account.

Datasheet 3: Carbon dioxide (CO_2)

1 General information

Table 71: Models selected for each source of emissions

Source of emissions	Model selected
Absorption by the plants	**ecoinvent v2** (Nemecek and Kägi, 2007)
Application of lime and urea	**IPCC 2006b Tier 1**

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2 Parameters for plant production: carbon sequestered by the plants

The quantities of carbon sequestered by crops are calculated using the method proposed by Nemecek et Kägi (2007) based on the quantity of dry matter produced by the crops and the carbohydrate, fat, protein and fiber content. These are based on the tables published by INRA (1988, 1989, 2007), Sauvant *et al* (2004) and nutritional information tables published by ANSES (2008). The biomass components are multiplied by carbon content factors (**Table 72).**This carbon is considered neutral so far as climate change is concerned.

Table 72: Carbon content of the various groups of compounds (Vertregt and Penning de Vries, 1987)

Group	C content (g/kg of DM)
Carbohydrate	**0.444**
Protein	**0.535**
Lipid	**0.774**

3 Parameters for plant production: emissions from liming

The quantities of carbonates applied during liming ("calcareous powder rock", $CaCO_3$, or dolomite, $CaMg(CO_3)_2$) are multiplied by their own emission factors (see IPCC 2006b, volume 4 chapter 11.3). Fertilizer containing added carbonate (eg: limestone ammonium nitrate, but not "nitrate of lime", calcium nitrate, $CaNO_3$) was taken into account using a factor to convert it into kg $CaCO_3$ (see comment in IPCC 2006b on calculating M, p. 11.27).

Equations used:

$$(1)\ CO_2 - C\ Emissions = (M_{Limestone} * EF_{Limestone}) + (M_{Dolomite} * EF_{Dolomite})$$

Where:

CO_2-C Emissions is the annual C emissions due to liming (tC/yr)
M is the annual quantity of calcium carbonate ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$), (t/yr)
EF is the emission factor, (tC): **$EF_{Limestone}$ = 0.12** / **$EF_{Dolomite}$ = 0.13**

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

Where:

CO_2 Emitted is the quantity of CO_2 emitted per year

Liming is considered only for carrots, cider apples and alfalfa and was not considered for other plant products as there was insufficient time and data was not easily available. A sensitivity analysis was carried out in October 2013 to evaluate the impact of liming on sugar beet.

4 Parameters for plant production: emissions from the application of urea

According to IPCC 2006b, the emissions from the application of urea or urea ammonium nitrate are calculated by multiplying the quantity of urea ($CO(NH_2)_2$) by a specific emission factor.

Equations used

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

Where:

CO_2-C Emissions is the annual C emissions from the application of fertilizer in the form of urea (tC/yr)
M is the annual quantity of fertilizer in the form of urea, (t/yr)
EF is the emission factor, (tC): **EF_{Urea} = 0.20**

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

Where:

CO_2 Emitted is the quantity of CO_2 emitted per year

As there was no information on the type of fertilizer applied (use of "French average fertilizer) the CO_2 emissions were calculated on the basis of the urea content in the fertilizer (see Appendix I).

Datasheet 4: Trace metals

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

1 General information

Table 73: Models selected for each source of emissions

Source of emissions	Model selected
Leaching: French crops	**SALCA-SM partially modified for France** (Freiermuth, 2006 et SOGREAH, 2007)
Runoff (by soil loss): French crops	
Accumulation in or losses from the soil: French crops	
Special French crops	
Tropical crops	**Not taken into account**

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2 Parameters for plant production

The SALCA-ETM model is based on mass balance by subtracting the mass of the trace metals in the outputs (the harvested product, co-products exported from the plot, leaching and soil loss into surface water, cf. figure 15) from the mass of the trace metals in the inputs (trace metals contained in the seeds, fertilizers and pesticides as well as the deposition of airborne trace metals). The difference in these flows is considered as emissions to the soil. These emissions may be negative, when the output masses are greater than the input masses. Considering uncertainties resulting from the parameters used, a negative balance should not be considered to indicate that the crops absorb metals and remove them from the soil.

Only the outputs which actually leave the field are included in this mass balance: the trace metals in the crop residues left on the field (eg: straw from cereals that is not exported, prunings, wood from fruit trees) were not taken into account and were considered as remaining in the soil.

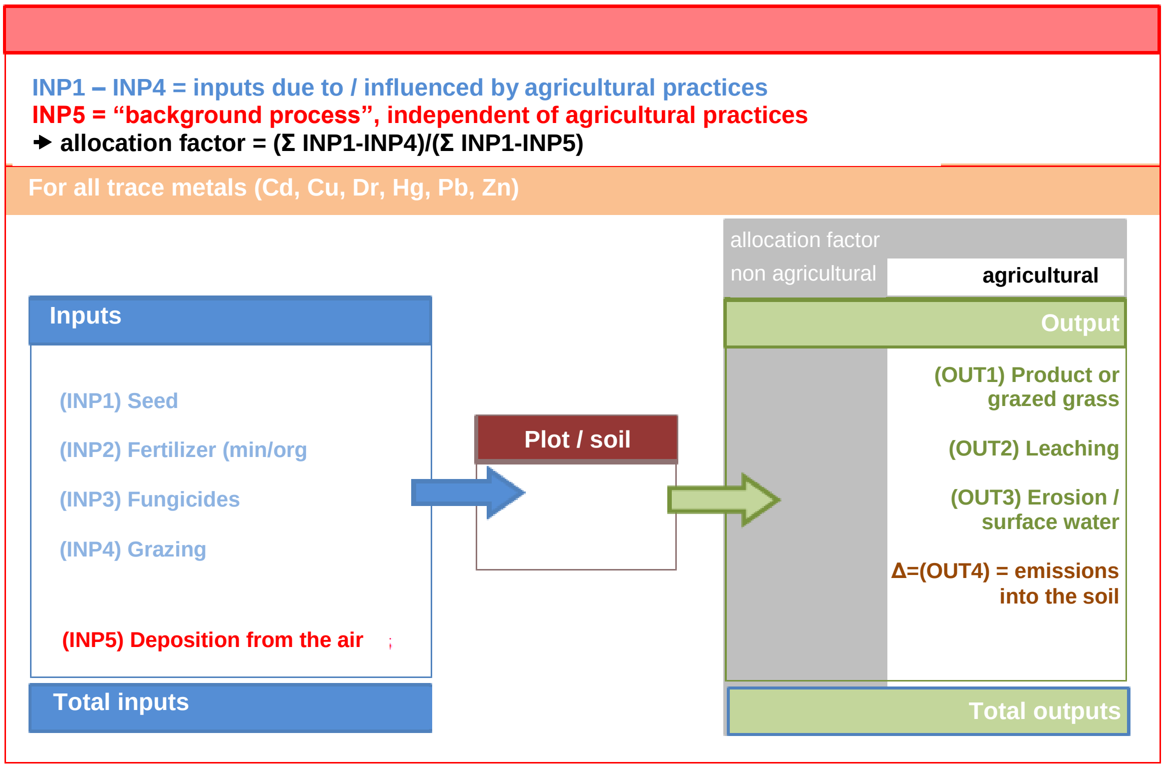

Figure 15: Schematic of the trace metal model used for AGRIBALYSE

The trace metal emissions were calculated for each source of emissions using the equations in **Table 74**.

Table 74: Simplified equations and main input data required for the SALCA-ETM-F model

	SALCA-ETM-F model
Equations	**Mass balance** $$\Delta F_{TMx} = \sum_{SFPIy} IN_y \times C_{y_x} - \left(\sum_{PPLREz} OUT_z \times C_{z_x}\right) * Alloc_x$$ $\forall\ x = \mathrm{Cd, Cu, Zn, Pb, Ni, Cr, Hg}$ *Where* **ΔF_{TMx}** Flow into the soil of the resulting trace metal substance TMx where x = particular trace metal (seven trace metals are taken into account: Cd, Cu, Zn, Pb, Ni, Cr and Hg) **IN_y** Quantity of input "SFPIy" containing TMx *Where "SFPI" covers the following types of input* 1. Seed 2. Fertilizer (mineral, organic, farm, sludge) 3. Pesticides 4. Sundry Inputs (excreta during grazing) **C_{y_x}** Content of trace metal in input SFPIy **OUT_z** Quantity of output PLRz carrying the trace metal TMx *Where PLR covers the following types of output* 1. Products harvested (including co-products and/or residues exported) 2. Leaching to the aquifer 3. Runoff to the surface water by soil loss **C_{z_x}** Content of trace metal from PLRz output **$Alloc_x$** Allocation factor for TMx output flow. This allocation factor only takes account of part of the output flows from the deposition of trace metals. The allocation is calculated for each trace metal: $$Alloc_x = \frac{\sum_{EPIFy} IN_y * T_{y_x}}{\left(\sum_{EPIFy} IN_y * T_{y_x} + Dep_x\right)} -$$ $\forall\ x = \mathrm{Cd, Cu, Zn, Pb, Ni, Cr, Hg}$ *where* **Dep_x** is the deposition of TMx (from the air)

The trace metal content of organic and mineral fertilizers was taken from the report SOGREAH (2007) and Menzi and Kessler (1998). If no information was available, the average values for each type of fertilizer were used (**Table 75**). For solid mineral fertilizers, TM release were calculated based on Raw matter instead of Dry Matte. This aproxmiation is acceptable considering that uncertainties on TM contents are much higher than the difference between raw/dry matter for solid fertilizers.

Table 75: Trace metal content of fertilizers (SL = sludge, CO = compost/unspecified organic matter, MF = mineral fertilizer, MA = manure, LI = slurry). The names for ecoinvent LCI data sets are used for the mineral fertilizers.

Type	Fertilisant		Teneur (en mg/kg MS)							
		MS	Cd	Cu	Zn	Pb	Ni	Cr	Hg	Source
SL	Limed sewage sludge	40%	1,6	287,3	629,9	82,3	24,8	41,2	1,7	SOGREAH (2007)
SL	Composted sewage sludge	29%	1,62	152,1	404,9	61,8	25,8	50,5	2,2	SOGREAH (2007), STEP
SL	Liquid sewage sludge	6%	1,6	287,3	629,9	82,3	24,8	41,2	1,7	SOGREAH (2007)
SL	Dried sewage sludge	93%	1,6	339	945	97	32	76,2	1,8	Menzi et Kessler (1998)
SL	Sugar beet vinasse	26%	0,64	21,5	52,93	3,2	3	8,7	0,15	SOGREAH (2007)
SL	Concentrated sugar beet vinasse	55%	0,64	21,5	52,93	3,2	3	8,7	0,15	SOGREAH (2007)
CO	Manure / slurry compost	52%	1	249,5	626	45,17	34,74	53,52	0,2	SOGREAH (2007), déjections animales
CO	Household waste compost	52%	4,62	164,37	554,28	325,92	60,35	126,34	1,64	SOGREAH (2007), OM
CO	Green waste compost	52%	1,07	109,77	325,66	106,05	25,51	42,81	0,63	SOGREAH (2007), biodéchets
CO	Feather meal	100%	0,2	7,3	135,3	8,3	2,8	65	0,1	Menzi et Kessler (1998)
MF	Ammonium nitrate	100%	0,7	5,8	1,7	0,6	1	6,5	0,1	SOGREAH (2007)
MF	Ammonium sulphate	100%	0,2	4,3	7,2	1	4,4	7,2	0	SOGREAH (2007), simple N
MF	Average mineral fertilizer, as K_2O	100%	0,01	2,32	0,44	0,05	0,15	0,1	0	SOGREAH (2007), simple K
MF	Average mineral fertilizer, as N	100%	0,2	4,3	7,2	1	4,4	7,2	0	SOGREAH (2007), simple N
MF	Average mineral fertilizer, as P_2O_5	100%	15,26	16,4	226	2,86	27,4	154	0,04	SOGREAH (2007), simple P
MF	Calcium ammonium nitrate	100%	0,7	5,8	1,7	0,6	1	6,5	0,1	SOGREAH (2007),
MF	Calcium nitrate	100%	0,2	4,3	7,2	1	4,4	7,2	0	SOGREAH (2007), simple N
MF	Diammonium phosphate	100%	14,15	26,9	230,73	1,63	27,62	199,26	0	SOGREAH (2007), MAP DAP
MF	Lime, from carbonation	100%	0,15	4	12,6	0,7	2,25	3,9	0,02	SOGREAH (2007), Carbonates
MF	Limestone, milled, loose	100%	0,35	6,3	8,85	2,5	2,5	6,18	0,25	SOGREAH (2007), Chaux calquiqes
MF	Magnesium oxide	100%	1,05	5,2	12,55	2,5	3,7	14,2	1,6	SOGREAH (2007), Chaux magnésiennes
MF	Monoammonium phosphate	100%	14,15	26,9	230,73	1,63	27,62	199,26	0	SOGREAH (2007), MAP DAP
MF	Nitric acid	100%	0	0	0	0	0	0	0	Menzi et Kessler (1998)
MF	Potassium chloride	100%	0,23	3,53	5,19	0,81	2,67	1,28	0,05	SOGREAH (2007), clorure de potassium
MF	Potassium nitrate	100%	6,17	16,89	124,83	2,51	14,37	84,35	0,22	SOGREAH (2007), NK / NPK
MF	Potassium sulphate	100%	0,14	5,87	10,98	0,59	1,94	3,74	0,07	SOGREAH (2007), sulfat de

Type	Fertilisant		Teneur (en mg/kg MS)							
		MS	Cd	Cu	Zn	Pb	Ni	Cr	Hg	Source
										potassium
MF	Single superphosphate	100%	12,3	18,38	190,77	2,35	25,13	97,38	0,11	SOGREAH (2007), autres superphosphat
MF	Triple superphosphate	100%	19,56	30,97	406,56	3,57	32,2	196,94	0,12	SOGREAH (2007), TSP
MF	Urea ammonium nitrate	100%	0,2	0,3	1,7	0,2	0,1	0	0,2	SOGREAH (2007), urée[1)]
MF	Urea	100%	0,2	0,3	1,7	0,2	0,1	0	0,2	SOGREAH (2007), urée[1)]
MA	Cattle manure	19%	0,3	23	119	3,8	4,4	7,5	0,13	SOGREAH (2007) Bovin - fumier
MA	Compost bedded cattle manure	22%	0,3	23	119	3,8	4,4	7,5	0,13	SOGREAH (2007) Bovin - fumier
MA	Cattle manure heap	31%	0,21	115,3	746,5	1,76	8,6	6,7	0,8	Menzi et Kessler (1998)
MA	Pig manure	60%	0,252 5	39,6	468,4	2,235	7,9	5,5	0,2	Menzi et Kessler (1998)
MA	Layer hen manure	68%	0,292	43,8	349,2	2,92	40	10	0,2	Menzi et Kessler (1998)
MA	Broiler manure	8%	0,178	37,1	162,2	3,77	4,3	3,9	0,4	Menzi et Kessler (1998)
LI	Cattle slurry	5%	0,16	19,1	123,3	2,92	3,1	2,1	0,4	Menzi et Kessler (1998)
LI	Thin cattle slurry	4%	0,21	115,3	746,5	1,76	8,6	6,7	0,8	Menzi et Kessler (1998)
If no information default → average value for each type of fertilizer										
SL	Limed sewage sludge	42%	1,28	184,79	452,6	54,97	18,9	37,77	1,28	
SL	Composted sewage sludge	58%	1,72	132,74	410,31	121,36	30,85	71,92	0,64	
SL	Liquid sewage sludge	100%	5,19	13,58	94,81	1,53	11,15	58,53	0,16	
SL	Dried sewage sludge	41%	0,28	44,62	320,18	3,05	11,62	7,45	0,27	
SL	Sugar beet vinasse	8%	0,19	71,7	444,63	2,55	6,15	4,85	0,6	

1) corrected for Cu, Ni, Pb, Hg
These data are based on technical instutes' references in priority, else SALCA data were used, and if note was available average data for each ferilizer type was used.

Table 76 gives the copper and zinc content in phytosanitary products (SOGREAH 2007, Perkow and Ploss 1994).

Table 76: Copper and zinc content in active substances in phytosanitary products. For copper and zinc based phytosanitary products, emissions to the environment were calculated using the "phytosanitary model" instead of SALCA-ETM. The following substances were taken into account in both models as their composition was more complex (trace metal plus active substance).

Active substance	Content (g/g)		
	Cu	Zn	Source
Mancozeb		0.025	SOGREAH (2007) p 53
Metiram zinc		0.18	SOGREAH (2007) p 53
Propineb		0.22	Perkow and Ploss (1994)

Zineb		0.24	Perkow and Ploss (1994)
Ziram		0.21	Perkow and Ploss (1994)

The trace metal contents for seeds, products and co-products harvested and exported from the field were based on Schultheiss *et al* (2004) or, if available, on more recent data from the Technical Institutes. The trace metal content of seeds was allocated to that of the products. If no information was available, the average values (allocated to product and co-product) were used (**Table 77).** If the values measured did not exceed the detection limit, the detection limit was taken as the value (if it was known).

Table 77: Trace metal content of products and co-products. The same values were used for seeds as for the products except for maize.

Product	Content (mg/kg DM)								
	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)
Carrots	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 maize	0.1	5	34.5	1.61	0.48	0.7	0.01	81	Houba and Uittenbogaard (1994)
Grain maize	0.03	2.5	21.5	0.3	1.16	0.32	0	72	Houba and Uittenbogaard (1994)
Seed maize	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 grassland	0.13	8.6	40	1.2	1.68	1.09	0.15	16,6	Houba and Uittenbogaard (1994)
Sunflowers	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)
Grapes	0,11	6,48	29,05	0,58	0,91	0,58	0,06	18	Average data used
Product, average	0.11	6.48	29.05	0.58	0.91	0.58	0.06	48	Average
Co-product, average	0.14	4.92	20.56	0.82	0.96	0.93	0.15	60	Average

1) for trace metals Cd, Cu, Zn, Ni and Pb (values for Carrot Root (ref) in Hermanescu *et al* (2011)). The average values were used for Cr and Hg.

Values for deposition from the air were also taken from SOGREAH (2007).

Table 78: Deposition of trace metals from the air in mg per hectare in France and Switzerland

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

All trace metal emissions (leaching, runoff and soil emissions) are multiplied by an allocation factor so that only emissions related to farming practices are taken into account. This allocation factor is calculated by dividing the sum of the inputs from agricultural activities (seed, fertilizer, phytosanitary products) by the sum of all the inputs (including deposition of trace metals from the air).

For crops grown in soil based production in greenhouses (tomatoes) the deposition of trace metals from the air was not taken into account as the greenhouses prevent them being deposited on the cultivated soil.

3 Calculating leached trace metals

The quantities of trace metals leached to the aquifers were estimated by multiplying the average leaching per hectare per year (**Table 79**) by the period for which the crop was grown (see datasheet 11, **Table 129**) and the area occupied. As there was no data specific to France, data for Switzerland, taken from the original SALCA-ETM model was used for France. As the trace metals are strongly linked to the geology of the soil, the data for Switzerland should be used with care for the French average (Baize *et al*, 2007).

Table 79: Average leaching per ha per year

Country	Average leaching (g per hectare per year)							
	Cd	Cu	Zn	Pb	Ni	Cr	Hg	Source
Switzerland	0.05	3.6	33	0.6	0	21.2	0.0113	Wolfensberger und Dinkel, 1997

4 Calculating trace metal runoff

The quantities of trace metals emitted by runoff and soil loss in the surface water were calculated using:

- The quantity of soil lost, in kg per hectare per year. This quantity is calculated using the soil loss model depending on the crop grown (see datasheet 5). If the period for which the crop is grown is greater than one year (eg: orchard, grassland), the soil loss model gives two values for the soil lost (for year 1 and for following years).
- The land occupation duration (**Table 129**),
- The average trace metal content per kg of soil. These contents depend on the category of the crop grown: arable, permanent meadow, special intensive crop

and grapevines. The data used was the total content and was taken from the BDAT database (RMQS, 2013). As only one value was available for mercury for arable crops, this value was used for all soil uses (**Table 80**).

- An eroded particle enrichment factor of 1.86 and a fraction of eroded earth arriving at a watercourse of 0.2 (Freiermuth R., 2006).

Table 80: Average content of trace metals in soils in France depending on the soil use

Type of crop	Content (mg/kg of soil)							
	Cd	Cu	Zn	Pb	Ni	Cr	Hg	Source
Permanent meadow	0.299	20.402	87.188	36.69	28.923	63.389	0.068	RMQS (2013)
Arable crops	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)
Grapevines	0.178	87.244	63.703	27.368	23.088	50.363	0.068	RMQS (2013)

5 Parameters for excretions during grazing

Trace metals from excretions during grazing were taken into account using an approach similar to the manure spreading. As the grazed grass data sets were based on grazing by cattle (see chapter B.2.7.7), the trace metal contents of cattle dung were used (**Table 75**).

6 Parameters for tropical crops

As there was no data for the trace metal contents in tropical soils or for deposition from the air, the trace metal flows were not calculated for tropical crops.

7 Parameters for livestock production

Any emissions during storage (at the side of fields, in ditches, etc.) were not taken into account assuming that the excretions were stored enclosed for most of the time.

Datasheet 5: Soil loss

1 General information

The RUSLE soil loss equation (Foster, 2005) was used with appropriate parameters.

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2 Parameters for plant production

The soil loss model applies only to crops grown in the open air. For soilless crops, the soil loss is by default 0. The soil losses were calculated using the equation in **Table 81.**

Table 81: RUSLE soil loss equation

USDA RUSLE soil loss equation
A = R * K * LS * C * P * f
Where **A** is the computed spatial and temporal average soil loss per unit area (t/ha/year) **R** is the rainfall-runoff erosivity factor **K** is the soil erodibility factor **L** is the slope length factor **S** is the slope steepness factor **C** is the cover-management factor **P** is the support practice factor **f** is the acre => hectare conversion factor = 2.47

For **R**, the values used were based on the map by Néboit-Guilhot, 1991. When the map was analyzed, a regional approach was considered and six main regions were defined (**Table 82**).

Table 82: Values for R and K for each region defined. K was calculated (see below)

Region	Region of France	R	K
Central	R11 - Ile-de-France, R24 - Centre, R26 - Burgundy, R74 - Limousin, R83 – Auvergne	40	0.30
North	R21 - Champagne-Ardenne, R22 - Picardy, R23 - Upper-Normandy, R25 - Lower-Normandy, R31 - Nord - Pas-de-Calais	30	0.35
North-East	R41 - Lorraine, R42 - Alsace, R43 - Franche-Comté, R82 - Rhône-Alpes	50	0.29
West	R53 – Brittany	30	0.35
South	R73 - Midi-Pyrenees, R91 - Languedoc-Roussillon, R93 - Provence-Alpes-Côte d'Azur, R94 – Corsica	100	0.30
South-West	R52 - Pays de la Loire, R54 - Poitou-Charentes, R72 - Aquitaine	80	0.31

K was calculated using the average soil composition (sand (0.05-2 mm), silt (0.002-0.05mm) and clay (<0.002mm)) for each region. The soil losses were calculated using RUSLE2, based on the GisSol database for the soil composition and information from INRA for the regional rainfall.

- For each of the six “soil loss regions” defined, a regional climate profile (with temperature and rainfall data for 2005-2009) and a regional soil profile were defined for RUSLE2 (**Table 86** to **Table 88**)
- The average soil loss was calculated by RUSLE2 using R for the region, a fixed slope of 2% and default values for the other parameters (eg. “contour farming” for the support practice, see P below)
- The soil loss calculated was compared with the results from the AGRIBALYSE model. K was modified until both models gave the same results.

Table 86 to **Table 88** show the averaging procedure for calculating the regional soil composition: **Table 83** gives the effective agricultural area (EAA) and the average clay, silt and sand content for each canton available in GisSol. The weightings were calculated (**Table 71**) by dividing the effective agricultural area in the canton by the effective agricultural area in the region. The weighted contents were added to give a weighted mean (**Table 85**).

Table 83: Extract from the GisSol database: effective agricultural area (ha) and average sand, silt and clay content per canton (g/kg)

Extract from the GISSOL database					
Period	Beginning of 2000 to end 2004				
Units	Values in g/kg of soil				
Number of cantons	2731				
Version	version 3.3.0.0 of 09/07/2012.				
Canton	**Number**	**EAA (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 cantons					

Table 84: Calculation of weighting per canton

Canton	Region	Weighting	Sand	Silt	Clay
AMBERIEU-EN-BUGEY	NE	0.001281815	0.2694759	0.563037183	0.392350715
BAGE-LE-CHATEL	NE	0.002018229	0.8385337	0.776897026	0.227656218
BELLEGARDE-SUR-VALSERINE	NE	0	0	0	0
BELLEY	NE	0.002081183	0.8148457	0.867291547	0.355174755
BRENOD	NE	0.001658621	0.3415597	0.713439039	0.415069790
CEYZERIAT	NE	0	0	0	0
CHALAMONT	NE	0.002350199	0.5743650	1.396793573	0.339862229
CHAMPAGNE-EN-VALROMEY	NE	0.002120492	0.5373961	1.016181958	0.448908060
CHATILLON-SUR-CHALARONNE	NE	0.005176702	1.2228405	2.622983037	0.834018428
And 2722 other cantons					

Table 85: Average per region (g/kg)

Soil loss region	Total area (ha)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)
Central	6,200,572	333	426	218
North	5,556,017	208	574	213
North-East	3,256,320	279	448	265
West	1,277,126	278	546	172
South	2,570,232	347	416	234
South West	4,896,927	365	423	205

The average monthly temperatures and average monthly rainfall from 2005 to 2009 were calculated from the data from the INRA weather station network (Climatik) by INRA, Rennes (Emmanuelle Garrigues). The average values were calculated using the data from a station close to the main town in each administrative region. The weighting factors were calculated by dividing the agricultural areas used in the administrative region by the area of the "soil loss region" (**Table 88**).

Table 86: Weather stations used to calculate the average temperatures and rainfall, grouped into six "soil loss" regions

Soil loss region	Administrative region	Area (km²)	Weighting	Data source	Weather station
CENTRAL	Auvergne	26013	20.7%	CLIMATIK	Clermont-Ferrand
CENTRAL	Burgundy	31582	25.1%	NASA	
CENTRAL	Center	39151	31.1%	CLIMATIK	Champhol
CENTRAL	Ile-de-France	12011	9.6%	CLIMATIK	Versailles
CENTRAL	Limousin	16942	13.5%	NASA	
NORTH	Lower-Normandy	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	Picardy	19399	22.2%	NASA	
NORTH-EAST	Alsace	8280	9.9%	CLIMATIK	Entzheim
NORTH-EAST	Franche-Comté	16202	19.4%	CLIMATIK	Meythet
NORTH-EAST	Lorraine	23547	28.2%	CLIMATIK	Tomblaine (Nancy)
NORTH-EAST	Rhône-Alpes	43698	52.4%	CLIMATIK	Romans-sur-Isère
WEST	Brittany	27208	100.0%	CLIMATIK	St Jacques de la Lande
SOUTH	Corsica	8680	7.7%	CLIMATIK	Lucciana
SOUTH	Languedoc-Roussillon	27376	24.3%	CLIMATIK	Mauguio
SOUTH	Midi-Pyrenees	45348	40.2%	CLIMATIK	Blagnac
SOUTH	Provence-Alpes-Côte d'Azur	31400	27.8%	CLIMATIK	Fourques
SOUTH-WEST	Aquitaine	41309	41.6%	CLIMATIK	Cestas
SOUTH-WEST	Pays de la Loire	32082	32.3%	CLIMATIK	Beaucouze
SOUTH-WEST	Poitou-Charentes	25810	26.0%	CLIMATIK	Lusignan

Table 87: Weighted mean monthly rainfall for each soil loss region from 2005 to 2009

Reg./month	CENTRAL	NORTH	NORTH-EAST	WEST	SOUTH	SOUTH-EAST
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**	**7582**
% area	20.61	23.39	26.10	13.71	10.82	5.38

Table 88: Weighted mean monthly temperatures for each soil loss region from 2005 to 2009

°C	CENTRAL	NORTH	NORTH-EAST	WEST	SOUTH	SOUTH-EAST
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
% area	20.61	23.39	26.10	13.71	10.82	5.38

These temperatures and rainfall were used to calculate K for each region shown in the right hand column of **Table 82**. Different weighting approaches were possible for the plant LCI data sets:

a) "French average" factors: R and K were weighted on the basis of the area of agricultural area per region
b) regional weighting: R and K were weighted depending on the average EAA for 2005 to 2009 per region per crop, based on data from the annual agricultural statistics (AGRESTE, 2005-2009) depending on the representativeness of the particular regions used for the data set.
c) values from a particular region: some crops were characterized for clearly defined regions (eg: carrots in Aquitaine, grassland in Auvergne). In these cases the factors for the region concerned were used without modification.

The slope length **LS** was set to 30 m . A fixed value of 2% was used for the slope which gave an LS of 0.27 (**Table 89**).

Table 89: Matrix for determining LS, based on data originally calculated for Michigan (http://www.iwr.msu.edu/rusle/lstable.htm)

	Slope length in feet (top row) and meters (second row))														
	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

	Slope length in feet (top row) and meters (second row))														
	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
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

C was calculated as the product of C1 and C2, i.e. depending on:

- The type of crop
- The type of tillage that causes the most soil loss using the following factors (**Table 90**). If several productions systems have been included in an average data set and the soil is tilled using different methods, C2 was weighted depending on the percentage of area concerned entered in the data collection module.

For soil-based crops grown in a greenhouse, C1 was taken to be the same as that used for orchards / fruit trees.

Table 90: Defining C1 and C2, depending on the type of crop and tilling method, source http://www.omafra.gov.on.ca/english/engineer/facts/00-001.htm

C1 Type of crop	C1
Fruit trees	0.10
Cereals (spring and fall)	0.35
Arable crop, not listed	0.42
Soil-based crop in greenhouse	0.05
Seasonal horticultural crop (including vine)	0.50
Hay and grazed grass	0.02
Beans, rapeseed, silage maize	0.50
Grain maize	0.40
C2 Soil tillage method	**C2**
Stubble plowing	0.60
Fall tillage	1.00
Spring tillage	0.90
No-till	0.25
Strip till	0.25
Ridge planting	0.35

P represents the way in which the farmer works the plot depending on the relief: in the direction of the slope or at right angles to it. P was set to 0.5 which is the value for contour farming. Contour farming works the land at right angles to the slope (**Table 91**) and reduces the risk of soil loss by runoff.

Table 91: Defining P depending on the orientation of the crop, source: http://www.iwr.msu.edu/rusle/lstable.htm

Support Practice (USLE)	P
Contour farming	0.50
Cross Slope	0.75
Strip cropping, contour	0.25
Strip cropping, cross slope	0.37
Up and Down Slope	1.00

3 Special cases

a) Permanent crop systems

The same approach was used for permanent crop systems (alfalfa, temporary grassland, orchards, grapevines, coffee and clementines). As the crops are planted (tillage/sowing) the first year only, the quantity of soil lost had to be calculated differently for years 2 to x with C2 set to 0.25 (equivalent to no till).

b) Calculating R for clementines

R was calculated for clementines using average regional data for rainfall (**Table 92**) as 60. K was 0.32 depending on the silt-clay content of the soil. Values for France were used for the slope, C1, C2 and P.

Table 92: Monthly rainfall in Morocco. Source: CIRAD (2013)

JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEP	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) Soil loss for tropical crops

As no data was available for the calculations, the quantity of soil lost could not be calculated and was taken to be zero for coffee (Brazil) and for rice (Thailand).

d) Soilless crops

There was no soil loss for soilless crops and the quantity of soil lost was zero.

Datasheet 6: Combustion emissions

1 General information

The model proposed in ecoinvent v2 (Nemecek and Kägi, 2007) was used with modifications.

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2 Parameters for plant and livestock production

16 substances emitted from burning fuel by powered machines are taken into account in ecoinvent v2 (Nemecek and Kägi, 2007).

Two different formulae are used:

- Ecoinvent formulae for CO, HC and NO, taking account of the speed and power of the machine, are used to calculate standard emissions per hour of operation (g/h) for each process considered. The standard values are then multiplied by the operation time for the process.
- The emission factors per kg of fuel consumed were calculated for the other gaseous emissions. These factors are fixed and are the same for all processes.

In AGRIBALYSE, all the emissions were calculated using fixed emission factors per kg of fuel, assuming the same average speed and power.

Table 93: Emissions of substances for diesel and gasoline (Nemecek and Kägi, 2007)

Substance	DIESEL (g/kg)	GASOLINE (g/kg)
Ammonia	0.0200	0.0400
Benzene	0.0073	9.4800
Benzo(a)pyrene)	3.0E-08	4.0E-05
Cadmium	1.0E-08	1.0E-05
Carbon dioxide, fossil	3120	3000
Carbon monoxide, fossil	5.4300	633
Chromium	5.0E-05	5.0E-05
Copper	0.0017	0.0017
NMVOC, non-methane volatile organic compounds	2.6500	10.9
Methane	0.1290	2.92
Nickel	7.0E-05	7.0E-05
Mono-nitrogen oxides (NOx)	41.8000	20.000
Dinitrogen oxide (N_2O)	0.1200	0.1300
Particulates, < 2.5 um	4.3200	3.0200
Sulfur dioxide	1.0100	0.0720
Zinc	0.0010	0.0010
Heat, waste	45.4 MJ	45.1 MJ

Heating emissions (in greenhouses and livestock buildings) were included by multiplying the quantity of fuel by the existing ecoinvent LCI data sets (**Table 94**). As the greenhouse heating systems are included in the AGRIBALYSE greenhouse LCI data set, the ecoinvent LCI data sets had to be modified by removing the boiler input.

Table 94: Heating systems and assignment to existing modified LCI data sets

Fuel	ecoinvent LCI data set	Comments
Livestock production		
Fuel oil	Light fuel oil, burned in boiler 100kW condensing, non-modulating/MJ/CH	
Natural gas	Natural gas, burned in boiler condensing modulating <100kW/MJ/RER	
Propane/butane	Natural gas, burned in boiler condensing modulating <100kW/MJ/RER	
Plant production		
Waste wood	Logs, softwood, burned in furnace of greenhouse/MJ/CH	No boiler (included in greenhouse LCI data set)
Coal	Hard coal, burned in furnace of greenhouse/MJ/RER	
Light fuel oil	Light fuel oil, burned in furnace 1MW of greenhouse/MJ/RER	
Heavy fuel oil	Heavy fuel oil, burned in furnace 1MW of greenhouse/MJ/RER	
Natural gas	Natural gas, burned in furnace >100kW of greenhouse/MJ/RER	
Propane	Natural gas, burned in furnace >100kW of greenhouse/MJ/RER	
Diesel	Diesel, burned in cogen 200kWe of greenhouse/MJ/CH	

<u>Comment on "waste wood" fuel.</u> There was no available LCI data set for "burning waste wood" or "waste wood" in ecoinvent 2.0. As the waste wood had to be prepared (eg shredded), the "soft wood" LCI data set was selected as a first estimate even though the impact was probably greater than waste wood.

Datasheet 7: Methane (CH_4)

1 General information

Table 95: Models selected for each source of emissions

Source of CH_4 emissions	Model selected
Enteric emissions	
Cattle	**IPCC 2006b Tier 2**
Sheep	**IPCC 2006b Tier 2**
Goats	**IPCC 2006b Tier 1**
Pigs	**IPCC 2006b Tier 1**
Poultry	**IPCC 2006b Tier 1**
Excretions in buildings and during storage	**IPCC 2006b Tier 2**
Excretions in grasslands and outdoor runs	**IPCC 2006b Tier 2**
Thai rice	**IPCC 2006b Tier 2**

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2 Parameters for livestock production: enteric emissions

1. Animal class definitions

Table 96: Correspondence between the AGRIBALYSE animal classes and the categories defined by the IPCC. Level of precision used to calculate the enteric methane emissions

AGRIBALYSE classes	IPCC-enteric CH4 emission classes	Method
Suckler cow - Replacement heifers +2 yrs	Other cattle	Tier 2
Suckler cow - Replacement heifers 0-1 yr	Other cattle	Tier 2
Suckler cow - Replacement heifers 1-2 yrs	Other cattle	Tier 2
Suckler cow - Genitors	Other cattle	Tier 2
Suckler cow - Suckler cows	Other cattle	Tier 2
Suckler cow - Cull cows at end of life	Other cattle	Tier 2
Suckler cow - Calf 0-1 yr	Other cattle	Tier 2
Beef cattle - Fattened steer or heifer + 2 yrs	Beef cattle	Tier 2
Beef cattle - Fattened steer or heifer 1-2 yrs	Beef cattle	Tier 2
Beef cattle - Calf <1 yr	Beef cattle	Tier 2
Dairy cow - Replacement heifers +2 yrs	Dairy cow	Tier 2
Dairy cow - Replacement heifers 1-2 yrs	Dairy cow	Tier 2
Dairy cow - Replacement heifers weaning-1 yr	Dairy cow	Tier 2
Dairy cow - Cull cows at end of life	Other cattle	Tier 2
Dairy cow - Dairy cow in production	Dairy cow	Tier 2
Dairy cow - Calf ("1 week" - weaning)	Dairy cow	Tier 2
Dairy cow - Calf (birth -"1 week")	Dairy cow	Tier 2
Milk goat - Kids (0 - 1 week)	Goat	Tier 1
Milk goat - Goat in production	Goat	Tier 1
Milk goat - Replacement kids 0-1 yr	Goat	Tier 1
Milk goat - Replacement kids 1-2 yrs	Goat	Tier 1
Rabbit - Fattening		
Rabbit - Breeding		
Milk ewe - Replacement lambs (0-weaning)	Lamb < 1 yr	Tier 2
Milk ewe - Replacement gimmer 0-1 yr	Lamb < 1 yr	Tier 2
Milk ewe - Replacement gimmer 1-2 years	Sheep	Tier 2
Lamb - Raising lambs	Sheep	Tier 2
Lamb - Lambs 0-weaning	Lamb < 1 yr	Tier 2
Lamb - Lambs weaning-sale	Lamb < 1 yr	Tier 2
Lamb - Replacement gimmer 1-2 years	Lamb > 1 yr	Tier 2
Lamb - Replacement gimmer weaning -1 yr	Lamb > 1 yr	Tier 2
Lamb - Ewe in production	Lamb > 1 yr	Tier 2
Lamb - Raising lamb	Lamb < 1 yr	Tier 2
Fattening duck - force feeding	Poultry	
Fattening duck - before force feeding	Poultry	
Fish - Sea bass / sea bream hatchery		
Fish - Trout hatchery		

AGRIBALYSE classes	IPCC-enteric CH4 emission classes	Method
Fish - Sea bass / sea bream fattening		
Fish - Trout fattening		
Pig - Suckling	Swine	Tier 1
Pig - Fattening	Swine	Tier 1
Pig - Post weaning	Swine	Tier 1
Beef calf	Beef cattle	Tier 2
Poultry - Broiler	Poultry	
Poultry - Replacement reproductive	Poultry	
Poultry - Layers	Poultry	
Poultry - Chickens	Poultry	
Poultry - Reproductives	Poultry	

2. Tier 1: emission factors

Table 97: Emission factors for enteric methane used for Tier 1 animal classes

Type of animal - IPCC name	Emission factor for developed countries – kg CH_4/head/yr
Goat	5
Goat	5
Swine (pigs)	1.5
Swine (pigs)	1.5

3. Tier 2: emission factors

Equation used

$$EF = \left[\frac{EC * \left(\frac{Y_m}{100}\right) * 365}{55.65} \right]$$

Where:

EF is the emission factor (kg CH_4/head/yr)
EC is the energy consumed (MJ/head/day)
Y_m is the methane conversion factor (%EC converted into CH_4)
55.65 is the energy content of methane (MJ/kg CH_4)

Table 98: Methane conversion factor

Type of animal - IPCC name	Methane conversion factor –according to IPCC
Sheep	6.5%
Lambs < 1 year	4.5%
Dairy cows	6.5%
Other cattle	6.5%

Calculating the energy consumed

- Data source: formulation of feed mixes and composition of rations contained in the data collection module
- Source of nutrition information: INRA tables (1988, 1989, 2007), Sauvant *et al* (2004), internal IDELE data.

- ✓ Determine the energy consumed (MJ/animal/day)

The emission factors were calculated

- ✓ Using the IPCC equations (2006b)

The enteric methane emissions for each feed ration were calculated and then averaged for the animal class and type of farm.

3 Parameters for livestock production: Managing excreta

1. Defining excreta management systems

Table 99: Correspondence between the excreta produced by animals in AGRIBALYSE and the IPCC excreta management systems

Type of excretion in AGRIBALYSE (harmonized list)	Management systems in IPCC 2006	System description
-Chicken manure, outdoor run **-Turkey manure, outdoor run** **-Layer hen manure, outdoor run** **-Duck manure, outdoor run** **To be defined**	Pasture/range/paddock	Excreta from animals at grass or in outdoor runs remains in situ and is not managed.
-Average cattle manure **-Wet cattle manure** **-Goat manure** **-Broiler manure** **-Horse manure** **-Sheep manure** **-Straw rich cattle compost** **-Straw rich cattle compost** **-Straw rich pig compost** **-Sheep manure compost** **-Straw rich pig slurry**	Solid storage	Manure stored in heap or stack outdoors, usually for several months. The manure can be stacked as it contains enough litter or loses enough moisture through evaporation.
-Average cattle slurry **-Diluted cattle slurry** **-Undiluted cattle slurry** **-Duck (for roasting or force fed) slurry** **-Rabbit slurry** **-Mixed pig slurry** **-Beef calf slurry** **-Effluent with low solids**	Liquid/slurry	Excreta stored as excreted by the animal or with addition of minimum amount of water, either in tanks or in pits outside the animal enclosures, usually for less than one year.
-Bedded pack cattle manure **-Bedded pack pig manure**	Deep bedding, cattle and swine	The bed of straw is built up gradually to absorb the moisture during the production period, sometimes for 6 to 12 months. This management system for livestock buildings can be combined with feedlots and pasture.

Type of excretion in AGRIBALYSE (harmonized list)	Management systems in IPCC 2006	System description
-Turkey manure **-Manure from ducks ready for force feeding**	Poultry manure with litter	Similar to bedded pack for cattle and swine except that it is not generally combined with feedlots or pasture. Generally used for poultry production except layers.
-Dry poultry droppings **-Layer manure**	Poultry manure without litter	May be similar to "pit storage below animal confinements" or may be created to dry the manure as it accumulates. This latter technique is a high heap manure management system and is a form of wind row composting.

2. Tier 2: emission factors

Equation used:

$$FE_{(T)}F = \left(VS_{(T)} * 365\right) * \left[B_{0(T)} * 0.67kg \Big/ m^3 * \sum_{S,k} \frac{FMC_{S,k}}{100} * GF_{(T,S,k)}\right]$$

Where:

$EF_{(T)}$ is the emission factor for the category *T* in kg CH_4/head/yr

$VS_{(T)}$ is the volatile solids excreted daily by the category *T* in kg DM/head/day

365 is the conversion of VS production to per year

$B_{0(T)}$ is the maximum CH_4 production capacity for the manure produced by the category *T* in m^3 CH_4/kg VS excreted

$FMC_{(S,k)}$ is the CH_4 conversion factor for the management system *S* for each climatic region *k*, in %

$GF_{(T,S,k)}$ is the fraction of the category *T* manure processed using the management system *S* in the climatic region *k*

Table 100: $B_{0(T)}$ used for AGRIBALYSE animal classes. Source: IPCC 2006b pages 10.91 to 10.97.

AGRIBALYSE class	IPCC-CH_4 enteric classes	$B_{o(T)}$ (m^3 CH_4/kg VS excreted)
Suckler cow	other cattle	0.18
Beef cattle	beef cattle	0.18
Dairy cow	dairy cows	0.24
Milk goat	goats	0.18
Ewe	sheep	0.19
Lamb	lamb < 1 year	0.19
Fattening duck	poultry	0.36
Pig	swine	0.45
Beef calf	beef cattle	0.18
Broiler	poultry	0.36
Poultry - Replacement reproductives	poultry	0.375
Poultry - Layers	poultry	0.39
Poultry - Chickens	poultry	0.39
Poultry - Reproductives	poultry	0.375

- Calculating the quantities of volatile solids excreted daily

Equation used:

$$SV = \left[EC * \left(1 - \frac{DF\%}{100}\right) + (UE * EC)\right] * \left[\left(\frac{1 - ASH}{18.45}\right)\right]$$

Where:

VS is the volatile solids excreted daily on the basis of dry organic matter, in kg DM/head/day

EC is the energy consumed, MJ/day

DF% is the digestibility of feed

(UE*EB) is the urinary energy expressed as a fraction of the EC

ASH is the ash content of the ration

18.45 is the conversion factor for the EC of the diet in MJ/kg DM

=> EC is the energy consumption

Calculated from the data in the data collection module: raw materials (RM) of feed/composition of rations:

- EC of RM -> source is the INRA tables (1988, 1989, 2007) + Sauvant *et al* (2004) + internal IDELE data
- EC energy consumed is the ∑ of EC of RM in the ration

=> DF% is the digestibility of feed (INRA tables)

Calculated from the data in the data collection module: raw materials (RM) of feed/composition of rations:

- DF% of RM -> source is the INRA tables (1988, 1989, 2007) + Sauvant *et al* (2004) + internal IDELE data
- DF% consumed is the ∑ of DF% of RM in the ration

=> (UE*EC) is the urinary energy expressed as fraction of the EC

Table 101: Urinary energy for each type of animal. Source: IPCC (2006b), volume 4.10, pages 10.50

type of animal	Urinary energy
Ruminants	0.04*EC
Ruminants with cereals > 85% in the food ration	0.02*EC
Other animals	0.02*EC

=> ASH is the ash content in the feeds

OM is the organic matter content in the excreta (%)

Table 102: Composed and raw feeds used in AGRIBALYSE, dry matter and ash content (Sauvant et al, 2004)

Ingrédient	MS%	MAT	Cendres (% MF)
Corn starch	88,10	0,80	0,20
Potatoe starch	83,00	0,80	0,25
Other: alfalfa proteine concentrate	91,80	50,20	11,20
Oat	88,10	9,80	2,70
Organic barley	88,10	9,80	2,70

Ingrédient	MS%	MAT	Cendres (% MF)
Wheat	86,80	10,50	1,60
Soft Wheat	86,80	10,50	1,60
Soft Wheat, organic	86,80	10,50	1,60
Soft wheat, no transportation	86,80	10,50	1,60
Soft wheat, local	86,80	10,50	1,60
Potatao proteine concentrate	92,30	77,60	0,90
Soy protein concentrate	87,60	43,30	
Fish protein concentrate	96,00	72,50	6,60
Corn gluten feed	88,00	19,30	6,40
DL Méthionine	99,50	58,40	
grass wrapping	55,00	7,37	
grass wrapping, sheep meadows with legumes	55,00	7,37	
grass wrapping, permanent meadows with legumes	55,00	7,37	
Grass silage	33,50	4,66	3,36
Grass silage, organic	33,50	4,66	3,36
Maïs silage	35,00	2,83	1,86
Maïs silage, organic	35,00	2,83	1,86
grass silage, permanent meadows without legumes	33,50	4,66	3,36
grass silage, permanent meadows with legumes	33,50	4,66	3,36
Soft wheat flour	88,20	12,70	2,40
Mais flour	87,30	9,00	2,30
Fish Flour from South America	94,30	62,60	20,80
Fish Flour from North America	94,30	62,60	20,80
Fish Flour from market (Europe)	94,30	62,60	20,80
Blood flour	90,00	84,00	4,45
White Faba bean	86,10	26,80	3,60
Colored faba bean, organic	86,50	25,40	3,60
Hay	85,00	13,10	7,17
Hay, organic	85,00	13,10	7,17
Alfalfa hay	85,00	13,10	7,82
Hay, permanent meadows Auvergne (68%) + temp. meadow (32%) North-West, sheep	85,00	13,10	7,17
Hay, permanent meadows Auvergne (14%) + temp. meadow (86%) North-West	85,00	13,10	7,17
Hay, permanent meadows Auvergne (20%) + temp. meadow (80%) North-West, sheep	85,00	13,10	7,17
Hay, permanent meadows Auvergne (24%) + temp. meadow (76%) North-West, sheep	85,00	13,10	7,17
Hay, permanent meadows Auvergne (25%) + temp. meadow (75%) North-West, sheep	85,00	13,10	7,17
Hay, permanent meadows North-West	85,00	13,10	7,17
Hay, permanent meadows, with legumes, North-West, goats	85,00	13,10	7,17
Hay, permanent meadows, without legumes, Auvergne	85,00	13,10	7,17
Hay, permanent meadows, without legumes, Auvergne, sheep	85,00	13,10	7,17
Hay, permanent meadows, with legumes, North-West	85,00	13,10	7,17
Wheat gluten feed	90,60	14,70	7,40
Rapeseed grain	92,20	19,10	4,00
Soy grain	88,10	34,80	5,20

Ingrédient	MS%	MAT	Cendres (% MF)
Soy grain, organic	88,10	34,80	5,20
Extruded Soy grain	88,10	34,80	5,20
Sunflower grain	93,00	16,00	3,40
Sunflower grain, organic	93,00	16,00	3,40
L-Lysine HCl	99,50	95,40	
L-Thréonine	99,50	73,10	
L-Tryptophane	99,50	85,30	
Milk for lambs	13,00	32,76	0,80
Milk for calves	13,00	32,76	0,80
Beer yeasts	93,30	46,50	
Deshydrated alfalfa	91,40	13,80	9,90
Deshydrated organic alfalfa	91,40	13,80	9,90
Mais grain	86,40	8,10	1,20
Mais grain, organic	86,40	8,10	1,20
Wheat Mais grain	64,80	6,10	0,90
Wheat Mais grain/local	64,80	6,10	0,90
Canne molasse	73,30	4,00	1,10
Barley	86,70	10,10	2,20
Barley, organic	86,70	10,10	2,20
Barley, no transport	86,70	10,10	2,20
Barley, local	86,70	10,10	2,20
Untreated straw	88,00	3,80	5,90
Permanent meadow, with legumes, North-West of France	20,00	3,44	2,00
Permanent meadow, Auvergne	20,00	3,44	2,00
Permanent meadow,with clover, Britanny	20,00	3,44	2,00
Temporary meadow,with clover, Britanny	20,00	3,44	2,00
Temporary meadow,with clover, organic, Britanny	20,00	3,44	2,00
Temporary meadow,without clover, Britanny	20,00	3,44	2,00
Permanent meadow, without legumes, Auvergne	20,00	3,44	2,00
Permanent meadow, without legumes, sheep, Auvergne	20,00	3,44	2,00
Permanent meadow, without legumes, North-West	20,00	3,44	2,00
Temporary meadow,with legumes, North West	20,00	3,44	2,00
Temporary meadow,without legumes, North West	20,00	3,44	2,00
Protein pea	86,40	20,70	3,00
Protein pea, organic	86,40	20,70	3,00
Lactoserum powder, without lactose	96,40	12,60	8,70
Sweet lactoserum powder	96,00	12,80	7,80
Skimmed milk powder	94,70	34,10	8,20
Soy protein (flour)	87,60	43,30	
Deshydrated Limon pulp	89,30	6,30	6,30
Deshydrated beetroot pulp	89,10	8,10	6,30
Wheat bran	87,90	14,90	3,40
Lard	100,00	0,00	
Soft Wheat bran	87,10	14,80	5,00
Soft Wheat bran, organic	87,10	14,80	5,00
Tallow	100,00	0,00	
Peanut meal	89,60	48,90	6,00
Rapeseed meal	88,70	33,70	7,00
Rapeseed meal, organic	88,70	33,70	7,00
Soy meal	87,60	43,30	6,50
Soy meal, organic	87,60	43,30	6,50
Sunflower meal	88,70	27,70	6,20
Sunflower meal, organic	88,70	27,70	6,20
Sunflower meal, raw	88,70	27,70	6,20
Sunflower meal, semi-shelled	89,70	33,40	6,70
Triticale	87,30	9,60	1,90
Triticale organic	87,30	9,60	1,90

Ingrédient	MS%	MAT	Cendres (% MF)
Urea	98,00	13,13	
If no data==> average value	**78,24**		**4,82**

4 Parameters for plant production: methane emissions from paddy fields

Assumptions:
Rice growing period = 120 days
Watering system during the rice growing period = permanently flooded
Irrigated: straw plowed in less than 30 days before planting
Rainfed: straws plowed in more than 30 days before planting

Thailand is the only country in South East Asia that uses specific emission factors for methane. These recently established standards can be used at country level to evaluate the total emissions but do not reflect the importance of conditions on the ground, crop systems and water management in determining CH_4 emissions.
The IPCC guidelines (2006b) propose a model for calculating daily emissions based on an emission factor EFc (Equation 1).

$$EF_i = EF_C \cdot SF_w \cdot SF_p \cdot SF_0 \cdot SF_{s,r} \qquad \text{(Equation 1)}$$

Where:

EF_i is the daily emission factor, adjusted for a given region, kg-CH_4.ha^{-1}.j^{-1}

EF_C is the basic emission factor for permanently flooded paddy fields without added organic matter

SF_w is the correction to take account of differences in watering during the growing period

SF_p is the correction to take account of differences in watering during the period before the crop

SF_0 is the correction to take account of the type and quantity of organic matter added

$SF_{s,r}$ is the correction for the type of soil, cultivar, etc, if available

EFc is based on the following specific growing conditions:

- The period for which the plots are not flooded before the rice is planted is less than 180 days (or the plot was replanted less than 180 days after the previous flooded crop, resulting in situation approaching multiple cropping)
- Continuous immersion during the growing period
- No organic fertilization or incorporation of residues

<u>Basic emission factor EFc</u>

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 conditions in Thailand because of the high soil, air and water temperatures, as well as significant solar radiation, factors known to have a determining effect on CH_4 emissions (increase in emissions). Specific emission factors were determined based on IPCC recommendations (2006b) and the experimental results of Yan *et al* (2003a) (**Table 103**).

Table 103: Methane emission factors EFc in the two Thai regions studied (kg-CH_4.ha^{-1}.j^{-1})

Region	EFc
North	**2.04**
North-East	**3.12**

Source: Yan *et al* (2003a).

All correction factors were determined using the average values recommended by IPCC (2006b).

Correction factors for watering (SFw and SFp)

SFw takes account of differences in watering during the growing period. IPCC (2006b) suggests using the values given in **Table 104**.

Table 104: Correction factors for watering during the growing period, SFw

Continuously flooded irrigation	Intermittent irrigation (single aeration)	Intermittent irrigation (multiple aeration)	Rainfed (regular)	Rainfed (drought prone)
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 factors were similar for both regions studied (North and North-East), the calculations take account of the two growing periods in both regions, *i.e.* dry and wet seasons. Specific conditions were also taken into account. For example, in the North East, because the area is drought prone, paddy fields are often irrigated even in the wet season as rainfed cultivation is not appropriate.

SFp takes account of differences in watering before the rice is planted. IPCC (2006b) suggests using the values given in **Table 105**.

Table 105: SFp, correction factors for water management before the crop is planted (preseason)

Preseason not flooded > 180 days	Preseason not flooded < 180 days	Preseason flooded > 30 days
0.68	**1**	**1.90**

Source: IPCC (2006b). Short flooding periods (< 30 days) for land preparation are not considered.

Correction factor for application of organic fertilizers

SFo takes account of the type and quantity of added organic matter. Equation 2 is used to determine SFo (IPCC, 2006b).

$$SF_0 = \left(1 + \sum_i ROA_i \cdot CFOA_i\right)^{0.59} \quad \text{(Equation 2)}$$

Where:

SF_0 is the correction factor for the type and quantity of organic matter applied.

ROA_i is the quantity of organic matter applied, tonne DM rice straw.ha^{-1}).

$CFOA_i$ is the conversion factor for organic fertilizer i, based on its effect relative to the straw applied shortly before establishing the crop (IPCC, 2006b)

According to field observations in the regions studied, organic amendments are limited to rice straw remaining in the field. The literature considers in general that there is a 1:1 ratio of dry grain to straw. Assuming an average dry grain yield from the previous year, the weight of dry straw will be between 3.4 tonnes.ha^{-1} in the north and 2.7 tonnes.ha^{-1} in the north east. This straw is returned to the fields and plowed in.

These amendments correspond to the basic value of ROA. **Table 106** gives alternative values for cases when the straw is burnt or grazed before being plowed in. These scenarios are ignored in AGRIBALYSE, even though these practices may well be used in the regions studied.

Table 106: ROA, organic amendments applied, straw returned to the field and plowed in (tonnes.ha^{-1}).

Incorporation of all residues in the soil	Grazing	Straw burned 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 CFOA conversion factors for organic amendment are given in **Table 107**.

Table 107: CFOA, conversion factor for organic amendment

Straw incorporated less than 30 days before crop is planted	Straw incorporated more than 30 days before crop is planted
1	**0.29**

Source: IPCC (2006b)

Table 108: Emission and correction factors, based on IPCC recommendations IPCC (2006b) and Yan *et al* (2003) for conditions in northern Thailand

Factors having an impact on emissions	Correction factors for emissions for each condition											
1.) Agro-ecological zone	North											
2.) Growing period	Wet season						Dry season					
3.) Cultivation system	Rainfed		Irrigated				Irrigated					
Basic default emission factor (kg-CH_4.ha^{-1}.j^{-1})	2.04		2.04				2.04					
3.1) Watering before establishing crop	Preseason not flooded > 180d		Preseason not flooded < 180 d				Preseason not flooded < 180 d					
	0.68		1				1					
3.2) Watering during growing period	Rainfed regular		Continuously flooded irrigation		Intermittent irrigation (single aeration)		Continuously flooded irrigation		Intermittent irrigation (single aeration)		Intermittent irrigation (multiple aeration)	
	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 amendment	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} j^{-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**

Table 109: Emission and correction factors, based on IPCC recommendations IPCC (2006b) and Yan *et al* (2003) for conditions in north eastern

Factors having an impact on emissions	**Correction factors for emissions for each condition**											
1.) Agro-ecological zone	North-East											
2.) Growing period	Wet season								Dry season			
3.) Cultivation system	Rainfed				Irrigated				Irrigated			
Basic default emission factor (kg-CH_4.ha^{-1}.j^{-1})	3.12				3.12				3.12			
3.1) Watering before establishing crop	Preseason not flooded > 180 d				Preseason not flooded < 180 d				Preseason not flooded < 180 d			
	0.68				1				1			
3.2) Watering during growing period	Rainfed regular		Rainfed drought prone		Continuously flooded irrigation		Intermittent irrigation (single aeration)		Intermittent irrigation (single aeration)		Intermittent irrigation (multiple aeration)	
	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 amendment	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} j^{-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**

Datasheet 8: Nitric oxide (NO)

For direct (on farm) emissions, only nitric oxide (NO) could be modeled based on avaiblable data and models. For indirect emissions, obtained from ecoinvent v.2.0/2.2 datasets, NOx (NO+ NO_2) emissions are provided. Thus, AGRIBALYSE® provides LCI results as NOx.

1 General information

Table 110: Models selected for each source of emissions

Source of emissions	Model selected
Excretions in buildings	**EMEP/EEA 2009, Tier 1**
Excretions during storage	**EMEP/EEA 2009, Tier 1**
Mineral and organic fertilizer	**EMEP/EEA 2009, Tier 1**
Thai rice	**Yan *et al*, 2003(b)**

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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.

2 Parameters for livestock production: excretions in buildings and during storage

The emission factors proposed by the EMEP/EEA (2009) method depend on the type of animal and the type of effluent (**Table 111**). They apply to the Annual Average Population (AAP) of animals. The number of animals per class (entered in the data collection module) was, therefore, weighted by the length of time each class of animal was present.

The assignment of animals in AGRIBALYSE to the type of animals in EMEP/EEA (2009) is the same as that used for calculating the NH_3 emissions (see datasheet 1).

The allocation between solid and liquid manure is based on the data in the LCI data sets calculated in the NH_3 model.

Table 111: NO emission factors used for AGRIBALYSE (AAP = Annual Average Population)

Type of animal	Excretion	Factor (kg NO/AAP)
Other cattle (young cattle, beef cattle and suckling cows)	liquid	0.002
Other cattle (young cattle, beef cattle and suckling cows)	solid	0.094
Sheep (and goats)	liquid	0
Sheep (and goats)	solid	0.005
Fur animals	liquid	0
Fur animals	solid	0.0002
Broilers (broilers and parents)	liquid	0.001
Broilers (broilers and parents)	solid	0.001
Fattening pigs (8-110 kg)	liquid	0.001
Fattening pigs (8-110 kg)	solid	0.045
Laying hens (laying hens and parents),	liquid	0.0001
Laying hens (laying hens and parents),	solid	0.003
Sows (and piglets to 8 kg)	liquid	0.004
Sows (and piglets to 8 kg)	solid	0.132
Other poultry (geese)	liquid	0.001
Other poultry (geese)	solid	0.001
Other poultry (turkeys)	liquid	0.005
Other poultry (turkeys)	solid	0.005
Dairy cows	liquid	0.007
Dairy cows	solid	0.154
Other poultry (ducks)	liquid	0.0104
Other poultry (ducks)	solid	0.004

3 Parameters for plant production: organic and mineral fertilizers

The parameters were defined according to the EMEP/EEA (2009) methodology, using the NO emission factor updated in 2013 (NJ Hutchings, 2012 personal communication), as there was a problem with the 2009 value. For both mineral and organic fertilizers, a single emission factor of 0.026 kg NO/kg N was applied to the quantity of nitrogen applied, after deducting the quantity of volatilized NH_3.

4 Parameters for plant production: Thai rice

Assumptions: Rice growing period = 120 days

Using an approach similar to that used for N_2O emissions (rice) but with fewer experimental results, Yan *et al*, (2003b) carried out a literature search for NO emissions. They defined: i) an emission factor for fertilization of 0.13% for each fertilizer unit applied and ii) base level emissions of 0.57 kg N-NO.ha^{-1}.yr^{-1}. Equation 1 is the NO emission calculation model for growing Thai rice used for AGRIBALYSE. However, this does not take account of intermittent irrigation periods, during which nitrification-denitrification processes occurred, leading to an increase in NO emissions.

$$\text{N-NO kg.ha}^{-1} = [0.0013 \times Nf] + [0.57 \times D/365] \quad \text{(Equation 1)}$$

Where:

Nf	is the total number of units applied by chemical fertilization, per hectare, during the growing period
0.0013	is the mean emission factor for fertilization (0.13%)
D	is the effective duration of the growing period
0.57	is the mean N-NO base level emissions during the year (kg.ha^{-1})
30/14	is the N-NO to NO conversion factor

Datasheet 9: Nitrate emissions (NO3-)

1 General information

Table 112: Models selected for each source of emissions

Source of emissions	Model selected
Annual French crops	**COMIFER 2001 adjusted (Tailleur *et al*, 2012)**
Grassland	**DEAC (Cariolle, 2002)**
Permanent crops and special French crops	**SQCB (Faist *et al*, 2009)**
Soilless or fertigated crops	**This report**
Tropical crops	**IPCC 2006b, Tier 1**
Thai rice	**This report**
Livestock production: outdoor runs	**Basset-Mens *et al*, 2007**

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2 Parameters for livestock production: storage of excreta at the edge of the field

This source of emissions was not taken into account. Although this subject is being studied, no useable data was available for setting the parameters for the calculation model.

3 Parameters for livestock production: outdoor runs

Based on their research, Basset-Mens *et al* (2007) calculated an emission factor of 17.5% of the nitrogen applied, for all types of livestock production.

4 Parameters for plant production: French arable crops

ARVALIS developed a model specifically to meet the AGRIBALYSE requirements based on the COMIFER table (2001).

This table proposed a qualitative approach applicable at plot scale to qualify the risk of leaching. It takes account of a “crop” risk and an “environment” risk (depending on the quantity of water percolating through the soil (CORPEN, 1991) and the mineralization conditions). However, the balance between nitrogen amendment and the crop requirements is not a parameter used in the COMIFER table. This was based on the assumption that there was no excess nitrogen fertilization for the previous crop to generate an excessive increase in the nitrogen residue.As the model required data that was not in the data collection module (information on the practices used for the following crops, soil-climate data), ARVALIS also applied this model to estimate nitrate emissions for the various major crops using statistical data on farming practices and an internal soil database. These emissions were estimated initially at plot scale and then averaged for administrative regions. For each crop, the average emissions at national level were calculated from the regional means weighted by the production volume. A sensitivity analysis was carried out to assess the effect of taking account of a fertilization management system not adapted to the crops on the estimates of the average quantities leached for each crop.

The main input data required for the modified COMIFER model (2001) are given in **Table 113.**

The approach for adjusting and implementing the model are described in more detail below.

Table 113: Main input data required to implement the models

Model	Input data
Methodology based on COMIFER model	Volume of production of the crop per region
	Following crop
	Intercrop following the crop studied
	Application of organic fertilizer in the fall
	Residue management
	Soil-climate data: water properties of the soil (characteristic humidity, root depth of crops), meteorological data (rain, potential evapotranspiration), organic matter content

General principles of the model

- ***Characterization of the "crop" risk***

The COMIFER model (2001) classifies conditions according to the following criteria, in order of importance.

1. Period without presence of vegetation able to absorb nitrogen (depending on the following crop and the planting of an intermediate crop)
2. Capacity of the following crop to absorb nitrogen in the fall (depending on the following crop)
3. Application of organic fertilizer in the fall (C:N ratio < 8)
4. Quantity of nitrogen provided by crop residues (depending on the crop studied and the residue management system)

It also classifies the risks for various growing conditions.

Table 114: Assessing the “crop” risk without effect of organic amendment

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)	Very long	+++	+	0	**very high**
Flageolet beans - maize		++	++	0	**very high**
Grain maize - maize		+++	+	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 criteria was drawn up on the basis of these table to estimate the risks for crop conditions not covered in the COMIFER classification.

- ***Characterization of the “environment” risk***

In the COMIFER model, the “environment” risk is defined by the combination of two criteria: i) the soil drainage index and ii) the organic matter content of the soil layer mineralization.

- ***Assignment of leaching quantities to each environment risk x crop risk combination***

The COMIFER model classifies the risk according to various crop risk x environment risk combinations. An average quantity of leached nitrate was determined for the time period starting from post-harvest to the beginning of the next winter drainage period, using experimental data and expert opinion. The matrix obtained was validated by the results of experiments undertaken at various sites with different environment and crop risks and for certain conditions not shown by estimates from the DEAC model (Cariolle. 2002; Jolivel. 2003).

Table 115: Quantity of nitrate (kg N-NO_3^-/ha per cropping campaign) for each crop risk - environment risk combination

		Crop risk				
		1	2	3	4	5
Environment 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

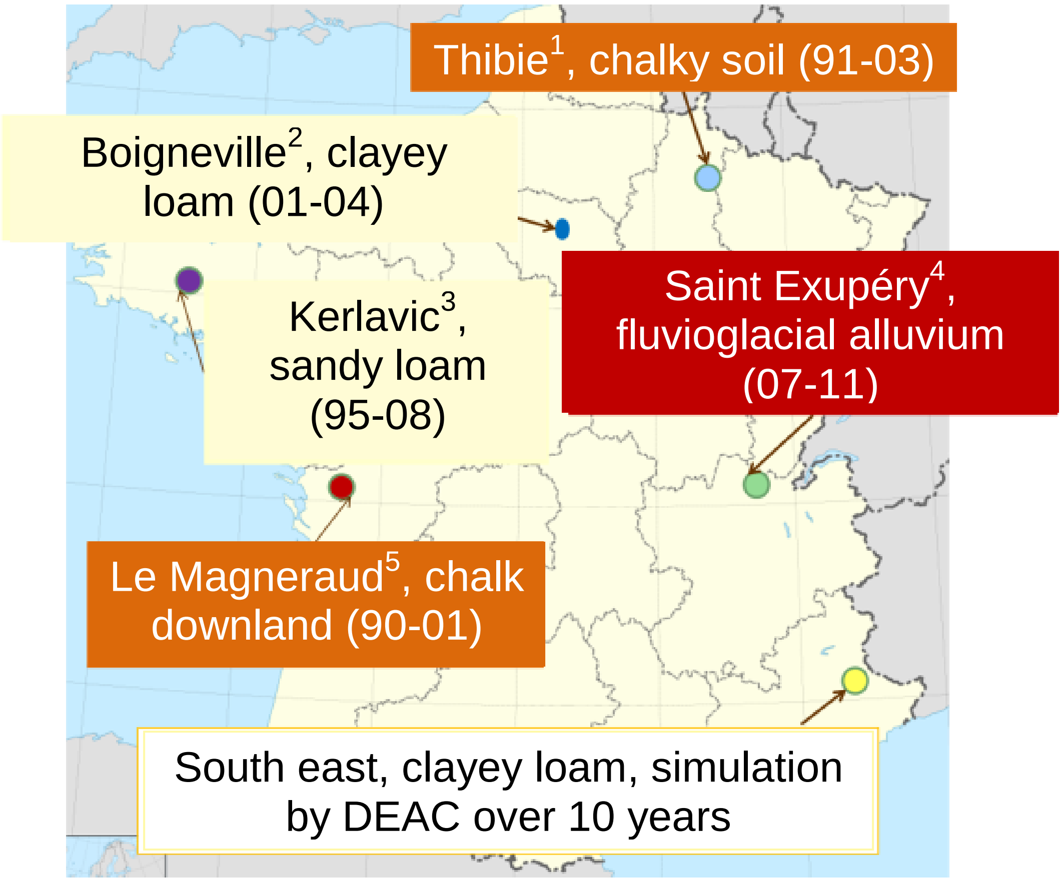

Figure 16: Experimental sites used to validate the values in the matrix (the experimental period is given in brackets), for example Le Magneraud 1990-2001 . [1] AREP, [2] ARVALIS, [3] CRB/ARVALIS, [4] ARVALIS/CREAS, [5] ARVALIS

Implementation of the model for the AGRIBALYSE® program

- ***Estimating the crop risks***

(i) For the national LCI data sets for main crops, the crop risk was estimated for the 10,000 plots covered by the SSP for the 2006 farming practices survey using the following information:
- residue management for the previous crop,
- use of an intermediate crop and the dates for drilling and harvesting to estimate the period without plants able to absorb nitrogen,
- application of organic matter in the fall: only spreading of slurry was taken into account as this is the main form of fertilizer with a C:N ratio of less than 8.

(ii) Still based on the farming practices survey, for each administrative region and each crop, the percentages of area occupied by each crop-to-crop combination were estimated for the preceding 5 crops. The data for the previous 5 years was used to reduce annual variations.
For example, in the Central region, 27% of area sown with soft wheat is followed by barley, 25% by soft wheat, 17% rapeseed, etc.

(iii) for each crop and each administrative region, the average risks were estimated for each crop – following crop combinations (cf **Table 116** for soft wheat in the Central region). The average risks for each crop and each administrative region were obtained from these risks for crop combinations weighted by the frequency of the combinations estimated in (ii).

Table 116: Average risk for soft wheat for each combination of soft wheat - following crop in the Central region

Crop → following crop combination	% area combination / total area soft wheat in the Central region	Crop risk score
Soft wheat → Durum wheat	1	4
Soft wheat → Soft wheat	25	4
Soft wheat → Rapeseed	17	1
Soft wheat → Silage maize	2	5
Soft wheat → Grain maize	10	4
Soft wheat → Winter barley	27	4
Soft wheat → Peas	3	4
Soft wheat → Sunflower	6	4
Weighted mean		3

The estimates for the percentage previous crop → following crop for each administrative region were compared with data from the agricultural census (2005-2009) to check their coherence. A sensitivity analysis showed that the crop risk estimates based on the farming practices survey and the agricultural census were similar.

Example
In Picardy, on the basis of the SSP survey, it was estimated that 8% of soft wheat plots were followed by peas. However, the average area under soft wheat in Picardy was 521,000 ha

and for peas it was 31,600 ha and so the percentage of soft wheat plots followed by peas could not be greater than 6%.

For the national LCI data sets for main crops not studied (triticale and faba beans), the risk was estimated on the basis of expert opinion and extrapolated from previous crops.

For organic crops (soft wheat, triticale and faba beans), data was taken from the standard cases selected.

- ***Estimating the environment risks***

The geographic French soil database managed by the INRA Soil Science Unit, Orleans, was used to estimate the "environment" risks. It describes a set of soil typology units, characterizing distinct types of soil. The soil typology units are described using attributes defining the nature and properties of the soils (eg: texture, water system, soil parent material, etc.).
The "environment" risk was estimated for each soil typology unit based on soil water retention capacity and climatic data from the Arvalis database covering 84 weather stations over the last 30 years. The areas corresponding to each risk category in each administrative region were then characterized to estimate the mean risk.

For re-using Nitrate emission model (**Table 115:** Quantity of nitrate (kg N-NO_3^-/ha per cropping campaign) for each crop risk - environment risk combination), especially at regional level, it is possible to estimate the environmental risk from the drainage index as described in Butler et al. (2012, table 9, figure 39) and COMIFER (2001).

- ***Estimating the quantities leached***

For each crop, the mean crop and environment risks for each of the administrative regions were used to estimate the quantities leached on the basis of the matrix **(Table 79).** The results were validated by comparing them with the literature where this was available for particular drainage basins (Thieu *et al*, 2010 ; Ducharne *et al*, 2007 et Ledoux *et al,* 2007).
These regional estimates were then weighted by the volume of production for the crop in each region to deduce the quantities of nitrate leached on average for each crop in France as a whole.

Taking account of the application of excess nitrogen

This was based on expert opinion as no information was available for estimating the frequency of "over fertilization" practices or on the excess quantities of nitrogen applied. An excess of 50 kg N/ha over the requirements of the crops was assumed to occur at a frequency of between 5% and 20%.

The relationship between the difference between the optimum dose of nitrogen and the stock of post harvest nitrate was determined during a COMIFER study and refined using subsequent ARVALIS data. The post harvest nitrate surplus resulting from an excess of 50 kg N/ha was used for each crop. Leaching factors to estimate the quantities leached from the surplus post harvest nitrate was defined for each soil risk level. For each crop, the surplus nitrogen leached was estimated for the overfertilized plots in each administrative region, by multiplying the post harvest surplus nitrate by the leaching factor for the mean soil risk in the administrative region. Depending on the environment risk, the estimates of the surplus nitrogen leached for plots used for cereals and rapeseed were between 7 and 12 kg $N\text{-}NO_3^-$/ha and for plots used for maize and sugar beet they were between 12 and 22 kg $N\text{-}NO_3^-$/ha.

For each crop, the mean leached quantities for each region were estimated assuming an application of an excess of 50 kg N/ha at different frequencies (5, 10, 15 and 20%). The results for the national means are given in figure 17. Depending on the frequency, there is an increase in leaching of 0 to 2 kg $N\text{-}NO_3^-$/ha for cereals and rapeseed and 1 to 3 kg $N\text{-}NO_3^-$ for maize and sugar beet compared with the initial estimates.

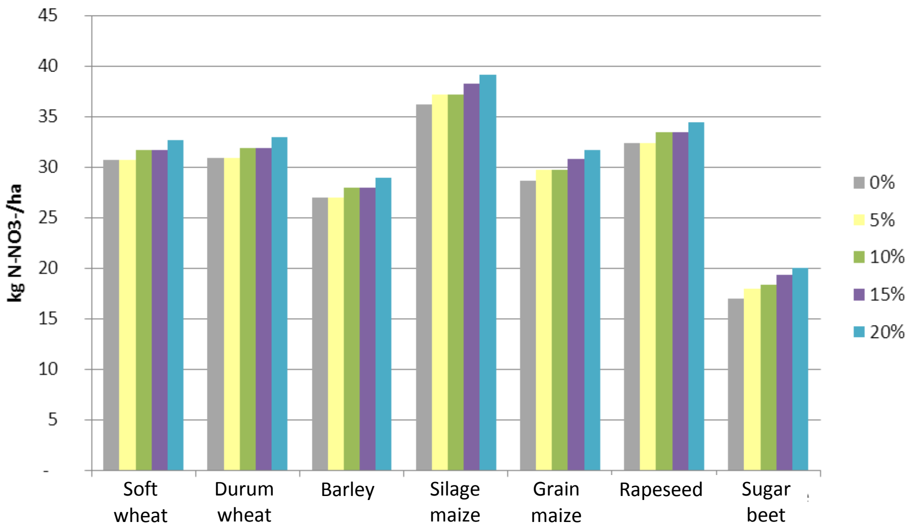

Figure 17: Effect of taking account of applying 50 kg N/ha excess nitrogen at varying frequencies on the estimated national average leaching

These results show that including the application of surplus nitrogen has little effect on the estimated average quantities leached per crop in France as a whole. The approach could, however, be improved (requires reliable estimates of the frequency of applying excess nitrogen and the quantities involved and the leaching factors for the surplus nitrate need to be consolidated).

5 Parameters for plant production: grassland / meadows

The DEAC model (Cariolle, 2002) was used. It takes account of the following parameters:

Table 117: Main input data required for using the models

Model	Input data
DEAC	Water leached
	Effective quantity of nitrogen applied
	Application over 100 units N after June 20 (yes / no)
	Proportion of legumes
	Proportion of grassland
	Nitrogen fertilization practices for previous crop

For "meadows with clover", as the proportion of legumes was relatively low (30%), the effect of the legumes on leaching was not taken into account.

Table 118 gives the annual leaching of $N\text{-}NO_3$ for various meadows and alfalfa. For temporary meadows and the two alfalfa crops, a one-off leaching correction due to plowing was taken into account (cf. column 3).

Table 118: Nitrate leached (kg N-NO_3 per hectare per year) from grassland and alfalfa, calculated using the DEAC model

Example: For one hectare of grassland on a temporary meadow without clover in the north west region (cf row "08 grazed grass…"), leaching was 23.5 kg N-NO_3 per hectare per year (=15 kg + 34 kg /4 yr – given that the temporary meadow is planted for 4 years).

LCI crop /data set	Annual leaching	Leaching (following plowing)
Grazed grass, permanent meadow, without clover, Auvergne	6	0
Baled grass, permanent meadow, without clover, Auvergne	2.7	0
Grass silage, horizontal silo, permanent meadow, without clover, Auvergne	3.6	0
Baled hay, permanent meadow, without clover, Auvergne	2.7	0
Grazed grass, permanent meadow, without clover, Northwestern region	20	0
Baled grass, permanent meadow, without clover, Northwestern region	18	0
Baled hay, permanent meadow, without clover, Northwestern region	23	0
Grazed grass, temporary meadow, without clover, Northwestern region	15	34
Baled grass, temporary meadow, without clover, Northwestern region	16	20
Baled hay, temporary meadow, without clover, Northwestern region	21	20
Grazed grass, permanent meadow, with clover, Northwestern region	19	0
Baled grass, permanent meadow, with clover, Northwestern region	12	0
Baled hay, permanent meadow, with clover, Northwestern region	12	0
Grazed grass, temporary meadow, with clover, Northwestern region	13	34
Baled grass, temporary meadow, with clover, Northwestern region	11	20
Grass silage, horizontal silo, temporary meadow, with clover, Northwestern region	11	20
Baled hay, temporary meadow, with clover, Northwestern region	11	20
Alfalfa, conventional, for deshydration	18.75	21
Alfalfa, conventional, for animal feeding	18.75	28

6 Parameters for plant production: perennial and special French crops

The SQCB nitrate model (Faist *et al*, 2009) was used for orchards, grapevines and special soil-based crops without fertigation (carrots). This model was initially developed by De Willigen (2000) and modified by SQCB. It is a model using the following formula with the coefficients fitted by regression:

$$N = \left[21.37 + \frac{P}{c * L} \left[0.0037 * S + 0.0000601 * N_{org} - 0.00362 * U \right] \right] \frac{1}{y} \frac{1}{1000}$$

Where:

- N is the quantity of nitrogen leached, in kg N/kg of yield
- S is the nitrogen supply, including crop residues, in kg N/ha
- U is the nitrogen uptake, in kg N/ha
- N_{org} is the quantity of nitrogen in the soil organic matter, in kg N/ha
- P is the precipitation and watering, in mm per year
- C is the soil clay content, in basis 100

L is the rooting depth, in meters

Y is the yield, in t WM/ha

This model has been validated for the following conditions:

i. rainfall between 40 mm and 2000 mm
ii. clay content between 3% and 54%
iii. rooting depth between 0.25 m and 2 m

Parameters

a) The sources for calculating the clay content (C) and precipitation (P) are the same as those used for the soil loss model (see Fiche 13). An exception was made for carrots which are mainly cultivated in sandy soils with an average clay content of 5%.
b) The yield (Y), the nitrogen supply (S) and the amount of irrigated water (P) were taken from the LCI data set in question using data entered when the data set was created.

The values given in **Table 119** were used for the other parameters (U, L and N_{org}).

Table 119: Values used to calculate nitrate leaching for special French crops and orchards

Crop	Rooting depth (L) in m	Nitrogen uptake (U) in kg N/t DM	N_{org} in kg N /ha
Carrots	0.6	1.45	2750
Peaches/nectarines (nursery)	0.8	4	5500
Peaches/nectarines (non productive)	0.8	5	5500
Peaches/nectarines (productive)	1.1	6	5500
Apples and cider apples (nursery)	0.8	4	5500
Apples and cider apples (non productive)	0.8	4.5	5500
Apples and cider apples (productive)	1.1	5	5500
Grapes/vine (tree nursery)	0,3	5	3500
Raisin/vine (non productive)	0,4	5	3500
Raisin/vine (productive)	0,9	7	3500

7 Parameters for plant production: special crops soil less or fertigated

For soilless tomatoes, leaching was calculated on the basis of water loss from the closed loop water circuit by multiplying the amount of water lost by the nitrate content (0.25 g N-NO_3/liter water).

Minimum leaching was assumed for fertigated crops. Although the risk of leaching is much lower in greenhouses or tunnels (owing to protection from the rain), it cannot be considered as zero (theoretical case of an ideal fertigation system). For soil-based tomato production in a tunnel with fertigation, 5% of the nitrogen applied was assumed to be leached, according to expert opinion. For shrubs, the leaching rate was set at 5% in phase 1, 45% in phase 2 and for roses it was set to 1%.

8 Parameters for plant production: clementines, mango, cocoa.

Nitrogen leaching is considered nul for these products which grow in « dry area », following IPCC last recommendations (update of 2007 repport in 2013, table 11.3). It is indicated that FrachLeach factor only applies where soil water holding capacity is exceeded, in other cases no leaching should be considered.

9 Parameters for plant production: coffee, palm oil

The IPCC method IPCC (2007) Tier 1 was used meaning a nitrate leaching factor of 30% of the nitrogen applied.

10 Parameters for plant production: Thai rice

Assumptions
Rice growing period = 120 days
NO_3 / rain water = 0.70 mg/l, i.e. 0.007g per ha per mm of rain
NO_3 / irrigation water = 0.11 mg/l i.e. 0.0011g per ha per mm of irrigation water

Nitrogen is the main fertilizer used for rice growing. The plants consume significantly more in the form of ammonium than in the form of nitrate, which is why ammonium and urea are the main fertilizers. Nitrate losses therefore come from biochemical processes (eg: denitrification) rather than direct losses of fertilizers.

The principles used to calculate nitrate emissions are: i) nitrates are components remaining from the nitrogen mass balance, the other components of which were calculated elsewhere; ii) most of these nitrates are leached by runoff and deep percolation and iii) these two processes depend on the proportion of water not used by the plant, i.e. the water use efficiency.

The estimated leached nitrates are modeled by combining the nitrogen mass balance with the water balance as proposed by Pathak *et al* (2004). The nitrogen inputs include fertilization, precipitation, irrigation water and soils (soil N stock, immobilization). The nitrogen outputs include: runoff, leaching, exports, soil loss (erosion), mineralization, volatilization and the denitrification processes.

Nitrogen mass balance

The nitrogen mass balance can be expressed as follows (Equation 1):

$$N_{in} - N_{out} - N_{soil} = 0 \qquad \text{(Equation 1)}$$

N_{in} (inputs) and N_{out} (outputs) flows are given in **Table 120**. N_{soil} is the nitrogen transferred to the soil. As the crop production system is the same for several years, it was assumed that the soils had a stable, long term nitrogen content and so the nitrogen transferred was considered negligible. Similarly, the soil organic matter dynamics were taken to be stable, with mineralization equal to immobilization. The other flows (symbiotic nitrogen fixation, inputs from underground water and export by weeds) were ignored (Pathak *et al*, 2004).

All the parameters in **Table 120** were known, assumed or ignored, with the exception of soluble nitrate losses by percolation and drainage.

N inputs were calculated depending on the composition of fertilizers and the doses applied.

N inputs from rain and irrigation water were calculated using the respective mean N contents, as were the precipitation and quantities of irrigation water over the period of time considered (growing period).

The nitrogen exported by the plants was calculated from the yield of grain and straw exported and their N content. If the straw was exported, burned or grazed, the nitrogen it contained was considered lost.

The nitrogen losses in the form N_2O, NO and NH_3 were calculated using the method described in the relevant datasheets.

N_2 emitted during denitrification is not a polluting emission. However, it must also be quantified to complete the mass balance. Brentrup *et al* (2000) propose an emission factor for nitrogen fertilization (Equation 2):

$$N\text{-}N_2 \text{ (kg/ha)} = (0.09 * \text{Total N units applied per ha}) \qquad \text{(Equation 2)}$$

It was assumed that most of the other components were nitrates (Nt), resulting from nitrification of the ammonia. If they were not absorbed by the plants, via evapotranspiration, they would probably be emitted as pollutants in the water compartment by percolation and drainage (Nl).

Table 120: Components of the nitrogen mass balance in paddy fields

N inputs (kg N ha^{-1})	N outputs (kg N ha^{-1})
N fertilizer	net N exports by the plants
	N lost by emission of N_2O, NO and NH_3
N precipitation	N lost by emission of N_2
N irrigation water	N lost by leaching
N mineralization of organic matter	N lost by drainage
	N immobilization by the organic matter
∑ inputs	**∑ outputs**
N mass balance: ∑ inputs - ∑ outputs - N_{soil} = 0	

Water balance

The water balance had to be calculated to determine the coefficient of efficiency of use of water, Ei. It was assumed that the proportions of nitrates leached (Nl) or drained during the growing season were correlated with the proportion of water not used by the plants: [1 - Ei].

$$Nl = Nt \times [1 - Ei] \qquad \text{(Equation 3)}$$

The water balance equation can be expressed as follows to determine the components from leaching and draining:

$$DPR + R = I + P - ET \qquad \text{(Equation 4)}$$

Where:

DPR	is the deep percolation from rainfall (mm)
R	is the runoff from the plot that can be expressed as surface drainage (mm)
I	is the irrigation water supplied daily (mm)
P	is the precipitation (mm)
ET	is the evapotranspiration (mm)

Note: the runoff is considered to be zero in normal conditions. Paddy fields are flat and managed so that the water does not overflow. The water level is kept at between 0 and 15 mm. However, particularly at the end of the growing period, excess water may be released.

The efficiency of irrigation or the efficiency of water use was defined as follows:

$$Ei = ET / [P + I] \qquad \text{(Equation 5)}$$

This may also be defined as a function of DPR and R:

$$1 - Ei = [DRP + R] / [P + I] \qquad \text{(Equation 6)}$$

Regardless of the calculation method, the water balance is required to calculate the proportion of nitrates lost by drainage or by leaching. Equation 6 requires fewer parameters and is simpler to use. The data for average monthly rainfall and evapotranspiration provided by the meteorological services may be used, as well as the data on irrigation collected in the zones studied. This was the method used for AGRIBALYSE.

Datasheet 10: Land occupation (m^2.yr) and transformation (m^2)

1 General information

Table 121: Models selected for each source of emissions

Source of emissions	Model selected
Land occupation	**ecoinvent v2** (Frischknecht *et al*, 2007)
Land transformation	**ecoinvent v2** (Frischknecht *et al*, 2007)

Land occupation and transformation is independent of soil carbon or biomass dynamics. Only the occupation of the land is considered here.

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2 Parameters for plant production: land occupation

The method used is described in the reports on ecoinvent version 2 (Frischknecht R. *et al*, 2007). The area of a given land occupation category is given in the LCI data set in m^2/year.

The land occupation categories are those defined in the CORINE Land Cover program (Bossard *et al* 2000).

Table 122: Land occupation categories used for AGRIBALYSE

AGRIBALYSE crop in data collection module	Land occupation category
Shrub	heterogeneous, agricultural
Sugar beet	arable
Durum wheat	arable
Soft wheat	arable
Coffee	permanent crop, fruit
Carrots	arable
Clementines	permanent crop, fruit
Rapeseed	arable
Faba beans	arable
Alfalfa	arable
Silage maize	arable
Grain maize	arable
Barley, malting quality	arable
Forage barley	arable
Grassland	pasture and meadow, extensive
Peaches/nectarines	permanent crop, fruit
Peas	arable
Apples	permanent crop, fruit
Cider apples	permanent crop, fruit
Potatoes	arable
Starch potatoes	arable
Permanent meadow	pasture and meadow, extensive
Temporary meadow	arable
Wine grapes	permanent crop, vine
Thai rice	arable
Roses, cut flowers	heterogeneous, agricultural
Tomatoes	heterogeneous, agricultural
Sunflowers	arable
Triticale	arable
Cocoao	permanent crop, vine
Mango	permanent crop, fruit

The land occupation is calculated by multiplying the area occupied by the period of time for which the area was occupied (see datasheet 11, **Table 129**). For permanent meadow, the assessment period is 1 year.

3 Land transformation for French crops

Following inconsistencies identified resulting from the calculation approach developed in AGRIBALYSE v1.2, land tranformation flows has been now set to 0. A more robust methodology should be implemented in the future to accompt for land transformation.

Datasheet 11: Phosphorus emissions (P)

1 General information

Table 123: Models selected for each source of emissions

Source of phosphorus emissions	Model selected
Emissions by soil loss	**SALCA-P** (Nemecek and Kägi, 2007 and Prashun *et al*, 2006)
Emissions by leaching	
Emissions by run-off	
Emissions from grazing and grassland	
Emissions during storage of manure	**Not considered**
Soilless crops	**This report**
Thai rice	**This report**

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2 Parameters for livestock production: emissions during storage of manure

The emissions during storage of manure were not taken into account as there was insufficient information on the processes involved.

3 Parameters for crop production: emissions from soil loss

Table 124: Simplified formulae and main input data required for the Prasuhn, 2006 model

	SALCA-P models
Formula	**Erosion**: $P_E = S_E \times P_S \times F_R \times F_{SR} \times t$ Where: P_E is the phosphorus emitted by soil loss to rivers ($kg.ha^{-1}.yr^{-1}$) S_E is the quantity of soil lost ($kg.ha^{-1}.yr^{-1}$, see datasheet 13) P_S is the phosphorus content in the upper part of the soil F_R is the eroded particle enrichment factor F_{SR} is the fraction of soil lost which reaches the river t is the land occupation time (number of days/365)

The quantity of soil eroded S_E is calculated in the soil loss model (see datasheet 5). For multiannual or perennial crops, the soil loss model gives one value for the first year and another value for the following years.

In the SALCA-P model, the measured soil content is that of total phosphorus. The French references usually refer to soluble phosphorus. According to experts (V. Prasuhn, Agroscope), 1 to 10% of total phosphorus is soluble, but no correlation has been established scientifically between these two parameters. Furthermore, apart from apatite, a large part of the total phosphorus, which is not soluble initially, will dissolve in the medium term. The phosphorus contained in the soil particles available for the plants (in the medium term)[7] should be used for the characterization model. This fraction is closer to the total phosphorus than to the soluble fraction. For these reasons, the Swiss value for total phosphorus was used (P_S = 0.00095 kg P/kg soil).

The value proposed by the original SALCA-P model was used for F_R (F_R = 1.86, cf. Prasuhn, 2006). An average value of 0.2 was used for F_{SR} which indicates an “unkonown” distance to the nearest surface water (river).

[7] 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»

Table 125: Simplified formulae and main input data required for the model: the original SALCA-P model included other factors which, for this simplified model, were set to 1 (cf Prasuhn, 2006)

	SALCA-P models
Formulae	**Leaching**: $P_L = P_{LM} \times F_{CSS} \times t$ where: P_L is the leached phosphorus ($kg.ha^{-1}.yr^{-1}$ P_{LM} is the average quantity of phosphorus leached depending on the land occupation category F_{CSS} is the correction factor for fertilization with slurry and/or sludge t is the occupation time (number of days/365)
	Runoff: $P_R = P_{RM} \times F_C \times F_s \times t$ where: P_R is the phosphorus lost by runoff to the rivers ($kg.ha^{-1}.yr^{-1}$) P_{RM} is the average quantity of phosphorus lost by runoff depending on the land occupation category F_C is the correction factor for the form of phosphorus applied (mineral, liquid/solid organic) F_s is the slope factor. F_s = 0 if the slope is less than 3% and 1 if it is more than 3% t is the occupation time (number of days/365)

The annual quantities lost by leaching and runoff depend on seven groups of crops. Each AGRIBALYSE crop was assigned to one of these groups (**Table 127**). **Table 126** gives the quantities of phosphorus emitted (runoff or leaching) for each type of crop and emission mechanism. These values are for Switzerland.

For cut grass (hay, silage, baled) taken into account in the grassland LCI data sets using both grazing and cutting production systems, the mean annual quantities lost by leaching and runoff were calculated according to the time spent as “grazing”, “temporary meadow” and “permanent meadow”. The total quantity of P lost by leaching and runoff was then allocated by mass to the various types of grass.

Table 126: Average annual quantities of phosphorus lost by leaching or runoff for each group of crops

Leaching	Value (P_{LM})	Units
market gardening	0.07	kg $P.ha^{-1}.yr^{-1}$
grazed grass	0.06	kg $P.ha^{-1}.yr^{-1}$
permanent meadow	0.06	kg $P.ha^{-1}.yr^{-1}$
temporary meadow	0.07	kg $P.ha^{-1}.yr^{-1}$
arable land	0.07	kg $P.ha^{-1}.yr^{-1}$
tropical[1)]	0.07	kg $P.ha^{-1}.yr^{-1}$
orchard	0.07	kg $P.ha^{-1}.yr^{-1}$
grapevines	0.07	kg $P.ha^{-1}.yr^{-1}$
Runoff	P_{RM}	
market gardening	0.175	kg $P.ha^{-1}.yr^{-1}$
grazed grass	0.15	kg $P.ha^{-1}.yr^{-1}$
permanent meadow	0.15	kg $P.ha^{-1}.yr^{-1}$
temporary meadow	0.25	kg $P.ha^{-1}.yr^{-1}$
arable land	0.175	kg $P.ha^{-1}.yr^{-1}$
tropical[1)]	0.175	kg $P.ha^{-1}.yr^{-1}$
orchard	0.175	kg $P.ha^{-1}.yr^{-1}$
grapevines	0.175	kg $P.ha^{-1}.yr^{-1}$

1) The values for the market gardening class were used for the tropical class (which does not exist in the original SALCA-P model).

Table 127: Assignment of AGRIBALYSE crops to crop groups

AGRIBALYSE crop in the data collection module	Type of crop
Peaches/nectarines	orchard
Apples (fruit)	orchard
Cider apples (fruit)	orchard
Grapes for wine	grapevines
Tomatoes, soil-based, outdoors	market gardening
Wine	grapevines
Coffee	tropical
Clementines	tropical
Sugar beet	arable land
Durum wheat	arable land
Soft wheat	arable land
Carrots	arable land
Rapeseed	arable land
Faba beans	arable land
Alfalfa	arable land
Silage maize	arable land
Grain maize	arable land
Barley, malting quality	arable land
Forage barley	arable land
Potatoes	arable land
Peas	arable land
Starch potatoes	arable land
Temporary meadow	temporary meadow
Permanent meadow	permanent meadow
Sunflowers	arable land

Triticale	arable land
Grazed grass	grazed grass

To calculate the correction factor F_C for runoff, the annual amendment of P_2O_5 from fertilizers must be averaged with weightings depending on the type and form (solid/liquid). For crops with a cultivation period of more than a year, the amendments must be divided by the cultivation period.

The categories defined are sludge, composts, solid manure, liquid manure and mineral fertilizer (**Table 128**). To calculate the correction factor F_{CLB} for leaching, only liquid fertilizer must be taken into account (liquid form and sundry liquids). The phosphorus content is taken from various French standards (see **Appendix I**).

Table 128: Correspondence between the fertilizers in the data collection module and the fertilizers used in the SALCA P model

Initial name in the DCM	Standardized name	Category for F_C / F_{CLB}
Limed sewage sludge	Limed sewage sludge	sludge / sundry liquids
Liquid sewage sludge	Liquid sewage sludge	sludge / sundry liquids
Semi-solid sewage sludge	Semi-solid sewage sludge	compost / sundry solid
Dried sewage sludge	Dried sewage sludge	compost / sundry solid
Manure / slurry compost	Green waste compost	compost / sundry solid
Household waste compost	Household waste compost	compost / sundry solid
Green waste compost	Green waste compost	compost / sundry solid
Sugar scum	Sugar scum	sludge / sundry liquids
Feather meal	Feather meal	compost / sundry solid
Compost bedded cattle manure	Average cattle manure	farm solid
Cattle manure heap	Average cattle manure	farm solid
Pig manure	Straw based pig manure	farm solid
Broiler manure	Broiler manure	farm solid
Rabbit slurry	Rabbit slurry	farm solid
Cattle slurry	Undiluted cattle slurry	farm liquid
Diluted cattle slurry	Diluted cattle slurry	farm liquid
Pig slurry	Mixed pig slurry	farm liquid
Sheep manure	Sheep manure	farm solid
Vegethumus	Vegethumus	compost / sundry solid
Concentrated sugar beet vinasse	Concentrated sugar beet vinasse	sludge / sundry liquids
Distillery vinasse	Concentrated sugar beet vinasse	sludge / sundry liquids
Poultry droppings	Dry poultry droppings	farm solid
Poultry manure	Layer manure	farm solid
Poultry slurry	Dry poultry droppings	farm liquid

The formulae for F_C and F_{CLB} are given below (the annual amendment of P_2O_5 should be used in these formulae)

$$F_C = 1 + \frac{0.7 \times \left(P_2O_{5\,Slurry\ and\ sludge}\right) + 0.2 \times \left(P_2O_{5\,Mineral\ fertilizers}\right) + 0.4 \times \left(P_2O_{5\,Manure\ and\ compost}\right)}{80}$$

$$F_{CLB} = 1 + \frac{0.2 \times \left(P_2O_{5\,Slurry\ and\ sludge}\right)}{80}$$

As for the soil loss model, the mean slope was defined as 2% which means that the slope factor (F_P) is zero (and consequently there is no phosphorus runoff).

The occupation period, i.e. the time for which the crop is grown, is the period between the harvest of the previous crop and the harvest of the inventoried crop (with the exception of rice for which a default occupation period of 120 days was assumed). Owing to the diversity of cropping sequences, the start of this period had to be calculated by weighting the harvest dates of the previous crops as a function of their frequency in cropping sequences for that crop. The occupation period calculated was used for all the models (trace metals, P and land use).

Table 129: Harvest dates used to calculate the occupation period for a crop

Crop	Harvest date (dd/mm)
Sugar beet	15/10
Durum wheat	08/07
Soft wheat	20/07
Carrots	10/06
Rapeseed	15/07
Faba beans	22/07
Forage maize	15/09
Grain maize	15/10
Barley	08/07
Winter peas	08/07
Spring peas	22/07
Potatoes	22/09
Starch potatoes	08/09
Temporary meadow	22/09
Sunflowers	11/09
Triticale	25/07

5 Parameters for plant production: Soilless and fertigated crops

Phosphate emissions for soilless and fertigated crops were calculated on the basis of expert opinion.

a) Soilless tomatoes. The emissions were calculated on the basis of waste water assuming a content of 0.06 g P-PO_4 per liter of water (CTIFL, 2013)
b) Fertigated tomatoes. The emissions were estimated at 5% of the amendments
c) Soilless roses, cut flowers. The losses were set at 1% of the amendments
d) Shrubs. The losses in phase 1 were set at 5% of the amendments and in phase 2 at 45%.

For fertigated systems, the phosphate losses were considered to be similar to nitrate losses.

6 Parameters for plant production: Thai rice

Assumptions:
Rice growing period = 120 days
P / rainwater = 0.045 mg/l i.e. 0.00045 g per ha per mm of rainwater
P / irrigation water = 0.125 mg/l i.e. 0.00125 g per ha per mm of irrigation water

Phosphorus (P) is an input into rice growing production systems through mineral fertilizers, irrigation and rainfall. The outputs from the system are exports through the crops, leaching and runoff. Leaching and runoff can cause eutrophication in the local environment. The phosphorus mass balance can be expressed as:

$$P_{in} - P_{out} - P_{soil} = 0 \qquad \text{(Equation 1)}$$

The components for P_{in} (inputs) and P_{out} (output) are given in **Table 130**. For P_{soil}, for a production system that is the same over several years, it was assumed that the soils had a stable, long term phosphorus content and so the phosphorus transferred to the soils was considered negligible. Similarly, the soil organic matter dynamics were taken to be stable, with mineralization equal to immobilization. As the paddy fields are flat and protected by dikes, the water rarely overflows (except in exceptional flooding). Soil loss by runoff is low and was ignored as a possible source of P loss.

Table 130: Components of phosphorus mass balance in paddy fields

P inputs (kg N ha^{-1})	P outputs (kg N ha^{-1})
P fertilizer **P precipitation** **P irrigation** **P immobilization (=mineralization of organic matter)**	P exports by the plants P lost by leaching P lost by runoff P losses by mineralization of organic matter (=immobilization)
∑ inputs	**∑ outputs**
P mass balance = ∑ inputs - ∑ outputs – P_{soil} = 0	

The inputs from fertilizers were calculated from the composition of the fertilizers and the quantities of fertilizer applied.

The quantities of P in rainwater and irrigation water were calculated using the average P content of the water and the amount of rain and irrigation water during the growing period.

The P exported by the plants was calculated from the yield in grain and straw exported and their P content. If the straw was exported, burned or grazed, the phosphorus it contained was considered to be lost.

The water balance had to be calculated to determine the P losses by runoff and leaching (Pl). The same methodology was used as for nitrates (see nitrate datasheet). It was assumed that the proportion of phosphorus leached (Pl) or drained during the growing season was correlated with the proportion of water not used by the plants: [1 - Ei].

$$Pl = Pt \times [1 - Ei] \qquad \text{(Equation 2)}$$

<u>Water balance</u>

See nitrate datasheet 8.

Datasheet 12: Dinitrogen oxide (N_2O)

1 General information

Table 131: Models selected for each source of emissions

Source of emissions	Model selected
Excretions in buildings and during storage	**CORPEN 1999a-199b-2001-2003-2006:** for calculating the quantities of nitrogen excreted by the animals
	For emission factors (and fraction leached): IPCC 2006b, Tier 2
Agricultural soils	**IPCC 2006b, Tier 1**
Soilless crops	**IPCC 2006b, Tier 1**
Grazing	**IPCC 2006b, Tier 1**
Thai rice	**IPCC 2006b, Tier 2 and Yan *et al*, 2003b**
Tropical crops	**IPCC 2006b, Tier 1**

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2 Parameters for livestock production: excretions in buildings and during storage

The quantities excreted were calculated using equations in CORPEN (1999a, 1999b, 2001, 2003, 2006). The emission factors depended on the storage system. The factors given in **Table 132** were used to calculate the N_2O emissions.

Table 132: N_2O emission factors depending on the excretion management system

AGRIBALYSE system	IPCC system	EF3 N_2O kg N_2O-N per kg N excreted
Covered slurry pit with natural crust	liquid/slurry, with natural crust cover	0.005
Covered slurry pit without natural crust	liquid/slurry, without natural crust cover	0
Non-covered slurry pit with natural crust	liquid/slurry, with natural crust cover	0.005
Non-covered slurry pit without natural crust	liquid/slurry, without natural crust cover	0
Covered manure heap	solid storage	0.005
Non-covered manure heap	solid storage	0.005
Pig manure with straw	solid storage	0.007

3 Parameters for plant production: agricultural soils

Figure 18 gives an overview of direct and indirect N_2O emissions for plant production. Only the emission factors (flows and figures in red) were used: the other flows (amendments, volatilization – in yellow – and leaching – in blue) were calculated by the ammonia, nitrate and nitric oxide models using data collected for each crop.

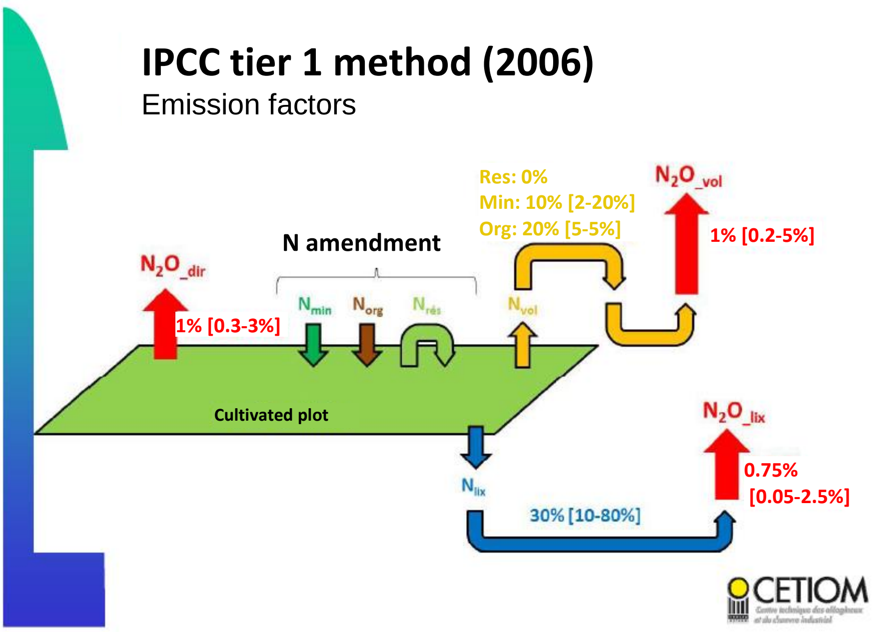

Figure 18: N_2O emissions model according to IPCC (2006b) tier 1.

The N_2O calculation model only uses IPCC (2006b) Tier 1 for the emission factors (EF1, EF4 and EF5, see equations 1 to 3 below).

Equation n°1: Direct N_2O emissions from managed soils (tier 1):

$$N - N_2O_{Direct} = N - N_2O_{N_{Inputs}} + N - N_2O_{OS} + N - N_2O_{PR}$$

Given that:

$$N - N_2O_{N_{Inputs}} is\ [(F_{MN} + F_{ON} + F_{CR} + F_{MNC}) \times EF_1] + [(F_{MN} + F_{ON} + F_{CR} + F_{MNC})_{RI} \times EF_{1RI}]$$

$$N - N_2O_{OS}\ is\ (F_{OS,CM,Temp} \times EF_{2CM,Temp}) + (F_{OS,CM,Trop} \times EF_{2,CM,Trop}) + (F_{OS,F,Temp,RN} \times EF_{2,F,Temp,RN}) + \left(F_{OS,F,Temp,PN} \times EF_{2,F,Temp,PN} + (F_{OS,F,Trop} \times EF_{2,Trop})\right)$$

$$N - N_2O_{PR} is\ (F_{PR,CPS} \times EF_{3PR,CPS}) + (F_{PR,SA} \times EF_{3PR,SA})$$

Where:

- N-N_2O_{Direct} is the direct annual N-N_2O emissions for managed soils, kg N-N_2O yr^{-1}
- N-$N_2O_{N\ Inputs}$ is the direct annual N-N_2O emissions from N inputs to managed soils, kg N-N_2O yr^{-1}
- N-N_2O_{OS} is the direct annual N-N_2O emissions for managed organic soils, kg N-N_2O yr^{-1}
- N-N_2O_{PR} is the direct annual N-N_2O emissions for urine and feces inputs to land used for pasture and outdoor runs, kg N-N_2O yr^{-1}
- F_{MN} is the annual quantity of mineral N fertilizer applied to the soil, kg N yr^{-1}
- F_{ON} is the annual quantity of animal manure, compost, sludge and other organic N amendment applied to the soil (Note: if sludge is included, cross check with the *Waste* LCI data sets to avoid double accounting of N_2O emissions from N in the sludge), kg N yrn^{-1}
- F_{CR} is the annual quantity of N returned to the soil in crop residues (air and underground), including nitrogen fixing crops and reseeding of forage/meadows, kg N yr^{-1}
- F_{MNC} is the annual quantity of mineralized N in the mineral soils from loss of carbon from soil organic matter owing to changes in land use or land management, kg N yr^{-1}
- F_{OS} is the annual area of organic soils drained/managed, ha (Note: the additional subscripts CM, F, Temp, Trop, RN and PN refer to cultivated land and meadows, forests, temperate, tropical, rich in nutrients and poor in nutrients, respectively)
- F_{PR} is the annual quantity of N from urine and feces deposited by the animals grazing in the meadows and outdoor runs, kg N yr^{-1} (Note: the additional subscripts CPS and SA refer to cattle, poultry and swine, and sheep and other animals, respectively)
- EF_1 is the N_2O emission factor for N inputs, kg N-N_2O (kg N inputs)$^{-1}$
- EF_{1RI} is the N_2O emission factor for N inputs to flooded rice, kg N-N_2O (kg N inputs)$^{-1}$
- EF_2 = is the N_2O emission factor for N inputs for drained/managed organic soils, kg N-N_2O $ha^{-1}.yr^{-1}$ (Note: the subscripted indices CM, F, Temp, Trop, RN and PN refer to cultivated land and meadows, forests, temperate, tropical, rich in nutrients and poor in nutrients, respectively)

EF_{3PR} is the N_2O emission factor for urine and feces deposited by the animals grazing in meadows and outdoor runs, kg N yr^{-1} (Note: the subscripted indices CPS and SA refer to cattle, poultry and swine, and sheep and other animals, respectively)

Equation n°2: N_2O emissions from the airborne deposition of volatized nitrogen from soil management (tier 1):

$$N - N_2O_{(AD)} = \left[(F_{MN} \times Frac_{GASF}) + \left((F_{ON} + F_{PR}) \times Frac_{GASO}\right)\right] \times EF_4$$

Where:

- $N\text{-}N_2O_{(AD)}$ is the annual quantity of $N\text{-}N_2O$ produced by airborne deposition of N volatilized from managed soils, kg N_2O–N yr^{-1}
- F_{MN} is the annual quantity of mineral N fertilizer applied to the soil, kg N yr^{-1}
- $Frac_{GASF}$ is the fraction of mineral N fertilizer volatilized in the form of NH_3 and NO_x, kg N volatilized (kg of N applied)$^{-1}$
- F_{ON} is the annual quantity of managed animal manure, compost, sludge and other organic N amendments applied to the soil, kg N yr^{-1}
- F_{PR} is the annual quantity of N from urine and feces deposited by animals grazing in the meadows, outdoor runs and plots, kg N yr^{-1}
- $Frac_{GASO}$ is the fraction of the organic N fertilizer materials applied (F_{ON}) plus the N from urine and feces deposited by grazing animals (F_{PR}) volatilized in the form of NH_3 and NO_x, kg N volatilized (kg of N applied or deposited)$^{-1}$
- EF_4 is the N_2O emission factor for airborne deposition of N on the soil and aquatic surfaces, [kg $N\text{-}N_2O$ (kg $N\text{-}NH_3$ + $N\text{-}NO_x$ volatilized)$^{-1}$]

Equation n°3: N_2O emissions from nitrogen leached from managed soil, in regions with leaching and runoff (tier 1):

$$N - N_2O_{(L)} = (F_{MN} + F_{ON} + F_{PR} + F_{CR} + F_{MNC}) \times Frac_{LEACH-(H)} \times EF_5$$

Where:

- $N\text{-}N_2O_{(L)}$ is the annual quantity of $N\text{-}N_2O$ produced by leaching and runoff after adding N to managed soils in regions with leaching and runoff, kg $N\text{-}N_2O$ yr^{-1}
- F_{MN} is the annual quantity of mineral N fertilizer applied to the soil in regions with leaching and runoff, kg N yr^{-1}
- F_{ON} is the annual quantity of managed animal manure, compost, sludge and other organic N amendments applied to the soil in regions with leaching and runoff, kg N yr^{-1}
- F_{PR} is the annual quantity of N from urine and feces deposited by animals grazing in meadows and outdoor runs in regions with leaching and runoff, kg N yr^{-1}
- F_{CR} is the annual quantity of N returned to the soil in crop residues (airborne and underground), including nitrogen fixing crops, and reseeding of forage/meadows in regions with leaching and runoff, kg N yr^{-1}
- F_{MNC} is the annual quantity of mineralized N in mineral soils, from loss of carbon from soil organic matter owing to changes in land use and land management in regions with leaching and runoff, kg N yr^{-1}

$Frac_{LEACH-(H)}$ is the fraction of all the N mineralized/added to managed soil in regions with leaching and runoffs and lost by leaching and runoff, kg N (kg of added N)$^{-1}$

EF_5 is the N_2O emission factor for N losses owing to leaching and runoff, kg N-N_2O (kg of N leached or runoff)$^{-1}$

To calculate the leached (NO_3) and volatilized (NH_3) fractions, this model used 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 the airborne and underground parts of crop residues (data defined in the data collection model)

To be consistent with the decision not to take account of changes in soil carbon stocks, account was not taken of N_2O emissions from mineralization of nitrogen caused by losses of organic matter caused by land use changes.
This approach was applied to all production systems for plants, annual crops, orchards, grapevines, meadows and soilless crops.

4 Parameters for plant production: grazing

For direct N_2O emissions from grazing, Tier 1 of the IPCC (2006b) model was applied without modification, using factors $EF3_{PRPCPP}$ (20% for cattle, pigs and poultry) and $EF3_{PRPSO}$ (10% for sheep, etc) depending on the type of animal grazing (this was defined for LCI data sets for grass grazed by one cow, and so a factor of 20% was applied). The leached and volatized fractions, required to calculate indirect emissions, were determined using the nitrate and ammonia calculation models.

5 Parameters for plant production: calculating N returned to the soil from reseeding of meadows (F_{CR})

The quantity of nitrogen returned to the soil from the reseeding of forage/meadows (included in F_{CR}, cf. equation 3 above) was calculated by applying formula 11.6 of IPCC (2006b), page 11.14ff and using the default values given in Table 11.2 of the IPCC (2006b) report. For permanent meadows, the annual reseeding was set at 0 (cf. column 3 of **Table 133**) which means that account was not taken of N returned to the soil.

Table 133 gives the quantities of nitrogen returned to the soil on reseeding of forage/meadows for AGRIBALYSE LCI data sets.

Table 133: Quantities of nitrogen returned to the soil on reseeding of forage/meadows for AGRIBALYSE LCI data sets

LCI data set / crop	Name of crop in Table 11.2 of IPCC (2006a)	% of area renewed each year	Nitrogen returned (kg N/(ha*yr)
Grazed grass, permanent meadow, without clover, Auvergne	perennial grass	0	0
Baled grass, permanent meadow, without clover, Auvergne	perennial grass	0	0
Grass silage, horizontal silo, permanent meadow, without clover, Auvergne	perennial grass	0	0
Baled hay, permanent meadow, without clover,	perennial grass	0	0

LCI data set / crop	Name of crop in Table 11.2 of IPCC (2006a)	% of area renewed each year	Nitrogen returned (kg N/(ha*yr)
Auvergne,			
Grazed grass, permanent meadow, without clover, Northwestern region	perennial grasses	0	0
Baled grass, permanent meadow, without clover, Northwestern region	perennial grasses	0	0
Grazed grass, temporary meadow, without clover, Northwestern region,	perennial grasses	0	0
Grazed grass, temporary meadow, without clover, Northwestern region	non n fixing forages	0.25	10.79
Baled grass, temporary meadow, without clover, Northwestern region	non n fixing forages	0.25	14.12
Baled hay, temporary meadow, without clover, Northwestern region	non n fixing forages	0.25	15.61
Grazed grass, permanent meadow, with clover, Northwestern region	perennial grass	0	0
Baled grass, temporary meadow, with clover, Northwestern region	perennial grass	0	0
Baled hay, permanent meadow, with clover, Northwestern region	perennial grass	0	0
Grazed grass, temporary meadow, with clover, Northwestern region	grass clover mixtures	0.25	18.99
Baled grass, temporary meadow, with clover, Northwestern region	grass clover mixtures	0.25	26.84
Grass silage, horizontal silo, temporary meadow, with clover, Northwestern region	grass clover mixtures	0.25	25.23
Baled hay, temporary meadow, with clover, Northwestern region	grass clover mixtures	0.25	29.31

6 Parameters for plant production: Thai rice

Assumptions: Rice growing period = 120 days

For a long time, N_2O and NO_x were not taken into account in rice production owing to the flooded conditions, which are unfavorable to nitrification. Yan *et al* (2003b) introduced a new approach by measuring N_2O emissions from paddy fields and unfertilized plots to determine emissions from fertilization. The model used is specific to rice, but not to rice grown in Thailand or South East Asia. They attempted to estimate the total emissions from the point of view of land use, taking account of emissions from land left fallow between rice crops (base level emissions). As AGRIBALYSE is based on LCI product data sets, it was decided to concentrate on emissions during the growing period. Based on the statistical analysis of 21 experiments, Yan *et al* (2003b) determined both the emission factor from average fertilizers (0.25% of all N fertilizer units applied) and a mean base level emission of 0.26 kg N-$N_2O.ha^{-1}$ for an average season of 117 days. Equation 1 shows this model which does not, however, take account of intermittent flooding conditions with drought prone periods, during which there is greater nitrification-denitrification, probably leading to an increase in N_2O emissions.

$$N\text{-}N_2O\ kg.ha^{-1} = [0.0025 \times Nf] + [0.26 \times D/117] \qquad \text{(Equation 1)}$$

Where:

Nf	is the total number of units from chemical fertilizers applied, per hectare, during the growing period
0.0025	is the average emission factor from fertilization (0.25%)
D	is the effective duration of the growing period
0.26 N $kg.ha^{-1}$	is the mean base level emission of N-N_2O during the growing period
44/14	is the N-N_2O to N_2O conversion factor

7 Parameters for plant production: tropical production

Nitrogen leaching is nul for cocoa, mango and clementine which grow in dry conditions (cf. § Nitrate) Consequently, no indirect N2O emissions are considered. For coffee and palm oil growing in more humid areas, indirect N2O emissions are considered based on leached fraction (cf. § Nitrate).

Datasheet 13: Active substances in pesticides

1 General information

Table 134: Models selected for each source of emissions

Source of emissions	Model selected
All crops	**ecoinvent v2** (Nemecek and Kägi, 2007)
Thai rice	**Expertise S. Perret (CIRAD)**
Soilless crops	**This report**
Soil under plastic film	**This report**

Bibliography

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.

2 Parameters for plant production: all crops

It was assumed that 100% of active substances applied were transferred to the soil. This method ensured comparability with databases such as ecoinvent. However, this approach only quantifies maximum possible emissions.

3 Parameters for plant production: soilless crops and special production systems

As there was no precise information on the distribution and fate of active substances in systems where the soil was protected (eg. soil covered with a mulching film or in greenhouses or tunnels) and for soilless crops, it was taken that 100% of the flows were ending into the soil.

4 Parameters for plant production: Thai rice

It was assumed that 100% of active substances were transferred to the soil and water compartments as they are not thought to concentrate in the rice grains or remain in the plots after harvest. In production zones, most of the pesticides used were insecticides, which were applied to the crop by hand at various stages when the paddy fields were flooded most of the time. In this conditions, it was, therefore, decided to split the emissions equally between the soil and the water (50% - 50%).

Table 135 gives the various approaches selected.

Table 135: Allocation of emissions from active substances in pesticides between the air, water and agricultural soil compartments

	Compartment		
Crop / production system	**Air**	**Water**	**Agricultural soil**
All crops (with the following exceptions)			100%
Soilless			100%
Rice	50%	50%	
Soil under plastic film			100%

Datasheet 14: Emissions from fish farms

1 General information

Table 136: Models selected for each source of emissions

Source of emissions	Model selected
Nitrogen	**Papatryphon *et al*, 2005**
Phosphorus	**Papatryphon *et al*, 2005**
Total suspended solids (TSS)	**Papatryphon *et al*, 2005**

N, P and TSS emissions from fish farms are considered separately because the emission mechanisms involved are significantly different from other livestock production systems.

General principle of the model
The model selected is based on a mass balance for inputs and outputs which requires a knowledge of the composition of the feed rations distributed to the animals, the biochemical composition of the fish and the quantity of undigested nutrients.

Bibliography

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.

2 Parameters: nitrogen losses

Equation (1) below was used.

$$N_{total\ waste} = N_s + N_i \qquad \text{Eq (1)}$$

$N_f = [(A_d – (A_d \times \% A_{nc})) \times (\% protein / 6.25)] \times (100 – ADC)\%$

$N_{nc} = A_d \times \% A_{nc} \times (\% protein / 6.25)$

$N_s = N_f + N_{nc}$

$N_g = (A_d \times T_N) / CI$

$N_i = N_c – N_f - N_g$

$N\text{-}NH_4 = N_i \times 0.8$

$NH_4 = N\text{-}NH_4 \times 1.26$

$N_{dissolved} = N_i – N\text{-}NH_4$

Where:

A_d is the feed distributed

% A_{nc} is the percentage of feed not consumed, estimated at 5%

% protein is the percentage of raw protein in the feed

ADC is the Apparent Digestibility Coefficient, estimated at 90% (±5%)

N_c is the nitrogen consumed

N_d is the nitrogen digested

N_f is the fecal nitrogen

N_i is the dissolved nitrogen

T_N is the nitrogen content of the fish (0.0256 to 0.0272 gN/g body mass)

N_g is the nitrogen content in the body mass increase

$N\text{-}NH_4$ is nitrogen in the form of ammonia

CI is the consumption index

3 Parameters: phosphorus losses

Equation (2) below was used:

$$P_{total\ waste} = P_s + P_i \qquad \text{Eq (2)}$$

Where:

$P_f = [(A_d – (A_d \text{ x } \% A_{nc})) \text{ x } (\% P)] \text{ x } (100 – ADC) \%$

$N_{nc} = A_d \text{ x } \% A_{nc} \text{ x } 90\% \text{ x } (\% P / 90\%)$

$P_s = P_f + P_{nc}$

$P_g = (A_d \text{ x } 0.0045) / CI$

$P_i = P_c – P_f - P_g$

Where:

A_d is the feed distributed

% A_{nc} is the percentage of feed not consumed, estimated at 5%

% P is the percentage of phosphorus in the feed

ADC is the Apparent Digestibility Coefficient, estimated at 50% (±10%)

P_c is the phosphorus consumed

P_d is the phosphorus digested

P_f is the fecal phosphorus

P_i is the dissolved phosphorus

P_g is the phosphorus content in the body weight increase, based on the P content of the fish body (0.40 to 0.45 gP/100 g body mass)

CI is the consumption index

4 Parameters: TSS

Equation (3) below was used:

$$TSS_{total\ waste} = TSS_f + TSS_{nc} \qquad \text{Eq (3)}$$

$TSS_f = \{[(A_d – (A_d \text{ x } \%A_{nc})] \text{ x } \sum [\% \text{ nutrient x } (100 – ADC)\%]\}$

$\sum [\% \text{ nutrient x } (100 – ADC) \%] = (\% \text{ proteins x } (100 – ADC)\%) + (\% \text{ lipids x } (100 – ADC)\%) + (\% \text{ carbohydrates x } (100 – ADC)\%) + (\% \text{ fiber x } (100 – ADC)\%) + (\% \text{ ash x } (100 – ADC)\%)$

$TSS_{nc} = (A_d \text{ x } \%A_{nc} \text{ x } \% \text{ dry matter})$

Where:

A_d is the feed distributed

% A_{nc} is the percentage of feed not consumed, estimated at 5%

% protein is the percentage of protein in the feed

% lipids is the percentage of lipids in the feed

% carbohydrates is the percentage of carbohydrates in the feed

% fiber is the percentage of fiber in the feed

% ash is the percentage of ash in the feed

ADC is the Apparent Digestibility Coefficient, estimated at 50% (±10%)

% dry matter is the percentage of dry matter in the feed

Datasheet 15: Extrapolation of seed and plant LCI data sets

1. General information

The seed LCI data sets were extrapolated for crops documented in GESTIM (Gac *et al*, 2010).

a) by recalculating the quantity of seed produced at the exit from the production site (taking account of losses)

b) by calculating an extrapolation factor based on a comparison of energy consumption according to GESTIM and data collected for the AGRIBALYSE program

c) by adding the transport and energy requirements for seed production given in GESTIM. As some of the losses are reused, these additional inputs were allocated by mass.

2. Parameters

Calculating the quantity produced. The quantity of seeds produced was calculated using the following formula.

$Q_{SP} = (R_{SC} * (1 - t_R)) * (1 - t_L)$

Where:

Q_{SP} is the quantity of seeds produced, at exit rather than on production
R_{SC} is the gross seed yield, at the farm gate
t_R is the reuse rate
t_L is the loss rate on the production site

The data for these parameters were taken from GESTIM (**Table 137**).

Table 137: Yield and loss/reject rates according to GESTIM (Gac *et al*, 2010)

Crop	Yield R_{SC} (kg/ha)	Reject rate t_R (%)	Reuse t_{RR} (%)	Loss rate t_L (%)	Reuse t_{RL} (%)
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
Maize	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
Starch potatoes	24840	3.51	0	13	100
Rye	4400	1.06	0	15	80
Sorghum grain	2170	3.27	0	12	80
Sunflowers	937	1.70	0	10	80
Triticale	3509	2.47	0	15	80
Other (average)		3	0	15	0

If the LCI seed data set was extrapolated for a crop not listed in GESTIM (eg: carrots), the yield at the farm gate was estimated based on expert opinion. Average values were used for the loss and reject rates (**Table 137**, row "Other").

Calculating the extrapolation factor to extrapolate the LCI seed data set from the LCI data set for a given crop. Table 130 gives the electricity and fuel consumptions taken into account for the production at the farm gate.

Table 138: Electricity and fuel consumption for seed production according to GESTIM (Gac *et al*, 2010)

Crop	Electricity kWh/ha	Fuel l/ha
Sugar beet	1500	204
Durum wheat	9	99
Soft wheat	52	92
Rapeseed	0	90
Maize	1545	159
Barley	16	103
Protein peas	48	102
Potatoes	50	267
Starch potatoes	53	267
Rye		86
Sunflowers	500	84
Triticale	14	89
Other	344.2	136.8

If the LCI seed data set was extrapolated for a crop not listed in GESTIM (eg: carrots), average consumptions were used (**Table 138**, row "Other").

The extrapolation factor was calculated using the following formula.

$$f_{Ex} = \max(\frac{C_{ElG}}{C_{ElA}}, \frac{C_{CaG}}{C_{CaA}}, 1) * \frac{R_{Seed}}{R_{Crop}}$$

Where:

f_{Ex} is the extrapolation factor
C_{ElG} is the electricity consumption according to GESTIM
C_{ElA} is the electricity consumption according to AGRIBALYSE
C_{CaG} is the fuel consumption according to GESTIM
C_{CaA} is the fuel consumption according to AGRIBALYSE
R_{Seed} is the seed yield (kg/ha)
R_{Crop} is the crop yield (kg/ha)

Each input used for producing the AGRIBALYSE crop was multiplied by this factor.

Adding processes related to seed production. Table 139 gives the inputs required for seed production.

Table 139: Distances and means of transport and energy consumption for seed production

Crop	Distances and means of transport (km)			Energy consumption	
	Field ➔ site		Site ➔ farm	Electricity	Natural gas
	Agricultural trailer	Lorry	Lorry	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	
Maize	15		230	40	681.12
Barley	15		230	20	
Protein peas	15		230	20	
Potatoes		15	305	37	
Starch potatoes		15	305	20	
Rye	15		230	20	
Sorghum grain	15		230	20	
Sunflowers	15		230	20	
Triticale	15		230	20	
Other		15	305	20	

These inputs were multiplied by the quantity of certified seed (R_{CS} * (1 - t_R)), and allocated to the quantity of seed produced (Q_{SP}) and the losses reused using an allocation factor (f_{AIL}), calculated using the following formula.

$f_{AIL} = ((t_R \times t_{RR}) + ((1 – t_R)\times t_L \times t_{RL})$

Where

f_{AIS} is 1 - f_{AIL}

f_{AIL} is the reused losses allocation factor
f_{AIS} is the seed allocation factor
t_{RR} is the reject reuse rate
t_{RL} is the loss reuse rate on the production site

The quantities of energy consumed (fuel and electricity) were adjusted by subtracting the AGRIBALYSE crop energy from the GESTIM crop energy so that they were the same as those given in **Table 138**.

Table 140 : LCIs used for commercial seeds

Seed LCI name	Type	Used for
Carrot seed, conventional, at farm gate	extrapolation	All carots in conventional production
Carrot seed, organic, at farm gate	extrapolation	Organic carots
clover seed ip, at regional storehouse	LCI ecoinvent	alfalfa
Durum wheat seed, conventional, national average, at farm gate	extrapolation	Hard wheat
Grain maize seed, conventional, national average, at farm gate	extrapolation	Grain and forrage maize
Grass seed IP, at regional storehouse	LCI ecoinvent	Grass, hay, pastures, grass in vineyards
Rapeseed, seed, conventional, at farm gate	extrapolation	rapeseed
Soft wheat seed, conventional, breadmaking quality, 15% moisture, at farm gate	extrapolation	All soft wheats in conventionnal
Spring barley seed, conventional, malting quality, national average, at farm gate	extrapolation	All barleys (forage and malt)
Spring pea seed, conventional, at farm gate	extrapolation	Spring pea
Starch potato seed, conventional, national average, at farm gate	extrapolation	Startch potato
Sugar beet seed, conventional, at farm gate	extrapolation	Sugarbeet rhizom
Sunflower, seed, conventional, 9% moisture, national average, at farm gate	extrapolation	sunflower
Triticale seed, conventional, national average, at farm gate	extrapolation	triticale conventionnal
Ware potato seed, conventional, at farm gate	extrapolation	Ware potatoes for fresh market
Winter pea seed, conventional, 15% moisture, at farm gate	extrapolation	Winter pea

Datasheet 16: Use of “Animal of 0 day” LCIs for initiating animal systems

Animal systems must be initiated by an “animal input”, incorporating impacts related to reproduction and gestation. Those impacts depends on the allocation rule between dam/milk/calf. Here are given each “animal input” used for system initiation. Then, all the other animal growth stages are added for building the “final product”.

Table 141 : Animal classes initiating animal production systems.

System	For the products coming from…	the LCI … was used for initiating the animal system.
Beef production		
101	Conventional lowland milk system, silage maize more than 30%	Calf of 0 day, conventional, lowland milk system,silage maize more than 30% (animal class), at farm gate
102	Conventional lowland milk system, silage maize 10 to 30%	Calf of 0 day, conventional, lowland milk system,silage maize 10 to 30% (animal class), at farm gate
103	Conventional lowland milk system, silage maize 5 to 10%	Calf of 0 day, conventional, lowland milk system,silage maize 5 to 10% (animal class), at farm gate
104	Organic lowland milk system, silage maize 5 to 10%	Calf of 0 day, organic, lowland milk system,silage maize 5 to 10% (animal class), at farm gate
105	Conventional highland milk system, grass fed	Calf of 0 day, conventional, highland milk system,grass fed (animal class), at farm gate
106	Conventional lowland beef fattening farm	Conventional lowland milk system, silage maize more than 30%, animal class 1, at farm
110	Conventional suckler cow system, more than 1.2 LU per ha	Calf of 0 day, conventional, suckler cow system,more than 1.2 LU per ha (animal class), at farm gate
108	Conventional suckler beef fattening farm (heifers), more than 1.2 LU per ha	Conventional suckler cow system, more than 1.2 LU per ha, animal class 1, at farm
109	Conventional suckler beef fattening farm (bulls), more than 1.2 LU per ha	Conventional suckler cow system, more than 1.2 LU per ha, animal class 1, at farm
107	Conventional suckler cow system, less than 1.2 LU per ha	Calf of 0 day, conventional, suckler cow system,less than 1.2 LU per ha (animal class), at farm gate
111	Conventional suckler beef fattening farm (bulls), less than 1.2 LU per ha	Conventional suckler cow system, less than 1.2 LU per ha, animal class 1, at farm
112	Conventional beef calf fattening system	Conventional lowland milk system, silage maize more than 30%, animal class 1, at farm

Sheep and goat production$		
113	Conventional milk sheep farm, Roquefort system	Lamb of 0 day, conventional, Roquefort system (animal class), at farm gate
114	Conventional goat farm, intensive forage area	Kid goat of 0 day, conventional, intensive forage area (animal class), at farm gate
115	Conventional sheep farm, indoor system	Lamb of 0 day, conventional, indoor production system (animal class), at farm gate
Pig production		
132	Conventional porc production, fed rapeseed meal	Pig, conventional, fed rapeseed meal (animal class), at farm gate
133	Conventional porc production, fed soybean meal	Pig, conventional, fed soybean meal (animal class), at farm gate
134	Conventional porc production, on-farm feed supply	Pig, conventional, on-farm feed supply (animal class), at farm gate
135	Conventional porc production, excess slurry treatment	Pig, conventional, excess slurry treatment (animal class), at farm gate
136	Conventional porc production, national average	Pig, conventional, national average (animal class), at farm gate
137a	Label Rouge porc production, with run system	Pig, Label Rouge, pig with run system (animal class), at farm gate
137b	Label Rouge porc production, outdoor system	Pig, Label Rouge, outdoor system (animal class), at farm gate
139	Organic porc production	Pig, organic (animal class), at farm gate

Datasheet 17: Allocation of P and K fertilizers and organic N fertilizer within cropping sequences

1. General information

As described in chapter B.3.3, P and K fertilizers and organic N fertilizer were allocated to cropping sequences. In the AGRIBALYSE program, this allocation was implemented by “corrective flows” whereby the LCI data sets include:
a) the inputs actually applied and entered in the data collection module
b) the input corrections (difference between real flows and allocated flows)
c) the emissions related to the inputs actually applied
d) and the emission corrections for the input corrections (N_2O, NH_3, NO, phosphorus and trace metal emissions).

This approach makes the allocation explicit. It is also required as the direct emissions calculation models need more precise data (see below).

2. Parameters

Table 142 gives the quantities of P and K fertilizers and organic N fertilizer applied to crops after allocating the shared inputs for the cropping sequence. These values were calculated using the method described in chapter B.3.3.

Table 142: Quantities of P and K fertilizer and organic N fertilizer after allocating the shared inputs for cropping sequences (Source: Arvalis, based on the 2006 survey on farming practices by the SSP)

Crop	Quantity allocated				
	Mineral K (kg K_2O/ha)	Total K % K_2O org	Mineral P (kg P_2O_5/ha)	Total P (kg P_2O_5/ha)	N_{org} (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 following faba beans	0	0	0	15	56
Organic soft wheat following alfalfa	0	0	0	20	6
Rapeseed	25	41	34	44	17
Faba beans	25	61	46	66	8
Organic faba beans	0	0	0	30	6
Forage maize	65	258	33	79	114
Grain maize	55	96	52	78	37
Barley, malting quality	34	59	38	52	15
Forage barley	34	59	38	52	15
Starch potatoes	161	259	25	37	43
Peas	41	63	26	33	9

Crop	Quantity allocated				
	Mineral K (kg K_2O/ha)	Total K % K_2O org	Mineral P (kg P_2O_5/ha)	Total P (kg P_2O_5/ha)	N_{org} (kg N/ha)
Potatoes	161	259	25	37	43
Sunflowers	23	34	25	32	11
Triticale	35	86	26	48	28
Organic triticale	0	0		45	44

Calculating the input flow correction

Four input flows were corrected using the following formula.

$\Delta FC_{fert} = FO_{fert} – FR_{fert}$

Where:

ΔFC_{fert} is the correction for the fertilizer fert (see below)
FO_{fert} is the original input of the fertilizer fert (set in the data collection module)
FR_{fert} is the allocated input of the fertilizer fert (see **Table 142)**
fert is mineral K, mineral P, organic P or organic N

Table 142 is used to calculate the quantity of organic P fertilizer as the difference between total P and mineral P as well as to calculate the quantities of organic and mineral K_2O fertilizer.

As the form in which the mineral fertilizers will be applied is not known, the correction factors for mineral K and mineral P were included in the LCI data sets 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").

Calculating the emission flow correction factor

The four input flows were corrected by adjusting (positive or negative) the following emissions:

a) Mineral PK fertilizer
   ➔ Phosphate emissions by leaching or runoff (PK fertilizer)
b) Organic N fertilizer
   ➔ Ammonia emissions (NH_3)
   ➔ Nitric oxide emissions (NO)
   ➔ Dinitrogen oxide emissions (N_2O)
c) Mineral PK and organic N fertilizers
   ➔ Trace metal emissions

Account was not taken of nitrate leaching. The emission flow correction was calculated on the basis of the particular direct emission calculation models.

a) Effects on phosphorus emissions

To estimate the effect of allocation on phosphorus emissions, it is necessary to know the quantities of phosphorus applied in: i) organic liquid, ii) organic solid and iii) mineral form. The quantity of organic phosphorus allocated according to **Table 128** was allocated between solid and liquid forms depending on the organic phosphorus fertilizer actually applied. If no organic fertilizer was applied to the crop, the allocation between solid and liquid forms was based on the composition of the average French organic manure for phosphorus amendment (**Table 151**).

Separate factors F_{CLB} and F_C were defined (see phosphorus model, datasheet 11), depending on the form of the amendment, and the quantities of phosphorus lost by leaching or runoff were calculated after allocation. The final corrected flows, added to the LCI data sets, were the difference between the flows without allocation and the flows after allocation:

$\Delta CFP_{R/L} = FOP_{R/L} - FRP_{R/L}$

Where:

$\Delta CFP_{R/L}$ is the correction factor for phosphorus lost by runoff / leaching

$FOP_{R/L}$ is the original flow for phosphorus lost by runoff / leaching

$FRP_{R/L}$ is the flow for phosphorus lost by runoff / leaching after allocation

b) Effects on ammonia (NH_3) and nitric oxide (NO) emissions

The type of manure applied (cattle slurry, pig slurry, etc., see datasheets 1 and 10) must be known in order to calculate NH_3 emissions. An average organic manure was defined for the calculation (**Table 143**) assuming that each kilogram of organic nitrogen applied produced an emission of 147 g of N-NH_3 ($NH_{3AvgOrg}$).

Table 143: Composition of average organic French manure (Source: Arvalis, based on the survey on farming practices 2006 of SPP) and calculation of the average NH_3 emissions per kg average organic manure

Manure	Form	% (for N)	% attributable	TAN	%EF NH_3	N-NH_3 (kg N/kg N)	% (for P)	form
Cattle manure	Average cattle manure	64.47	68.84	0.19	0.79	1.05E-01	46	farm solid
Dry layer droppings	Dry poultry droppings	4.16	4.45	0.10	0.69	3.22E-03	8	farm solid
Broiler manure	Broiler manure	4.07	4.34	0.17	0.79	5.87E-03	12	farm solid
Compost from animals	Straw rich cattle manure compost	3.34	3.57	0.05	0.71	1.27E-03	2	farm solid
Vinasse	Concentrated sugar beet vinasse	3.03	3.23	0.10	0.81	2.62E-03	0	sundry liquid
Sheep manure	Sheep manure	2.82	3.01	0.10	0.90	2.71E-03	2	farm solid
Sludge	Sludge	2.79	2.98	0.71	0.40	8.46E-03	5	sundry liquid
Green waste compost	Green waste compost	2.66	2.84	0.10	0.71	2.12E-03	1	compost solid
Other food industry sludge		2.55					3	
Pig slurry	Mixed pig slurry	2.34	2.50	0.71	0.40	7.15E-03	7	farm liquid
Cattle slurry	Undiluted cattle slurry	1.84	1.96	0.50	0.55	5.39E-03	2	farm liquid
Other industrial sludge		1.47					2	
Laying hen slurry		1.27					3	
Other effluent		0.83					1	
Rabbit slurry	Rabbit slurry	0.74	0.79	0.07	0.51	2.64E-04	2	farm liquid
Pig manure	Straw rich pig manure	0.70	0.75	0.32	0.81	1.93E-03	1	farm solid
Duck manure	Manure from ducks ready for force feeding	0.29	0.31	0.30	0.71	6.71E-04	1	farm solid
Household waste compost	Household waste compost	0.26	0.28	0.10	0.71	2.08E-04	0	compost solid
Semi solid poultry droppings		0.18					1	
Sugar scum	Sugar scum	0.10	0.11	0.10	0.81	8.92E-05	1	sundry liquids
Sheep slurry		0.06					0	
Calf slurry	Beef calf slurry	0.02	0.02	0.84	0.55	1.08E-04	0	farm liquid
Total		**100.0**				**0.147**	**100**	
Total attributable		**93.64**						

This average fertilizer can be used to calculate the NH_3 emission flow correction directly by multiplying this factor by the quantity of organic N allocated:

$\Delta NH_3 = NH_{3AvgOrg} \times \Delta CF_{Norganic}$

Where:

ΔNH_3 is the NH_3 emission flow correction

$\Delta FC_{Norganic}$ is the correction for organic N

$NH_{3AvgOrg}$ is the NH_3 emissions per kg average organic N (calculated using **Table 143**)

The same approach was used for NO emissions using an average emission factor of 0.026.

c) Effects on dinitrogen oxide emissions (N_2O)

Allocating the quantity of organic nitrogen also affects the direct and indirect emission of dinitrogen oxide:

- The direct N_2O emissions are calculated by applying the emission factor to the corrected flow of organic nitrogen.
- The corrected flows for indirect N_2O emissions due to the volatilization of NH_3 and NO_x are calculated by applying the emission factors to the corrected NH_3 and NO_x flows

$\Delta N_2O_{dir} = \Delta CF_{Norg} \times EF1$

$\Delta N_2O_{indir} = (\Delta NH_3 + \Delta NO_x) \times EF4$

Where:

ΔN_2O_{dir} is the correction for direct N_2O emissions
ΔN_2O_{indir} is the correction for indirect N_2O emissions
ΔFC_{Norg} is the correction for the organic nitrogen input
ΔNH_3 is the correction for NH_3 emissions
ΔNO_x is the correction for NO_x emissions
EF1 is emission factor 1 (for direct emissions, see N_2O model)
EF4 is emission factor 4 (for indirect emissions, see N_2O model)

d) Effects on trace metal emissions

The allocation of organic PK and organic N affects trace metal flows by

1. Increasing (or decreasing) the trace metals leached or in runoff by adjusting the output flow allocation factor ($Alloc_x$ see datasheet 4, **Figure 15**)
2. Increasing (or decreasing) the trace metal flows into the soil depending on the quantity of fertilizer allocated

To calculate these effects, it is necessary to know how the input trace metal flows from the fertilizer have been allocated:

$\Delta IN_x = \Sigma\ \Delta CF_y \times T_{y_x}$

Where: ΔIN_x is the corrected input flows of TM_x (x = Cd, Cu, Zn, Pb, Ni, Cr or Hg)
T_{y_x} is the trace metal content TM_x (x = Cd, Cu, Zn, Pb, Ni, Cr or Hg) of the fertilizer allocated (y = ΔFC_{Norg}, ΔFC_{PMin} and ΔFC_{KMin})
ΔCF_y is the flow of fertilizer allocated (y = ΔFC_{Norg}, ΔFC_{PMin} and ΔFC_{KMin})

Average fertilizers were used to calculate the trace metal content of the fertilizers allocated (the quantity of nitrogen was used for the organic fertilizers allocated). The output flow allocation factor can be calculated from the trace metal flows from the fertilizers allocated (ΔIN_x).

$$Alloc_x' = \frac{IN_x + \Delta IN_x}{(IN_x + \Delta IN_x) + Dep_x}$$

Where:

$Alloc_x'$ is the output flow allocation factor for trace metals after allocation
IN_x is the initial trace metal input flow TM_x

ΔIN_x is the corrected trace metal input flow TM_x
Dep_x is the deposition of trace metals TM_x (deposition from the air)

This data is used to calculate the effects on trace metal emissions.

$\Delta LI_x = LI_x \times (Alloc_x' - Alloc_x)$
$\Delta RU_x = RU_x \times (Alloc_x' - Alloc_x)$
$\Delta SO_x = \Delta IN_x$

Where:

ΔLI_x is the corrected flow for leached trace metals
LI_x is the quantity of trace metals leached before taking account of fertilizer allocation
$Alloc_x'$ is the trace metal output flow allocation factor after allocation
$Alloc_x$ is the trace metal output flow allocation factor before taking account of fertilizer allocation
ΔRU_x is the corrected trace metal TM_x flow lost by runoff/erosion
RU_x is the quantity of trace metal TM_x lost by runoff/erosion before taking account of fertilizer allocation
ΔIN_x is the corrected flow of trace metal TM_x inputs
ΔSO_x is the corrected flow of TM_x into the soil

Datasheet 18: Meteorological data for calculating Thai rice emissions

The calculation of nitrate and phosphorus emissions for Thai rice requires a water balance to be calculated. The meteorological data for calculating the water balance is given in **Table 144**.

Table 144: Effective precipitation and irrigation requirements for rice growing production systems and the production zones studied (seeding in wet and dry seasons)

Crop production system			Total precipitation			Actual evapotranspiration	Irrigation requirements
Region	**Season**	**Watering system**	**Period**	**Mean total precipitation (mm)**	**Mean effective precipitation (mm)**	**(mm)**	**(mm)**
North (Nam Mae Lao basin)	Wet	Rainfed	July - October	1126.9	620.47	480	-
	Wet	Irrigated					0.00
	Dry	Irrigated	February – May	272.9	272.9	603.3	418.40
North east (Lam Sieo Yai basin)	Wet	Rainfed	July - October	707.7	628.5	646.07	-
	Wet	Irrigated					74.03
	Dry	Irrigated	February - May	117.2	117.2	668.8	608.37

Appendix E: Changes in soil carbon stocks

1 Introduction

Taking account of the greenhouse gas flows was discussed at the seminar on selecting the calculation models to be used for direct emissions in AGRIBALYSE, which took place on May 19 and 20, 2011. Proposals were made for emissions of CH_4, CO_2 and N_2O from agricultural production. However, it was decided that further consideration should be given to the issue of taking account of changes in soil carbon stocks.

The general brief for the AGRIBALYSE program stipulates that the methodology and deliverables of the program must conform to (among others) the JRC ILCD handbook. Regarding carbon storage, it states: “To take account of the emission or capture of greenhouse gases from or by the soil or land use change, account should be taken of the emission factors proposed by the IPCC, unless more specific data is available”.
It was, therefore, recommended that the IPCC methodology for greenhouse gases and soil carbon storage should be used for drawing up LCAs.

AGRIBALYSE does not aim to produce comparative LCAs, as for biofuels where a methodology is proposed to take account of land use change.
The AGRIBALYSE program was designed to quantify the carbon flows from changes in the area of permanent meadows and other types of land use and changes in practices. The methodologies proposed for biofuels (European Commission, 2010) were, therefore, not considered to be very suitable.

Research
The phenomenon of changes in soil carbon stocks under existing surfaces is well accepted and has been established by many studies.
A. Benoist (2009) suggests that:

- Stocks of organic matter including soil carbon depend on many parameters, in particular the climate, the nature of the soil and its use.
- The levels of carbon stocks can be estimated using IPCC methods (2003).

New methods were developed by A. Benoist to allow changes in soil carbon to be taken into account reversibly and slowly. However, these methods, which define the Global Warming Potential (GWP) are still not at a stage where they can be used easily in LCA software.

Research has been carried out by the Institut de l’Elevage on carbon storage by meadows as a means of attenuating the effect of breeding livestock on the greenhouse effect.

A working group was set up to determine how to take account of changes in soil carbon stocks. This group comprised the following persons, some of whom but not all were involved in the AGRIBALYSE program:

- Anthony Benoist (CIRAD)
- Cécile Bessou (CIRAD)
- Jean-Baptiste Dollé (IDELE)

- Armelle Gac (IDELE)
- Etienne Mathias (CITEPA)
- Anne Paillier (ADEME)
- Thibault Salou (INRA)
- Aurélie Tailleur (ARVALIS)
- Hayo van der Werf (INRA)

❖ The situations studied

Changes in soil carbon stocks are likely to be observed:

- during land use change (LUC)
- on existing agricultural land where it is caused by changes in cultivation practices

Changes in soil carbon stocks were not taken into account for products from overseas.

I- Soil carbon storage/release without land use change

Carbon is known to be stored in permanent meadows but the causes are not easy to identify. The cause may be a result of changing climate, which causes carbon sequestration owing to greater biomass, or of intensification in meadow management practices. For LCAs, only the effects of meadow management practices on carbon storage and the effect of crop management practices on carbon release should be taken into account.
Several methods were identified and assessed.

The method proposed by the IPCC, using C stock adjustment factors depending on the meadow or crop management practices, met this aim and so it was decided:

- To consider using this method for AGRIBALYSE
- To determine whether it was consistent with other approaches (decision by the European Commission of June 10, 2010 on guidelines for the calculation of land carbon stocks and Carboeurope study)
- To be sure that this methodology was effectively applicable for an LCA

IPCC methodology (2003)

The carbon storage levels in meadows depend on various factors, in particular intensification, fertilization and irrigation. For cultivated land, it is affected by various parameters: the type of tillage, fertilization practices (in particular the application of organic amendments), the degree of crop intensification (number of crops in a cropping sequence), irrigation practices and drainage.
LCI data sets for calculating carbon stocks can be produced using Tier 1, 2 or 3 methods, each method requiring an increasing level of detail.

Tier 1

A Tier 1 approach is based on soil carbon stock change factors. These factors depend on the land use (F_{LU}), the carbon inputs (F_{I}) and management practices (F_{MG}). These factors are estimated over a period of 20 years.

The soil organic carbon (SOC) stock can be calculated using the following equation (Eq 1) for a reference stock (SOC_{ref}) depending on the type of soil and climate.

$$SOC = SOC_{ref}.\ F_{LU}.\ F_{MG}.\ F_I \qquad (Eq\ 1)$$

Tier 2

The Tier 2 approach is similar but emission factors specific to the country considered should be used.

Tier 3

The Tier 3 approach uses dynamic models rather than emission factors to estimate the carbon flows.

Strengths

- Method recommended by the JRC ILCD handbook
- Method consistent with the decision of the European Commission of June 10, 2010

Weaknesses

- It is difficult to choose the reference period for the initial carbon stock. Although the IPCC opted for a 20 year period, other reference periods are found in the literature: 13 years, 25 years and 100 years (Schulz *et al*, 2009; Labouze *et al*, 2008; Reijnders and Huijbregts 2008; Wicke *et al*, 2008).
- There is a lack of data for characterizing agricultural practices for the initial conditions
- The grain size of the data for the IPCC method is not coherent with the list of AGRIBALYSE products

Decision of the European Commission of June **10, 2010** on guidelines for the calculation of land carbon stocks for directive 2009 on the greenhouse gas emissions from biofuels (European Commission, 2010).

The following equation (Eq 2) can be used for calculating carbon stocks:

$$SOC = SOC_{ST}.\ F_{LU}.\ F_{MG}.\ F_I \qquad Eq\ 2$$

Where:

SOC is the soil organic carbon content

SOC_{ST} is the soil organic carbon content in the top soil between 0 and 30 cm (C mass / ha)

F_{LU} is the land use type

F_I is the input factor

F_{MG} is the soil management factor

Values for the various factors are provided for cultivated land, permanent crops and meadows as well as for SOC_{ST} (t of C/ha) depending on the climatic region and type of soil, values specific to France can be used.

This method had the same strengths and weaknesses as the IPCC (2006b) method.

CarboEurope study (Schulz *et al*, 2009)

This study provided CO_2 flows for ecosystems in Tg C/yr, in particular for meadows and cultivated land in Europe, see **Table 145.**

Table 145: Areas and carbon flows measured for grassland and cropland in Europe

Type of land use	Area (million km^2)	Flow (Tg C/yr)	Uncertainty (Tg C/yr)
Grassland	0.57	-32	4
Cropland	1.08	11	2

Strengths

- This method provides data on annual flows
- The data comes from measurement campaigns

Weaknesses

- There is no distinction between direct human emissions and emissions from other sources such as climate change. This method overestimates flows from direct human emissions.
- This method does not provide data for different crop and meadow management practices.

Conclusions for AGRIBALYSE

After assessing the various possibilities, the methodology proposed in IPCC 2003 was considered to be the most appropriate and easiest to implement in the framework of the AGRIBALYSE program and its constraints.

Access to data on changes in crop production practices over the past 20 years was, however, a major obstacle to implementing the method. It was estimated that this data, when it was available, was not easy to use. It would be necessary to start by collecting this information but this did not fit into the AGRIBALYSE program schedule and there were insufficient resources available.

In view of this, it was decided not to take account in AGRIBALYSE of changes in soil carbon stocks for land management changes.

II- Taking account of changes in soil carbon stocks for land use change (deforestation, growing crops on meadows, etc)

A similar approach to that described above was used to select a calculation model. The method used by CITEPA, based on the recommendations of IPCC 2003, for national greenhouse gas data sets (United Nations Framework Convention on Climate Change National Inventory Report (UNFCCC NIR), CITEPA, 2012) was considered to be the most directly applicable for AGRIBALYSE. However, this method gives very rough results, with the same storage factor for each hectare of permanent grassland and the same release factor for each hectare of cropland, for any geographical location or crop grown. A method was, therefore, defined, based on the CITEPA method, to calculate specific emission factors for each type of crop. Both methods are described below.

Notes:

- Cropland = annual crops, **including temporary meadows**

- Grassland = grassed area used for agricultural purposes

Comment: Changes in soil carbon stocks were not taken into account for permanent crops (grapevines and trees). The areas concerned and the representativeness of the Teruti-Lucas data were considered insufficient for these products. Moreover, for grapevines, it was difficult to define reference carbon stocks because of the nature of the land usually used for grapevines. The carbon stocks for crops and grapevines are very different and the method defined by the IPCC is not suitable as it overestimates the actual flows.

2 Constructing land use change matrices

The first stage is the same for both methods. This involves determining and quantifying the areas that have undergone land use change within the past 20 years to construct land use change matrices. This is done using data from the Teruti network (Teruti-Lucas since 2005), This records the land use for over 300,000 points throughout France. Teruti-Lucas distinguishes land occupation, which is the physical occupation of the land, from land use, which indicates the nature of human activities on this land. The land occupation and use codes are given below.

Table 146: Teruti-Lucas codes for permanent grassland and annual cropland

	Land occupation codes	Land use codes
Annual cropland	2110 (wheat) to 2530 (temporary meadows) 2730 (nurseries) to 2742 (other crops) 6030 (bare land) 9999 (not known)	All All 111 to 114 (agriculture) 111 to 112 (agriculture)
Permanent grassland	4020 (Land with bushes and trees<5%) 5021 to 5025 (grassland) 9999 (not known)	111 to 120, 364-365, 402 (agriculture, forestry, protected zones, etc.) 111 to 120, 364-365, 402 (see above) 113 to 114, 364-365 (forestry, protected zones)

Using this data, CITEPA is able to produce matrices showing land use changes between permanent grassland and annual cropland over 20 years.

The data needs to be adjusted by CITEPA to take account of the fact that:

- Changes in land use between permanent grassland and annual cropland are relatively frequent over a period of 20 years
- The land monitored by Teruti has changed since 1981

The data is processed to give a continuous estimate over the last 20 years (*Figure 19*). The areas in AGRIBALYSE that have undergone a land use change are given in **Table 147**.

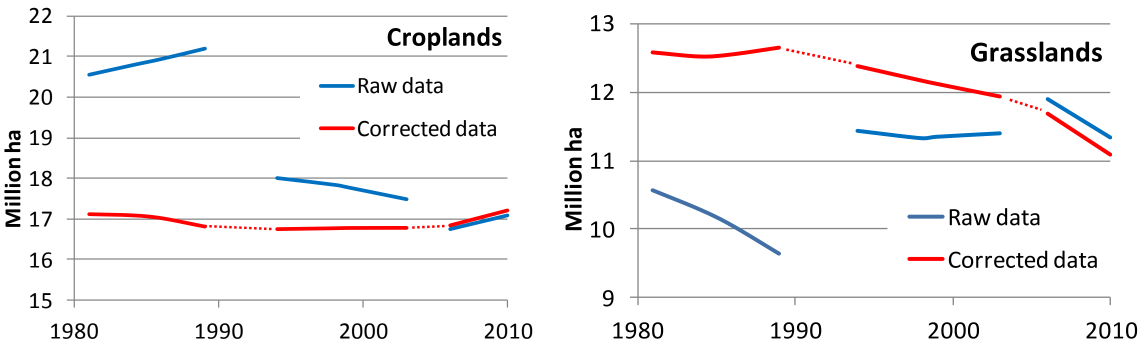

Figure 19: Land use change between croplands and grasslands between 1981 and 2010, before and after correction

Table 147: 20 year land use change matrix between croplands and grasslands in France for the period 1990-2010 considered in AGRIBALYSE, according to UNFCCC (CITEPA, 2012)

Land use change	Area (ha/yr)
Cropland converted into grassland	118,158
Grassland converted into cropland	159,732

3 Simplified method for estimating soil carbon flows

The carbon stocks for grasslands and croplands were calculated, at national scale, using the RMQS database (Martin *et al*, 2011). The stocks are given in **Table 148.**

Table 148: National average carbon stocks for grasslands and croplands, according to the RMQS database

Land use	Mean soil C stock (tC/ha)
Grassland	72.7
Cropland	53.3
Δ Grassland, cropland	19.4

Using the matrix created in stage 1, the areas with land use change within the past 20 years were determined for each AGRIBALYSE reference period (2005-2009).

The changes in soil carbon stocks for each year in the reference period ($EF_{Grassland\_LUC}$ and $EF_{Cropland\_LUC}$), and the average annual emission factors ($EF_{Grassland\_Tot}$ and EF_{Crop_Tot}) were determined using the following equations (Eq 3 and Eq 4).

$$EF_{Grassland\_Tot} = \frac{Grassland\ subject\ to\ LUC}{Total\ grassland\ area}\ x\ EF_{Grassland\_LUC} \quad \text{Eq. 3}$$

$$EF_{Crop\_Tot} = \frac{Cropland\ subject\ to\ LUC}{Total\ cropland\ area}\ x\ EF_{Crop\_LUC} \quad \text{Eq. 4}$$

The emission factors calculated are given in **Table 149**. These emission factors were applied to each hectare of cropland, including temporary meadow, and grassland.

Table 149: Total areas of subject to LUC from grassland to cropland and from cropland to grassland in France during the AGRIBALYSE reference period (2005-2009). CO_2 emission factors per ha of new cropland and per ha of new grassland and per ha of total cropland and grassland.

Land use change	Area (ha)	Emission factor ($t\ CO_2$/ha)
Grassland to cropland, 2005-2009	3,222,728	3.40
Cropland to grassland, 2005-2009	2,764,221	- 3.16
Total cropland, 2005-2009	16,686,248	0.66
Total grassland, 2005-2009	11,139,626	- 0.78

4 Method for estimating soil carbon flows for specific crops

The first two stages of constructing the 20 year matrix and defining carbon stocks for grassland and cropland are the same as for the CITEPA method described above.

Unlike the CITEPA method which is used at national scale, this method was applied to 22 administrative regions in France.

Negative emissions (carbon sequestration) were assigned to regions with permanent meadows and positive emissions were assigned to regions with dominantly annual crops. This approach gave regional emissions for permanent meadows and annual crops. In the following stage the emissions were allocated between the different types of crop within each region, depending on the relative area of each crop during the reference period 2005-2009, using the statistics database of the Office de la Statistique et des Études (SSP) of the French Ministry for Food, Agriculture and Fisheries (AGRESTE, 2012).

An emission factor for each crop for France was calculated using a weighted mean of the regional emission factors for each crop.

The emission factors calculated using this method are given in **Table 150**. For this method, the single emission factor defined above for permanent meadows is used.

Table 150: Crop specific CO_2 emission factors per ha of annual crops per year

Annual crop	Emission factor (t CO_2/ha)
Sugar beet	0.30
Durum wheat	0.72
Soft wheat	0.58
Rapeseed	0.56
Faba beans	0.38
Silage maize	0.79
Grain maize	0.68
Barley	0.57
Protein peas	0.50
Potatoes	0.36
Temporary meadow	0.89
Sunflowers	0.73
Triticale	0.92

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Appendix F: Taking account of water in Life Cycle Assessments

This appendix is based on the results of a literature search carried out in spring 2012 by Sandra Payen (CIRAD).

1 Background

For life cycle assessments, water has until now been considered as a potential receptor of pollutant emissions. The quality of the water, in particular the impact categories eutrophication, acidification and ecotoxicity has been taken into account. However, until now, water has not been taken into account as a resource. Recent methodological developments now make it possible to take account of the impact of water consumption.
A literature search carried out by CIRAD assessed the strengths and weaknesses of the various approaches developed. *Figure 20* below shows recently developed methods, organized according to their position in the initial cause to end effect chain.

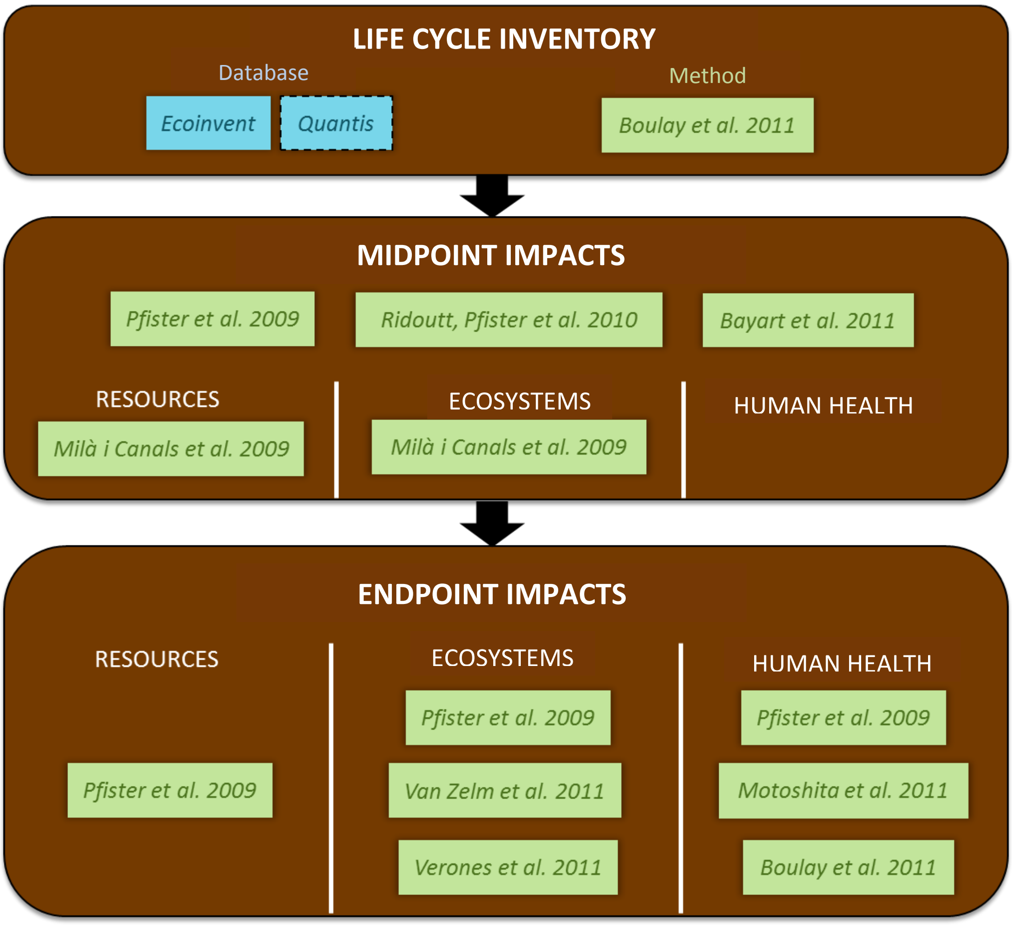

Figure 20: Main methods for taking account of the impacts of water consumption: position in the cause and effect chain

The methods developed for including water in LCAs do not give a thorough assessment of all impacts of water use. The UNEP/SETAC Life Cycle Initiative Project on Water Use in LCA (WULCA), was set up to determine the most appropriate aspects to be taken into account in an LCA and the impacts of water use. Bayart *et al* (2010) defined the complete theoretical framework for taking account of water in an LCA which should serve as a basis for future methodological developments. For characterization factors, however, they refer to the existing methods cited above and the method developed by Pfister *et al* 2009.

2 Method selected

Although it is disputed, the framework proposed by Pfister *et al* (2009) was the most advanced and was in a usable state. It was the only method which analyzed the mid and end point impacts for ecosystems, human health and resources using regionalized characterization factors taking account of the local scarcity of water in drainage basins, with global coverage. The local characterization factors, calculated with a spatial resolution of 5 minutes of arc, are available free on line on a GIS layer compatible with Google Earth.

Data required for implementing this method

The data required to implement this method are the quantity of fresh water consumed (not drawn off) by the production processes and the location of these take off points.

A distinction can be drawn between the water consumed directly by farms (water for irrigation, cleaning, drinking, etc) and the water consumed indirectly by the processes related to the product life cycle (water for fabricating inputs).

- Direct water use

▸ Crop irrigation water (including forage for the animals), cleaning water, drinking water for the animals.

Ideally, the LCI data set should be based on primary data from farms. However, the theoretical water requirements can be evaluated using the CROPWAT software developed by the FAO, from which rainfall is deducted to give the irrigation water requirements. The effective rainfall can be calculated using the USDA or FAO formulae.

- Indirect water use (background)

▸ Water consumed for fabricating inputs and for transport.

The ecoinvent database gives the quantity of water that may be used during the life cycle of over 4,000 products and processes (although only the quantity of water drawn off is given).

Application for AGRIBALYSE

The LCI data set produced for AGRIBALYSE is currently unable to use the method developed by Pfister as the quantity of water drawn off was entered into the data collection module. It is necessary to calculate the water **consumed** and to locate the place where the water was drawn off before this method can be used.

The Pfister method only takes account of **water consumed**. In agriculture, some of the water may drain back into the aquifer by drainage and/or excessive irrigation.

The AGRIBALYSE LCI data set will, therefore, quantify the volume of water drawn off. Calculating the impact of water use using the method proposed by Pfister is one of the priorities for future development of the program.

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Appendix G: Assignment of data collection module inputs to ecoinvent LCI data sets

Describing agricultural system requires to describe and quantify all the inputs inf the farming systems. The correspondance between Input names and background LCI is managed through Means-InOut platform (INRA 2016).

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Appendix H: Composition of organic fertilizers

The DM content of organic fertilizers was provided b the technical insitutes. When no data was available, we used SALCA references, then as last option we used an average by “fertilizer type”.

Table 151: Composition of organic fertilizers

Organic fertilizer	DM (% whole matter)	OM (% whole matter)	ASH (% whole matter)	Total N (kg/t)	N-NH4 (kg/t)	Available N (%)	Plant available N (kg/t)	P_2O_5 (kg/t)	K_2O (kg/t)	MgO (kg/t)	SO_3 (kg/t)	Reference
Sewage sludge				7.62				7.23	1.02			Sludge data
Limed sewage sludge				7.5				8	1			6
Composted sewage sludge				7				7	1.5			6
Liquid sewage sludge				3				2.5	0.9			6
Semi-solid sewage sludge				10				7.5	0.8			6
Dried sewage sludge				40				60	5			6
Straw rich cattle compost	33	21	12	8	0.4			5	14			1
Straw rich pig compost	45.3	28.3	17	13.3	1.4			18.4	24.8	7.1	11.1	4
Sheep manure compost	36	26	10	11.5	0.575			7	23			2
Straw rich pig slurry	24.8	14.7	10.1	6.1	1.7			8.8	7.4	6.2	4.1	4
Household waste compost				6				4	5	4		5
Green waste compost				8				4	10	1		10
Sugar scum (alkaline amendment)							3	8.5	0.4	5	10	10
Effluent with low solids	0.35	0.2	9	0.35	0.23			0.135	0.425			1
Feather meal				130								7
Dry poultry droppings	77.5	55.1	22.4	38.2	4.0	90	34.3	37.9	25.3	7.7		11
Average cattle manure	20.6	17.0	3.6	5.5	1.1			2.3	7.9			1
Bedded pack cattle manure	22.1	18	4.1	5.8	0.6			2.3	9.6			1
Wet cattle manure	19	16	3	5.1	1.5			2.3	6.2			1
Duck manure (ready for force feeding)	25	20	5.0	5.43	1.63	90	4.89	7.07	6.29			11
Goat manure	45	36	9	6.1	0.61			5.2	7			2
Turkey manure	57.5	46.6	11.0	18.5	5..2	90	16.7	12.9	13.8	3.9		11
Straw rich pig manure	30.8	23.6	7.2	9.4	3			7.7	14	3.4	5	4
Layer manure	60.0	37.7	22.4	15.0	4.8	90	13.5	21.9	18.2			12
Broiler manure	67.5	56.8	10.8	19.1	3.3	90	17.2	13.9	18.4	4.7	3.7	11
Horse manure	35.1	27.8	22.2	4.84	0.49			3.05	8.46			3
Sheep manure	30	23	7	6.7	0.67			4	12			2

Organic fertilizer	DM (% whole matter)	OM (% whole matter)	ASH (% whole matter)	Total N (kg/t)	N-NH4 (kg/t)	Available N (%)	Plant available N (kg/t)	P_2O_5 (kg/t)	K_2O (kg/t)	MgO (kg/t)	SO_3 (kg/t)	Referenc e
Average cattle slurry	7.5	6.0	6.0	2.6	1.3			1.0	3.1			1
Diluted cattle slurry	5	4	12	1.6	0.8			0.8	2.4			1
Undiluted cattle slurry	10	8	0	3.5	1.75			1.2	3.8			1
Duck manure (for roasting or force fed)	12.5	10	2.5	6.16	2.48	90	4.928	5.4	5.1	1.9		11
Rabbit slurry	28	20.9	7.1	7.6	0.5	80	6.08	11.8	5.9	2		13
Mixed pig slurry	3.6	2.5	1.1	3.5	2.5			2.1	2.5	0.6	0.7	4
Beef calf slurry	1.1	0.5	0	1.5	1.25			0.4	2.4			1
Chicken manure, outdoor run	23	19.5	3.5	13.8	2.3	40	5.52	17.3	22.9			11 & 14
Turkey manure, outdoor run	23	18.8	4.2	8.6	2.4	40	3.4	11.6	12.4			11 & 14
Layer hen manure, outdoor run	23	17	6	7.3	2.3	40	2.9	7.8	6.35			11 & 14
Duck manure, outdoor run	23	18.4	4.6	13.7	4.1	40	5.48	19.1	17			11 & 14
Pig slurry, fattening, outdoor run	6.84	4.59	2.14	5.8	3.7			3.2	4.8	1.2	1.5	4
Sow manure, gestation, outdoor run	2.33	1.17	0.73	2.2	1.7			1.5	1.5	0.3	0.5	4
Sow manure, suckling, outdoor run	3.15	1.69	0.71	2.8	1.7			1.9	2	0.4	0.6	4
Piglet manure, outdoor run	6.73	4.92	2.26	5.2	2.7			3.6	4.5	1.2	1.7	4
Cattle feces, grazing	20	5.4	14.6									15
Vegethumus							20	5	10	25		8
Concentrated sugar beet vinasse	55						21	0	75	2	10	9

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Appendix I: Building average fertilizer LCI data sets

Table 152 and **Table 153** summarize the French average N, P and K fertilizer data sets based on mineral fertilizer sales data provided by UNIFA for the period 2005 to 2009.
The data sets were built in two steps. The means for each type of fertilizer used during the period studied were calculated and were assigned to the corresponding ecoinvent fertilizer LCI data sets (**Table 152**). A breakdown of the fertilizers (**Table 153**) was used to create average fertilizer LCI data sets for the N, P_2O_5 and K_2O equivalent contents.

Step 1: Table 152 gives the annual mean consumption in France for fertilizer for the period 2005 to 2009. Column 2 gives the ecoinvent LCI data set corresponding to each type of fertilizer, defined on the basis of several criteria:

a) **Direct correspondence:** There was an ecoinvent data set for the type of fertilizer. For example, "Ammonitrates" are assigned to "ammonium nitrate, as N, at regional storehouse, RER" (**Table 153**).
b) **Indirect correspondence:** There was no direct ecoinvent LCI data set for the type of fertilizer. However, the information on the composition of the fertilizer (source GESTIM) makes it possible to define the fertilizer as a combination of several existing ecoinvent data sets. For example, "UAN" is produced by combining "Urea, as N, at regional storehouse" and "ammonium nitrate, as N, at regional storehouse, RER". 1 kg of UAN can be considered as the combination of 0.348 kg urea and 0.457 kg ammonium nitrate (the rest being water, cf "Fraction" column in **Table 153**).
c) **Correspondence with other types of fertilizer:** This approach was only used for organo mineral fertilizers. N, P_2O_5 and K_2O nutrients from these fertilizers were added pro rata to all the other forms of fertilizer used (**Table 153**).

Step 2: Table 153 lists the quantities of ingredients of the fertilizers applied. Column 1 gives the name of the ingredient, column 2 gives the corresponding ecoinvent LCI data set. Columns 3 and 4 give the quantities of the ingredient and nutrient (the same as the corresponding columns in **Table 152**). Column 5 adds the nutrients from organo-mineral fertilizer amendments. Column 6 gives the fractions of the nutrients that are assigned to different ecoinvent data sets (cf indirect correspondence). Columns 7 and 8 give the final assignment of nutrients to each ecoinvent data set. This data was used to build the average fertilizer LCI data set.

For fertilizers, Ecoinvent v3 "transformation processes" have been used, and transport added, following GESTIM references.
To assess transportation impacts, it is necessary to know both the distance and the weight of the fertilizers. When the weight was not directly available, because only fertilizing values were provided (ex : N units), then converson factors were applied :

Total weight = N x 1/28% + P2O5 x 1/18%+ K2O x 1/25%.

Table 155 and

Table 156 summarize the calculations for fertilizer transport distances for the fertilizers used in France. The first part (in green) gives information on the source of the fertilizer, means of transport used and distances travelled. The sub-table on the left in blue gives the distances for each type of fertilizer for each “transport model”.

Table 152: Mean annual deliveries of fertilizer in France between 2005 and 2009 (Source: UNIFA).
Column 3 gives the quantity of fertilizer used, columns 4 to 6 give the quantities of nutrients in this fertilizer. *Note:* Between 2005 and 2009, each year 1,551,887 t of DAP/MAP were spread on fields which is equivalent to an amendment of 276,495 tonnes of nitrogen (kg N) and 716,727 tonnes of phosphorus (kg P_2O_5)

Fertilizer	Correspondence	Tonnage	t N	t P	t K
- AMMONITRATES	direct correspondence with existing ecoinvent LCI data set	15,686,424	4,844,129		
- UAN	indirect correspondence with ecoinvent LCI data sets (GESTIM)	10,301,899	3,055,924		
- UREA	direct correspondence with ecoinvent LCI data set	3,002,222	1,380,913		
- OTHER SIMPLE N	direct correspondence with ecoinvent LCI data set	1,437,386	445,655		
Total	Total	30,427,931	9,726,621		
- TSP	direct correspondence with ecoinvent LCI data set	922,301		419,621	
- OTHER SUPERPHOSPHATES	direct correspondence with ecoinvent LCI data set	310,560		60,018	
- OTHER SIMPLE P	indirect correspondence with ecoinvent LCI data sets (GESTIM)	340,735		61,602	
- SIMPLE P	- SIMPLE P	1,573,596		541,241	
- POTASSIUM CHLORIDE	direct correspondence with ecoinvent LCI data set	2,291,553			1 374 932
- OTHER SIMPLE K	direct correspondence with ecoinvent LCI data set	494,259			196 211
- SIMPLE K	- SIMPLE K	2,785,812			1 571 143
- SUPERPOTASSIUM	indirect correspondence with ecoinvent LCI data sets (GESTIM)	2,705,710		498,433	658 114
- PHOSPHORUS POTASSIUM	indirect correspondence with ecoinvent LCI data sets (GESTIM)	377,562		51,184	65 095
- OTHER PK	indirect correspondence with ecoinvent LCI data sets (GESTIM)	773,807		87,895	132 845
- BINARY PK	- BINARY PK	3,857,079		637,512	856 054
- DAP - MAP	direct correspondence with ecoinvent LCI data set	1,551,877	276,495	716,727	
- OTHER NP	direct correspondence with ecoinvent LCI data set	1,005,782	204,965	171,532	
- NK - NPK	indirect correspondence with ecoinvent LCI data sets (GESTIM)	6,717,677	996,357	677,445	1 075 104
- ORGANO-MINERAL	added to N P K of the LCI data sets pro rata to N / P / K composition	605,745	27,057	35,913	59 098
- NP, NK, NPK, ORGANO-MINERAL COMPOUNDS	- NP, NK, NPK, ORGANO-MINERAL COMPOUNDS	9,881,081	1,504,874	1,601,617	1 134 202

Table 153: AGRIBALYSE average fertilizer LCI data sets according to N/P/K composition

Note (row UAN): Between 2005 and 2009, in France, each year 10,301,899 t of UAN were applied which is equivalent to an amendment of 3,055,924 tonnes of nitrogen (kg N). For the average fertilizer, the fraction from organo mineral fertilizers for this nutrient (27,057 t N) was allocated pro rata to all the LCI data sets. This corresponds to an additional 7,379 t N for UAN (column t N + pro rata). As ecoinvent does not have a UAN data set, UAN was split using GESTIM data making each kg UAN equivalent to 0.348 kg urea and 0.457 kg ammonium nitrate (cf “Fraction” column). The UAN applied can be considered to be 1,324,260 t N in the form of urea and 1,739,043 t of N in the form of ammonium nitrate. The last column gives the contribution of UAN to 1 kg of all N amendment in France: 118 g (included in the average fertilizer LCI data set as “urea”) and 155 g (included in the average fertilizer LCI data set as “ammonium nitrate”).

Average mineral fertilizer, as N, at regional storehouse, FR							
Ingredient	**ecoinvent LCI data set**	**t**	**t N**	**t N + pro rata**	**Fraction**	**t N**	**LCI data set**
- AMMONITRATES	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**
- UAN	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**
- UREA	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 N FERTILIZER	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 FERTILIZER	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-MINERAL	repartis sur les autres	605,745.00	27,057.00				
TotaL		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							
Ingredient	**ecoinvent LCI data set**	**t**	**t P**	**t P allocated**	**Splitting**	**t P**	**LCI data set**
- 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 P FERTILIZER	Phosphate fertiliser, as P2O5 {RER}| single superphosphate production | Alloc	340,735.00	61,602.00	62,408.10	1	62,408.10	**0.022**

	Rec						
- DAP - MAP	Phosphate fertiliser, as P2O5 {RER}| diammonium phosphate production | Alloc Rec	1,551,87.,00	716,727.00	726,105.84	1	726,105.84	**0.261**
- OTHER NP FERTILIZER	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-MINERAL	repartis sur les autres	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**
- PHOSPHORUS 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 PK	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**
Total		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

Ingredient	ecoinvent LCI data set	t	t K	t K allocated	Splitting	t P	LCI data set
- 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 K FERTILIZER	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**
- PHOSPHORUS 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 PK	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-MINERAL	repartis sur les autres	605,745.00	59,098.00				**0.000**
Total		13,966,313.00	3,561,399.00	3,561,399.00		3,561,399.00	**1.000**

Table 154: Example of 8-10-20 mineral fertilizer

Composition of 8-10-20 fertilizer	Correspondence	Content kg/t	Factor	LCI data set
N	average mineral fertilizer, as N, at regional storehouse, FR	80	1.00	**80.00**
P	average mineral fertilizer, as P2O5, at regional storehouse, FR	100	1.00	**100.00**
K	average mineral fertilizer, as K2O, at regional storehouse, FR	200	1.00	**200.00**
other components	Production of other components is ignored, but the quantity is taken into account for transport	620		
Total		1000		

Table 155: Recalculation of transport models for fertilizers, based on GESTIM (GAC *et al*, 2010)

Distance (km)	Source									
Means of transport	**F**	**EU 15**	**Russia**	**Ukraine**	**N Africa**	**Arabia**	**Cent America**	**Chile**	**Qatar**	**China /Austr**
Road	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%
UAN	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%
Potassium	0%	97%	2%	0%	0%	0%	0%	0%	1%	0%

Transport model (tkm) **GESTIM Original**

Type	Road **Transport Lorry > 16,t aver. RER**	Boat transport, transoceanic freight ship ; **OCE**
TM N fertilizer	150	0
TM Urea	225	1595
TM AN/CAN	250	120
TM UAN	190	525
TM MAP/DAP	190	2255
TM TSP	215	1705
TM Potassium	392.5	90
TM Average fertilizer	230.36	898.57

Table 156: Assignment of Transport models (TM) to LCI data sets

Fertilizer LCI data sets used for AGRIBALYSE	Tr Model => cf Table 155
average mineral fertilizer, as K, at regional storehouse, FR	TM Potassium
average mineral fertilizer, as N, at regional storehouse, FR	TM N fertilizer
average mineral fertilizer, as P, at regional storehouse, FR	TM TSP
ICV ecoinvent Copper, primary, at refinery/RER U	TM Average
ICV ecoinvent ammonium nitrate, as N, at regional storehouse, RER	TM AN/CAN
ICV ecoinvent calcium nitrate, as N, at regional storehouse, RER	TM AN/CAN
ICV ecoinvent chemicals inorganic, at plant, GLO	TM Average
ICV ecoinvent diammonium phosphate, as N, at regional storehouse, RER	TM MAP/DAP
ICV ecoinvent Magnesium oxide, at plant, RER	TM Average
ICV ecoinvent Zinc, primary, at regional storage/RER U	TM Average
ICV ecoinvent Manganese oxide (Mn2O3), at plant, CN	TM Average
ICV ecoinvent Lime, from carbonation, at regional storehouse, CH	TM Average
ICV ecoinvent Limestone, milled, loose, at plant, CH	TM Average
ICV ecoinvent Magnesium sulphate, at plant, RER	TM MAP/DAP
ICV ecoinvent Monoammonium phosphate, as N, at regional storehouse	TM MAP/DAP
ICV ecoinvent Potassium chloride, as K2O, at regional storehouse. RER	TM Potassium
ICV ecoinvent Potassium nitrate, as K2O, at regional storehouse, RER	TM Potassium
ICV ecoinvent Potassium sulphate, as K2O, at regional storehouse, RER	TM Potassium
ICV ecoinvent Single superphosphate, as P2O5, at regional storehouse, RER	TM TSP
ICV ecoinvent Triple superphosphate, as P2O5, at regional storehouse, RER	TM TSP
ICV ecoinvent Urea ammonium nitrate, as N, at regional storehouse, RER	TM Urea
ICV ecoinvent Urea, as N, at regional storehouse	TM Urea
ICV ecoinvent Ammonium sulphate, as N, at regional storehouse, RER	TM N fertilizer

Appendix J: Building the machinery data sets

Table 157 gives the groups of machinery used for the data collection module and the data required for parameterizing the ecoinvent LCI data set (see B.2.1). Of the 191 machines defined in AGRIBALYSE® data collection module, 186 can be assigned to one of the six existing "agricultural machinery" LCI data sets in ecoinvent v2.0: - tractors; harvesters; trailers; agricultural machinery, general; agricultural machinery, tillage; slurry tankers. A new LCI data set "electric machinery" has been created for the remaining 5 AGRIBALYSE® machines. These 7 groups (6+1) were subdivided according to the life times of machines to take into account the different use of a certain number of components (tires, oil and filters for the engine). This gives a total of 14 machinery groups with an average lifetime and weight (see row in blue gray). These groups (1st column) correspond to the 14 AGRIBALYSE® machinery LCI data sets, based on ecoinvent and parametrized according to weight and lifetime of machines in use in France.

The unit processes for these 14 groups of machine are given in **Table 157**.

Table 157: Groups of machines listed in the data collection module as 14 AGRIBALYSE groups of machines

Groups of machines and summary of values used for the "production machine XY" data set	Machine in the DCM	Rating (kW); width (m), capacity (m^3)	Life time (h)	Weight of machine (kg)
Tractor, LT 7'500h, production (based on Tractor)	Tracked vehicle		7200	450
	Vineyard tractor		7200	2300
	Tractor 30 kW	28 kW	7200	1375
	Tractor 50-60 kW	50-60 kW	7200	3'000
	Tractor, soil disinfection contractor	257 kW (350 bhp), 4 WD	7500	11800
Value used			7200	5400
Tractor, LT 10'000h, production (based on Tractor)	Mini tractor Kubota L3608	20 kW	9000	1100
	Telescopic 100 bhp		10000	4500
	Tractor 200 bhp	147 kW (200 bhp), 4 WD	9600	9000
	Tractor 80-100 kW (110-140 bhp)	110-140 bhp (80-100 kW)	10000	5300
	Tractor 80-100 KW (110-140 bhp)		10000	5300
	Orchard tractor 51.4 kW, 4 WD	51.4 kW	10500	2400
Value used for			10000	4500
Tractor, LT 12'000h, production (based on Tractor)	High clearance tractor 44.1 kW 4 WD	44.1	12000	2200
	High clearance tractor 73.5 kW, 4 WD	73.5	12000	4000
	High clearance cultivator gasoline		15000	800

Groups of machines and summary of values used for the "production machine XY" data set	Machine in the DCM	Rating (kW); width (m), capacity (m^3)	Life time (h)	Weight of machine (kg)
	Self driver 265 kW		12000	5500
	Self propelled 360 kW		12000	5500
	Tractor 160 bhp, 4 WD	160 bhp	12000	6440
	Tractor 300 bhp	300 bhp	12000	9500
	Tractor 58.8 kW 4 WD	58.8	12000	2800
	Tractor 77.2 kW, 4 WD	77.2 kW	12000	3500
	Tractor 90 bhp, 4 WD	90 bhp	12000	4300
	Tractor Massey Ferguson	50 kW	15000	2358
	Tractor TMF 275 (Mango)	77.2	15000	3000
	Back hoe loader	104 kW	12000	20600
Value used			12000	5500
Harvester/Machine with engine, LT < 5'000h, production (based on Harvester)	Self-propelled vine lifter		3000	5000
	Self-propelled sugar beet harvester 6 rows	265 kW, 6 rows	2500	15100
	Self-propelled carrot sprayer Aquitaine	102.9 kW (140 bhp), 3000 l tank, 24 m bar	3600	7335
	Self-propelled forage harvester 600 bhp with trailer	600 bhp	4000	9000
	Self-propelled forage harvester	8 rows, 480 bhp	4000	9000
	Self-propelled grape harvester		3000	5800
	Combine harvester, 200 bhp, 5.5m	200 kW, 5.5 m	4000	10000
	Cultivator with water pump 1600l/min	4kW	700	30
	Quad	5 bhp	1600	285
Value used			3000	8000
Harvester/Machine with engine, LT 5'000-10'000h, production (based on Harvester)	Self-propelled harvester 3 rows	147 kW (200 bhp)	6000	14000
	Sprayer 18 bhp engine	13 kW	7200	150
	Self-propelled harvester		6400	9500
	Self-propelled carrot harvester	147 kW (200 bhp)	6000	14000
Value used			7200	5400
Harvester/Machine with engine, LT > 10'000h, production (based on Harvester)	Self-propelled sprayer	220 kW (300 bhp)	18000	9100
	Self-propelled work platform	14.7 kW	12000	2250
Value used			15000	6000
Trailer, < 20 t, production (based on Trailer)	Trailer (Clementine harvester)	na	10000	500
	Trailer 4 palox crates		6000	760

Groups of machines and summary of values used for the "production machine XY" data set	Machine in the DCM	Rating (kW); width (m), capacity (m^3)	Life time (h)	Weight of machine (kg)
	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, production (based on Trailer)	Trailer body 21 tonnes	21 tonnes	15000	8100
	Trailer body, 2 axles - 15 t		6000	5883
Value used			10000	7000
Slurry tanker 5'000 lt, production (based on Slurry tanker)	Slurry spreader / 5000l vacuum tank	5000 l	5000	1690
Value used			5000	1700
General machinery, with tires, LT < 2'500h, production (based on Agricultural machinery, general)	Potato harvester	2 rows, standard, 75 cm	1800	5500
	Baler 17 bales / h	17 bales / h	1000	2000
	Manure spreader, 5t	5t	2400	3848
	Fertilizer spreader, centrifugal, 1500l	24 m, 1500 l	800	550
	Planter, 4 rows, 75 cm	4 rows	1500	2000
	Maiden tree planter		1000	500
	Nursery planter, 4 rows	4 rows	2250	1060
	Nursery planter/transplanter		2250	300
	Duster for orchards	Towed 600 liters	240	260
	Round baler		1800	1773
	Cider apple harvester		1875	1200
	Rice combine harvester Kaset Phattana	120 kW, 3 m	2000	4000
	Disk drill for no till, 4m	4 m	1200	5300
	Standard drill, 4m	4 m	1200	1000
	Tine coulter drill	3 m	900	680
	Tine coulter drill(3 m)	3 m	900	680
	Single seed drill, pneumatic delivery - 6 rows	6 rows (3m)	1200	1000
Value used			1500	2000
General machinery, with tires, LT 2'500-5'000h, production (based on Agricultural machinery, general)	Swather 9m	9 m	3000	3200
	Towed carrot harvester 1 row	1 row	4800	5500
	Towed sprayer, 2000 L, two horizontal turbines	2000 L	4000	650
	Slurry spreader with hanging bar, 1500-2000l	1 axle, 1500-2000 l	5000	1000

Groups of machines and summary of values used for the "production machine XY" data set	Machine in the DCM	Rating (kW); width (m), capacity (m^3)	Life time (h)	Weight of machine (kg)
	Manure spreader, 8-10t	2 axles, 8-10 t	5000	3500
	Soil disinfection machine	13 coulters, 4,75 m, 2 1000 l tanks	4500	3500
	Potato planter, 4 rows, 75 cm	4 rows 75 cm automatic	3000	1000
	Spreader Jacto Arbus 2000 (Mango)		2000	820
	Towed sprayer, 2500l	24 m, 2500 l	3000	2600
	3 strip seed drill	5.5 m	3600	2250
	Pneumatic seed drill		900	550
Value used			4000	2500
General machinery, with tires, LT > 5'000h, production (based on Agricultural machinery, general)	Towed swather1.83 m	1.83 m	6000	3370
	Towed carrot harvester 3 rows	3 rows	6000	9000
	3 strip spreader, 6-8 tonnes	6-8 tonnes	9000	3120
	Towed sprayer, 3000l	24 / 28 m, 3000 l	6000	2500
	Towed carrot harvester		6000	9000
Value used			7800	6200
machine portée (basée sur "Agricultural machinery, tillage"	Swather for pruning wood	2.5 m	200	250
	Nursery maiden tree lifter		7200	1500
	Sprayer		2300	900
	Hoeing machine		2300	900
	Hoeing machine, 2 rows	2.5 m	2400	450
	Hoeing machine, 3.6 m		1800	550
	Hoeing machine, with camera, 4 m	camera, 4 m, tines	3000	1600
	Three row hoeing machine	5.5 m	4800	770
	Hoeing machine for grapevines	2.5	1500	550
	Flail shredder	4.5	2300	2100
	Flail	2.5 m	200	645
	Pruning shredder (vines)		2300	530
	Pruning shredder (clementines)	na	1000	500
	Haulm topper	4 rows	3000	1000
	Haulm topper (carrots)	4.8 m	2400	2600
	Ridger	4 rows	3000	1000
	Ridger with roller molders	2 ridges	2400	300
	Ridger for tunnel		450	450

Groups of machines and summary of values used for the "production machine XY" data set	Machine in the DCM	Rating (kW); width (m), capacity (m^3)	Life time (h)	Weight of machine (kg)
	Plow, single, reversible		3000	1350
	Plow, single		3000	400
	Plow, 5 furrow, 3 point	5 furrow, 3 point	3000	1000
	Plow, 8 furrow	3.2 m	4800	3150
	Disk plow, Kubota	3-4 disks	1500	200
	Plow, 4 furrow, attachment	4 furrow	480	1039
	Furrow plow		2500	163
	Plow for grapevines, single		900	150
	Plow, 6 furrow		4800	1760
	Chisel plow, 2.5m	2.5 m	2300	709
	Chisel plow, 4.5m	4.5 m	1570	1029
	Compressor attachment		2300	900
	Compressor attachment for secateurs	compressor + 600 l tank	3750	500
	Disk harrow (Mangoes)		2500	1000
	Harrow. 36 disk. 5.5m		2300	3000
	Disk harrow, 4m	4 m	2100	3000
	Heavy cultivator + roller	3 m	2400	1300
	Rotary tiller, 2m	2 m	2300	330
	Triple bed former	5.5 m	3600	3900
	Under vine weeder		2300	800
	Disk harrow 2.5 m	2.5 m	800	780
	Disk harrow, independent disks, 4m	4 m	1500	2100
	Disk harrow, semi attached, 5.5 m	5.5 m	3600	3900
	Disk harrow attachment, 5.5m	5.5	1500	2100
	Chisel plow, 4 m	4 m	4800	1000
	Chisel plow, 7 chisels	7 chisels	2400	1000
	Chisel plow, 5 chisels	3	3000	900
	Chisel plow		2300	1000
	Wire unspooler		2250	80
	Hail net unspooler		2250	600
	Weed burner		1500	550
	Disk for harrow		300	200

Groups of machines and summary of values used for the "production machine XY" data set	Machine in the DCM	Rating (kW); width (m), capacity (m^3)	Life time (h)	Weight of machine (kg)
	Topping machine		1800	200
	Leaf stripper		1800	500
	Leaf stripper (vines)		2300	100
	3 point forklift		6000	460
	Post driver		3000	335
	Post driver		2300	700
	Stone burier	2.1 m	1500	860
	Spooler		2250	400
	Forage harvester attachment, single row	1 row	3000	480
	Chemical vine disbudder		2300	450
	Mechanical vine disbudder		2300	450
	Spreader 500 l		1800	126
	Fertilizer spreader 500 l	1.45 m	800	126
	Spreader attachment. 1000 kg	1000 kg	2300	150
	Spreader attachment, 2500 l	28	800	463
	Fertilizer spreader, centrifugal, 500 l	500 l	2300	193
	Tedder, 3 m		3000	370
	Mower, 7 m	7 m	1500	3200
	Mower conditioner attachment, 3m	3 m	1500	1075
	Rotary mower, 3m	3 m	2300	643
	Binder		1800	150
	Front forklift		1000	150
	Rotary cultivator, 4 m	4 m	1800	1270
	Front bucket	2.1 m	900	320
	Tine harrow		2300	600
	Rotary topper		2300	900
	Rotary topper. orchard	3.6 m	700	530
	Gyro-cep rotary topper sunflower		2300	200
	Reciprocating harrow. 3m	3m	2300	1686
	Vibrating harrow with roller	2.05 m	900	625
	Chain harrow for mechanical weeding, 12m		610	1020
	Rotary harrow	4 m	1800	1380

Groups of machines and summary of values used for the "production machine XY" data set	Machine in the DCM	Rating (kW); width (m), capacity (m^3)	Life time (h)	Weight of machine (kg)
	Rotary harrow+ roller	2 m	750	780
	Rotary harrow with roller 3 m		1800	960
	Rotary harrow, 4m	4 m	2010	1686
	Rotary harrow, with roller 2,5 m	2.5 m	800	840
	Rotary harrow		300	500
	Injector for soil disinfection		1800	300
	Intervine blade		1500	40
	Cutter for trimming fruit tree row		500	750
	Soil disinfection machine, Normandy	10 coulters	2400	800
	Scarifier, 5.5	5.5 m	2300	552
	Triple mulching film laying machine	3 strips 1.65 to 1.90 m	2400	1000
	Bale trailer		6000	3150
	Coarse pruner		2300	900
	Sprayer 2000 l with cannon		4000	800
	Sprayer 3400 l, 24 m	24 m	3000	2300
	Backpack sprayer Mitsubishi TU 26	2 kW	2300	12
	Recycling tunnel sprayer		2300	450
	Lance sprayer	na	1000	200
	Sprayer, 1200 l tank, 18 m bar		3000	650
	Sprayer attachment 1000L, 24 m bar	24 m	4800	990
	Sprayer attachment 400 l	2 m	3000	200
	Sprayer attachment 600 L, 4 rows	4 rows	3000	500
	Sprayer attachment 800 l with 12 m bar	12 m	4800	950
	Sprayer attachment , 800l	15 m, 800 l	2300	477
	Sprayer greenhouse, vertically trained crops	20 bhp, 400 liter tank, vertical bar	2400	500
	Sprayer 18 m, 1200 l	18 m, 1200 l	3000	1000
	Spray bar		2300	150
	Ditcher		4800	400
	Trimming machine		2300	900
	Rotavator	2 m	1800	405
	Rotavator		4800	685
	Rotavator 3 m	3 m	2400	1000

Groups of machines and summary of values used for the "production machine XY" data set	Machine in the DCM	Rating (kW); width (m), capacity (m^3)	Life time (h)	Weight of machine (kg)
	Spader	2 m	1800	830
	Tedder	3	1500	300
	Roller harrow, 3m	3m, attachment	3000	1130
	Roller, 9m	9m	1410	4500
	Potato lister		2300	450
	Shaker		375	800
	Baler stacker		2400	550
	Subsoiler, 2 m		375	450
	Subsoiler, 6 furrows, 3 m	6 furrows, 3 m	2400	770
	Subsoiler		2300	900
	Subsoiler		2500	300
	Augur		3000	290
	Mower, cider apple orchard 3.4 m	3.4 m	700	650
	Saw with lance for pruning cider orchards	0.95 kW	500	6.3
	Spring tine harrow 6.3 m		1800	910
	Spring tine harrow, 3m	3 m	2300	538
	Spring tine harrow, 5m	5m, mounted	1300	750
Value used			2300	900
Agricultural machinery with electronic motor, production	Electric fork lift on rails	0.37 kW	2500	300
	Conveyor	0,18 kW	1500	41
	Brush cutter Honda UMK 435T	2kW, 2m	250	12
	Potting machine	4.12 kW	1500	1200
	Compost hopper	4 kW	2250	1500
Value used			2300	900

Table 158: Unit processes for the 14 groups of agricultural machinery used in the AGRIBALYSE LCI data sets. The unit processes were calculated by parameterizing the basic ecoinvent LCI data sets with the average life time and average weight (cf table above).

Input	Units	Quantity	Comment
Tractor, LT 10,000h, production/FR. FU = kg per life time, based on " Tractor, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Aluminium, production mix, at plant/RER	kg	0.045	Production
Chromium steel 18/8, at plant/RER	kg	0.03	Production
Copper, at regional storage/RER	kg	0.02	Production
Electricity, medium voltage, at grid/FR	kWh	1.5	Production
Flat glass, uncoated, at plant/RER	kg	0.01	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.84	Production
Lead, at regional storage/RER	kg	0.01	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.84	Production
Lubricating oil, at plant/RER	kg	0.0066	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.92	Production
Polypropylene, granulate, at plant/RER	kg	0.03	Production
Steel, converter, unalloyed, at plant/RER	kg	0.67	Production
Steel, low-alloyed, at plant/RER	kg	0.07	Production
Synthetic rubber, at plant/RER	kg	0.1	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Zinc, primary, at regional storage/RER	kg	0.01	Production
Electricity, medium voltage, at grid/FR	kWh	0.55939	Maintainance (filter, oil)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	7.1399	Maintainance (filter, oil)
Electricity, medium voltage, at grid/FR	kWh	0.4862	Maintainance (tires)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	6.2057	Maintainance (tires)
Lead, at regional storage/RER	kg	0.04	Maintenance (filter)
Paper, woodfree, coated, at integrated mill/RER	kg	0.008	Maintenance (filter)
Polypropylene, granulate, at plant/RER	kg	0.004	Maintenance (filter)
Lubricating oil, at plant/RER	kg	0.28453	Maintenance (oil)
Synthetic rubber, at plant/RER	kg	0.2925	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.00125	Repair
Aluminium, production mix, at plant/RER	kg	0.01125	Repair
Chromium steel 18/8, at plant/RER	kg	0.0075	Repair
Copper, at regional storage/RER	kg	0.005	Repair
Electricity, medium voltage, at grid/FR	kWh	0.41556	Repair
Flat glass, uncoated, at plant/RER	kg	0.0025	Repair
Lead, at regional storage/RER	kg	0.0025	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	5.304	Repair
Polypropylene, granulate, at plant/RER	kg	0.0075	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.1675	Repair
Steel, low-alloyed, at plant/RER	kg	0.0175	Repair
Synthetic rubber, at plant/RER	kg	0.025	Repair
Zinc, primary, at regional storage/RER	kg	0.0025	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	0.005445	Production
Heat, waste, high. pop.	MJ	9.574	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0048	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0036615	Maintainance (filter, oil)
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0031824	Maintainance (tires)
Carbon dioxide, fossil, low. pop.	kg	0.0013612	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.00272	Repair
Disposal, building, glass sheet, to final disposal/CH	kg	0.0025	Waste management
Disposal, building, glass sheet, to final disposal/CH	kg	0.01	Waste management
Disposal, paper, 11.2% water, to municipal incineration/CH	kg	0.008	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.004	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.00875	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.035	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.0066	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.28453	Waste management

Input	Units	Quantity	Comment
Tractor, LT 12,000h, production/FR. FU = kg per life time, based on "Tractor, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Aluminium, production mix, at plant/RER	kg	0.045	Production
Chromium steel 18/8, at plant/RER	kg	0.03	Production
Copper, at regional storage/RER	kg	0.02	Production
Electricity, medium voltage, at grid/FR	kWh	1.5	Production
Flat glass, uncoated, at plant/RER	kg	0.01	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.84	Production
Lead, at regional storage/RER	kg	0.01	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.84	Production
Lubricating oil, at plant/RER	kg	0.0066	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.92	Production
Polypropylene, granulate, at plant/RER	kg	0.03	Production
Steel, converter, unalloyed, at plant/RER	kg	0.67	Production
Steel, low-alloyed, at plant/RER	kg	0.07	Production
Synthetic rubber, at plant/RER	kg	0.1	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Zinc, primary, at regional storage/RER	kg	0.01	Production
Electricity, medium voltage, at grid/FR	kWh	0.67127	Maintainance (filter, oil)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	8.5679	Maintainance (filter, oil)
Electricity, medium voltage, at grid/FR	kWh	0.61585	Maintainance (tires)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	7.8605	Maintainance (tires)
Lead, at regional storage/RER	kg	0.048	Maintenance (filter)
Paper, woodfree, coated, at integrated mill/RER	kg	0.0096	Maintenance (filter)
Polypropylene, granulate, at plant/RER	kg	0.0048	Maintenance (filter)
Lubricating oil, at plant/RER	kg	0.34144	Maintenance (oil)
Synthetic rubber, at plant/RER	kg	0.3705	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.001375	Repair
Aluminium, production mix, at plant/RER	kg	0.012375	Repair
Chromium steel 18/8, at plant/RER	kg	0.00825	Repair
Copper, at regional storage/RER	kg	0.0055	Repair
Electricity, medium voltage, at grid/FR	kWh	0.45711	Repair
Flat glass, uncoated, at plant/RER	kg	0.00275	Repair
Lead, at regional storage/RER	kg	0.00275	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	5.8344	Repair
Polypropylene, granulate, at plant/RER	kg	0.00825	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.18425	Repair
Steel, low-alloyed, at plant/RER	kg	0.01925	Repair
Synthetic rubber, at plant/RER	kg	0.0275	Repair
Zinc, primary, at regional storage/RER	kg	0.00275	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	0.005445	Production
Heat, waste, high. pop.	MJ	9.574	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0048	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0043938	Maintainance (filter, oil)
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.004031	Maintainance (tires)
Carbon dioxide, fossil, low. pop.	kg	0.0014974	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.002992	Repair
Disposal, building, glass sheet, to final disposal/CH	kg	0.00275	Waste management
Disposal, building, glass sheet, to final disposal/CH	kg	0.01	Waste management
Disposal, paper, 11.2% water, to municipal incineration/CH	kg	0.0096	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.0048	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.009625	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.035	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.0066	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.34144	Waste management
Tractor, LT 7,500h, production/FR. FU = kg per life time, based on "Tractor, CH"			
Electricity, medium voltage, at grid/FR	kWh	0.40276	Maintainance (filter, oil)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	5.1407	Maintainance (filter, oil)
Electricity, medium voltage, at grid/FR	kWh	0.30469	Maintainance (tires)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	3.8889	Maintainance (tires)
Lead, at regional storage/RER	kg	0.0288	Maintenance (filter)

Input	Units	Quantity	Comment
Paper, woodfree, coated, at integrated mill/RER	kg	0.00576	Maintenance (filter)
Polypropylene, granulate, at plant/RER	kg	0.00288	Maintenance (filter)
Lubricating oil, at plant/RER	kg	0.20486	Maintenance (oil)
Synthetic rubber, at plant/RER	kg	0.1833	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Aluminium, production mix, at plant/RER	kg	0.045	Production
Chromium steel 18/8, at plant/RER	kg	0.03	Production
Copper, at regional storage/RER	kg	0.02	Production
Electricity, medium voltage, at grid/FR	kWh	1.5	Production
Flat glass, uncoated, at plant/RER	kg	0.01	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.84	Production
Lead, at regional storage/RER	kg	0.01	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.84	Production
Lubricating oil, at plant/RER	kg	0.0066	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.92	Production
Polypropylene, granulate, at plant/RER	kg	0.03	Production
Steel, converter, unalloyed, at plant/RER	kg	0.67	Production
Steel, low-alloyed, at plant/RER	kg	0.07	Production
Synthetic rubber, at plant/RER	kg	0.1	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Zinc, primary, at regional storage/RER	kg	0.01	Production
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.001	Repair
Aluminium, production mix, at plant/RER	kg	0.009	Repair
Chromium steel 18/8, at plant/RER	kg	0.006	Repair
Copper, at regional storage/RER	kg	0.004	Repair
Electricity, medium voltage, at grid/FR	kWh	0.33244	Repair
Flat glass, uncoated, at plant/RER	kg	0.002	Repair
Lead, at regional storage/RER	kg	0.002	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	4.2432	Repair
Polypropylene, granulate, at plant/RER	kg	0.006	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.134	Repair
Steel, low-alloyed, at plant/RER	kg	0.014	Repair
Synthetic rubber, at plant/RER	kg	0.02	Repair
Zinc, primary, at regional storage/RER	kg	0.002	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	0.005445	Production
Heat, waste, high. pop.	MJ	9.574	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0048	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0026363	Maintainance (filter, oil)
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0019943	Maintainance (tires)
Carbon dioxide, fossil, low. pop.	kg	0.001089	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.002176	Repair
Disposal, building, glass sheet, to final disposal/CH	kg	0.002	Waste management
Disposal, building, glass sheet, to final disposal/CH	kg	0.01	Waste management
Disposal, paper, 11.2% water, to municipal incineration/CH	kg	0,00576	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0,00288	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.007	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.035	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.0066	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.20486	Waste management
Harvester/Machine with engine, LT <5,000h, production/FR. FU = kg per life time, based on “Harvester, CH”			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Aluminium, production mix, at plant/RER	kg	0.045	Production
Chromium steel 18/8, at plant/RER	kg	0.03	Production
Copper, at regional storage/RER	kg	0.02	Production
Electricity, medium voltage, at grid/FR	kWh	1.5	Production
Flat glass, uncoated, at plant/RER	kg	0.01	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.84	Production
Lead, at regional storage/RER	kg	0.01	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.84	Production
Lubricating oil, at plant/RER	kg	0.002	Production

Input	Units	Quantity	Comment
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.92	Production
Polypropylene, granulate, at plant/RER	kg	0.03	Production
Steel, converter, unalloyed, at plant/RER	kg	0.7	Production
Steel, low-alloyed, at plant/RER	kg	0.07	Production
Synthetic rubber, at plant/RER	kg	0.07	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Zinc, primary, at regional storage/RER	kg	0.01	Production
Electricity, medium voltage, at grid/FR	kWh	0.068497	Maintainance (filter, oil)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.87427	Maintainance (filter, oil)
Electricity, medium voltage, at grid/FR	kWh	0.19947	Maintainance (tires)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	2.5459	Maintainance (tires)
Lead, at regional storage/RER	kg	0.012	Maintenance (filter)
Paper, woodfree, coated, at integrated mill/RER	kg	0.0024	Maintenance (filter)
Polypropylene, granulate, at plant/RER	kg	0.0012	Maintenance (filter)
Lubricating oil, at plant/RER	kg	0.025608	Maintenance (oil)
Synthetic rubber, at plant/RER	kg	0.12	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.001	Repair
Aluminium, production mix, at plant/RER	kg	0.009	Repair
Chromium steel 18/8, at plant/RER	kg	0.006	Repair
Copper, at regional storage/RER	kg	0.004	Repair
Electricity, medium voltage, at grid/FR	kWh	0.33244	Repair
Flat glass, uncoated, at plant/RER	kg	0.002	Repair
Lead, at regional storage/RER	kg	0.002	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	4.2432	Repair
Polypropylene, granulate, at plant/RER	kg	0.006	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.14	Repair
Steel, low-alloyed, at plant/RER	kg	0.014	Repair
Synthetic rubber, at plant/RER	kg	0.014	Repair
Zinc, primary, at regional storage/RER	kg	0.002	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	3.50E-05	Production
Heat, waste, high. pop.	MJ	8.012	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0048	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.00044834	Maintainance (filter, oil)
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0013056	Maintainance (tires)
Carbon dioxide, fossil, low. pop.	kg	7.00E-06	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.002176	Repair
Disposal, building, glass sheet, to final disposal/CH	kg	0.002	Waste management
Disposal, building, glass sheet, to final disposal/CH	kg	0.01	Waste management
Disposal, paper, 11.2% water, to municipal incineration/CH	kg	0.0024	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.0012	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.007	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.035	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.002	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.025608	Waste management
Harvester/Machine with engine, LT >10,000h, production/FR. FU = kg per life time, based on "Harvester, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Aluminium, production mix, at plant/RER	kg	0.045	Production
Chromium steel 18/8, at plant/RER	kg	0.03	Production
Copper, at regional storage/RER	kg	0.02	Production
Electricity, medium voltage, at grid/FR	kWh	1.5	Production
Flat glass, uncoated, at plant/RER	kg	0.01	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.84	Production
Lead, at regional storage/RER	kg	0.01	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.84	Production
Lubricating oil, at plant/RER	kg	0.002	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.92	Production
Polypropylene, granulate, at plant/RER	kg	0.03	Production
Steel, converter, unalloyed, at plant/RER	kg	0.7	Production
Steel, low-alloyed, at plant/RER	kg	0.07	Production
Synthetic rubber, at plant/RER	kg	0.07	Production

Input	Units	Quantity	Comment
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Zinc, primary, at regional storage/RER	kg	0.01	Production
Electricity, medium voltage, at grid/FR	kWh	0.34248	Maintainance (filter, oil)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	4.3713	Maintainance (filter, oil)
Electricity, medium voltage, at grid/FR	kWh	1.4461	Maintainance (tires)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	18.458	Maintainance (tires)
Lead, at regional storage/RER	kg	0.06	Maintenance (filter)
Paper, woodfree, coated, at integrated mill/RER	kg	0.012	Maintenance (filter)
Polypropylene, granulate, at plant/RER	kg	0.006	Maintenance (filter)
Lubricating oil, at plant/RER	kg	0.12804	Maintenance (oil)
Synthetic rubber, at plant/RER	kg	0.87	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.001375	Repair
Aluminium, production mix, at plant/RER	kg	0.012375	Repair
Chromium steel 18/8, at plant/RER	kg	0.00825	Repair
Copper, at regional storage/RER	kg	0.0055	Repair
Electricity, medium voltage, at grid/FR	kWh	0.45711	Repair
Flat glass, uncoated, at plant/RER	kg	0.00275	Repair
Lead, at regional storage/RER	kg	0.00275	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	5.8344	Repair
Polypropylene, granulate, at plant/RER	kg	0.00825	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.1925	Repair
Steel, low-alloyed, at plant/RER	kg	0.01925	Repair
Synthetic rubber, at plant/RER	kg	0.01925	Repair
Zinc, primary, at regional storage/RER	kg	0.00275	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	3.50E-05	Production
Heat, waste, high. pop.	MJ	8.012	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0048	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0022417	Maintainance (filter, oil)
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0094656	Maintainance (tires)
Carbon dioxide, fossil, low. pop.	kg	9.63E-06	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.002992	Repair
Disposal, building, glass sheet, to final disposal/CH	kg	0.00275	Waste management
Disposal, building, glass sheet, to final disposal/CH	kg	0.01	Waste management
Disposal, paper, 11.2% water, to municipal incineration/CH	kg	0.012	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.006	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.009625	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.035	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.002	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.12804	Waste management
Harvester/Machine with engine, LT 5,000 to 10,000h, production/FR. FU = kg per life time, based on "Harvester, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Aluminium, production mix, at plant/RER	kg	0.045	Production
Chromium steel 18/8, at plant/RER	kg	0.03	Production
Copper, at regional storage/RER	kg	0.02	Production
Electricity, medium voltage, at grid/FR	kWh	1.5	Production
Flat glass, uncoated, at plant/RER	kg	0.01	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.84	Production
Lead, at regional storage/RER	kg	0.01	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.84	Production
Lubricating oil, at plant/RER	kg	0.002	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.92	Production
Polypropylene, granulate, at plant/RER	kg	0.03	Production
Steel, converter, unalloyed, at plant/RER	kg	0.7	Production
Steel, low-alloyed, at plant/RER	kg	0.07	Production
Synthetic rubber, at plant/RER	kg	0.07	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Zinc, primary, at regional storage/RER	kg	0.01	Production
Electricity, medium voltage, at grid/FR	kWh	0.14613	Maintainance (filter, oil)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	1.8651	Maintainance (filter, oil)

Input	Units	Quantity	Comment
Electricity, medium voltage, at grid/FR	kWh	0.55269	Maintainance (tires)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	7.0543	Maintainance (tires)
Lead, at regional storage/RER	kg	0.0256	Maintenance (filter)
Paper, woodfree, coated, at integrated mill/RER	kg	0.00512	Maintenance (filter)
Polypropylene, granulate, at plant/RER	kg	0.00256	Maintenance (filter)
Lubricating oil, at plant/RER	kg	0.05463	Maintenance (oil)
Synthetic rubber, at plant/RER	kg	0.3325	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.00125	Repair
Aluminium, production mix, at plant/RER	kg	0.01125	Repair
Chromium steel 18/8, at plant/RER	kg	0.0075	Repair
Copper, at regional storage/RER	kg	0.005	Repair
Electricity, medium voltage, at grid/FR	kWh	0.41556	Repair
Flat glass, uncoated, at plant/RER	kg	0.0025	Repair
Lead, at regional storage/RER	kg	0.0025	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	5.304	Repair
Polypropylene, granulate, at plant/RER	kg	0.0075	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.175	Repair
Steel, low-alloyed, at plant/RER	kg	0.0175	Repair
Synthetic rubber, at plant/RER	kg	0.0175	Repair
Zinc, primary, at regional storage/RER	kg	0.0025	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	3.50E-05	Production
Heat, waste, high. pop.	MJ	8.012	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0048	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.00095647	Maintainance (filter, oil)
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0036176	Maintainance (tires)
Carbon dioxide, fossil, low. pop.	kg	8.75E-06	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.00272	Repair
Disposal, building, glass sheet, to final disposal/CH	kg	0.0025	Waste management
Disposal, building, glass sheet, to final disposal/CH	kg	0.01	Waste management
Disposal, paper, 11.2% water, to municipal incineration/CH	kg	0.00512	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.00256	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.00875	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.035	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.002	Waste management
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH	kg	0.05463	Waste management
General machinery, with tires, LT <2,500h, production/FR. FU = kg per life time, based on "Agricultural machinery, general, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Brass, at plant/CH	kg	0.005	Production
Chromium steel 18/8, at plant/RER	kg	0.05	Production
Electricity, medium voltage, at grid/FR	kWh	1.25	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.7	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.7	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.1	Production
Steel, converter, unalloyed, at plant/RER	kg	0.85	Production
Steel, low-alloyed, at plant/RER	kg	0.06	Production
Synthetic rubber, at plant/RER	kg	0.03	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.001	Repair
Brass, at plant/CH	kg	0.001	Repair
Chromium steel 18/8, at plant/RER	kg	0.01	Repair
Electricity, medium voltage, at grid/FR	kWh	0.33244	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	4.2432	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.17	Repair
Steel, low-alloyed, at plant/RER	kg	0.012	Repair
Synthetic rubber, at plant/RER	kg	0.006	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	3.50E-05	Production
Heat, waste, high. pop.	MJ	7.024	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.004	Production

Input	Units	Quantity	Comment
Carbon dioxide, fossil, low. pop.	kg	7.00E-06	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.002176	Repair
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.001	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.005	Waste management
General machinery, with tires, LT >5,000h, production/FR. FU = kg per life time, based on "Agricultural machinery, general, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Brass, at plant/CH	kg	0.005	Production
Chromium steel 18/8, at plant/RER	kg	0.05	Production
Electricity, medium voltage, at grid/FR	kWh	1.25	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.7	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.7	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.1	Production
Steel, converter, unalloyed, at plant/RER	kg	0.85	Production
Steel, low-alloyed, at plant/RER	kg	0.06	Production
Synthetic rubber, at plant/RER	kg	0.03	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Synthetic rubber, at plant/RER	kg	0.0583	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.001375	Repair
Brass, at plant/CH	kg	0.001375	Repair
Chromium steel 18/8, at plant/RER	kg	0.01375	Repair
Electricity, medium voltage, at grid/FR	kWh	0.45711	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	5.8344	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.23375	Repair
Steel, low-alloyed, at plant/RER	kg	0.0165	Repair
Synthetic rubber, at plant/RER	kg	0.00825	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	3.50E-05	Production
Heat, waste, high. pop.	MJ	7.024	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.004	Production
Carbon dioxide, fossil, low. pop.	kg	9.63E-06	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.002992	Repair
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.001375	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.005	Waste management
General machinery, with tires, LT 2,500-5,000h, production/FR. FU = kg per life time, based on "Agricultural machinery, general, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Brass, at plant/CH	kg	0.005	Production
Chromium steel 18/8, at plant/RER	kg	0.05	Production
Electricity, medium voltage, at grid/FR	kWh	1.25	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.7	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.7	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.1	Production
Steel, converter, unalloyed, at plant/RER	kg	0.85	Production
Steel, low-alloyed, at plant/RER	kg	0.06	Production
Synthetic rubber, at plant/RER	kg	0.03	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Synthetic rubber, at plant/RER	kg	0.0165	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.00125	Repair
Brass, at plant/CH	kg	0.00125	Repair
Chromium steel 18/8, at plant/RER	kg	0.0125	Repair
Electricity, medium voltage, at grid/FR	kWh	0.41556	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	5.304	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.2125	Repair
Steel, low-alloyed, at plant/RER	kg	0.015	Repair
Synthetic rubber, at plant/RER	kg	0.0075	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Carbon dioxide, fossil, low. pop.	kg	3.50E-05	Production
Heat, waste, high. pop.	MJ	7.024	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.004	Production

Input	Units	Quantity	Comment
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	8.75E-06	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.00272	Repair
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.00125	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.005	Waste management
General machinery, without tires, LT 8,000h, production/FR. FU = kg per life time, based on "Agricultural machinery, tillage, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.0025	Production
Brass, at plant/CH	kg	0.005	Production
Chromium steel 18/8, at plant/RER	kg	0.1	Production
Electricity, medium voltage, at grid/FR	kWh	1.25	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.7	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.7	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.1	Production
Steel, converter, unalloyed, at plant/RER	kg	0.84	Production
Steel, low-alloyed, at plant/RER	kg	0.05	Production
Synthetic rubber, at plant/RER	kg	0.0025	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.0005	Repair
Brass, at plant/CH	kg	0.001	Repair
Chromium steel 18/8, at plant/RER	kg	0.02	Repair
Electricity, medium voltage, at grid/FR	kWh	0.33244	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	4.2432	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.168	Repair
Steel, low-alloyed, at plant/RER	kg	0.01	Repair
Synthetic rubber, at plant/RER	kg	0.0005	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	1.00E-05	Production
Heat, waste, high. pop.	MJ	7.706	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.004	Production
Carbon dioxide, fossil, low. pop.	kg	2.00E-06	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.002176	Repair
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.0005	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.0025	Waste management
Trailer, < 20 t, production/FR. FU = kg per life time, based on "Trailer, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Aluminium, production mix, at plant/RER	kg	0.19	Production
Brass, at plant/CH	kg	0.005	Production
Chromium steel 18/8, at plant/RER	kg	0.02	Production
Electricity, medium voltage, at grid/FR	kWh	1.25	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.7	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.7	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.1	Production
Steel, converter, unalloyed, at plant/RER	kg	0.7	Production
Steel, low-alloyed, at plant/RER	kg	0.03	Production
Synthetic rubber, at plant/RER	kg	0.05	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Electricity, medium voltage, at grid/FR	kWh	0.55269	Maintainance (tires)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	7.0543	Maintainance (tires)
Synthetic rubber, at plant/RER	kg	0.3325	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.001	Repair
Aluminium, production mix, at plant/RER	kg	0.038	Repair
Brass, at plant/CH	kg	0.001	Repair
Chromium steel 18/8, at plant/RER	kg	0.004	Repair
Electricity, medium voltage, at grid/FR	kWh	0.33244	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	4.2432	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.14	Repair
Steel, low-alloyed, at plant/RER	kg	0.006	Repair
Synthetic rubber, at plant/RER	kg	0.01	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management

Input	Units	Quantity	Comment
Carbon dioxide, fossil, low. pop.	kg	3.00E-05	Production
Heat, waste, high. pop.	MJ	5.814	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.004	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0036176	Maintainance (tires)
Carbon dioxide, fossil, low. pop.	kg	6.00E-06	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.002176	Repair
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.001	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.005	Waste management
Trailer, > 20 t, production/FR. FU = kg per life time, based on "Trailer, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Aluminium, production mix, at plant/RER	kg	0.19	Production
Brass, at plant/CH	kg	0.005	Production
Chromium steel 18/8, at plant/RER	kg	0.02	Production
Electricity, medium voltage, at grid/FR	kWh	1.25	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.7	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.7	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.1	Production
Steel, converter, unalloyed, at plant/RER	kg	0.7	Production
Steel, low-alloyed, at plant/RER	kg	0.03	Production
Synthetic rubber, at plant/RER	kg	0.05	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Electricity, medium voltage, at grid/FR	kWh	0.97379	Maintainance (tires)
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	12.429	Maintainance (tires)
Synthetic rubber, at plant/RER	kg	0.58583	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.001	Repair
Aluminium, production mix, at plant/RER	kg	0.038	Repair
Brass, at plant/CH	kg	0.001	Repair
Chromium steel 18/8, at plant/RER	kg	0.004	Repair
Electricity, medium voltage, at grid/FR	kWh	0.33244	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	4.2432	Repair
Steel, converter, unalloyed, at plant/RER	kg	0.14	Repair
Steel, low-alloyed, at plant/RER	kg	0.006	Repair
Synthetic rubber, at plant/RER	kg	0.01	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	3.00E-05	Production
Heat, waste, high. pop.	MJ	5.814	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.004	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.0063739	Maintainance (tires)
Carbon dioxide, fossil, low. pop.	kg	6.00E-06	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.002176	Repair
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.001	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.005	Waste management
Slurry tanker, 5,000 lt, production/FR. FU = kg per life time, based on "Slurry tanker, CH"			
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.005	Production
Brass, at plant/CH	kg	0.005	Production
Chromium steel 18/8, at plant/RER	kg	0.05	Production
Electricity, medium voltage, at grid/FR	kWh	1.25	Production
Hard coal, burned in industrial furnace 1-10MW/RER	MJ	0.7	Production
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	0.7	Production
Natural gas, burned in industrial furnace >100kW/RER	MJ	4.1	Production
Steel, converter, unalloyed, at plant/RER	kg	0.82	Production
Steel, low-alloyed, at plant/RER	kg	0.05	Production
Synthetic rubber, at plant/RER	kg	0.05	Production
Transport, freight, rail/RER	tkm	0.1	Production
Transport, lorry >32t, EURO4/RER	tkm	0.4	Production
Zinc, primary, at regional storage/RER	kg	0.02	Production
Synthetic rubber, at plant/RER	kg	0.0475	Maintenance (tires)
Alkyd paint, white, 60% in solvent, at plant/RER	kg	0.001	Repair
Brass, at plant/CH	kg	0.001	Repair
Chromium steel 18/8, at plant/RER	kg	0.01	Repair
Electricity, medium voltage, at grid/FR	kWh	0.33244	Repair
Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	MJ	4.2432	Repair

Input	Units	Quantity	Comment
Steel, converter, unalloyed, at plant/RER	kg	0.164	Repair
Steel, low-alloyed, at plant/RER	kg	0.01	Repair
Synthetic rubber, at plant/RER	kg	0.01	Repair
Zinc, primary, at regional storage/RER	kg	0.004	Repair
Electricity, medium voltage, at grid/FR	kWh	0.13889	Waste management
Transport, lorry >32t, EURO4/RER	tkm	0.04	Waste management
Carbon dioxide, fossil, low. pop.	kg	3.00E-05	Production
Heat, waste, high. pop.	MJ	6.254	Production
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.004	Production
Carbon dioxide, fossil, low. pop.	kg	6.00E-06	Repair
NMVOC, non-methane volatile organic compounds, unspecified origin, high. pop.	kg	0.002176	Repair
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.001	Waste management
Disposal, plastics, mixture, 15.3% water, to municipal incineration/CH	kg	0.005	Waste management

Appendix K: Building the agricultural processes

Table 159 gives the groups of agricultural processes used for the data collection module and the parameters required for the ecoinvent LCI data sets (see B.2.1). Column 1 gives the name in French, column 2 gives the name of the AGRIBALYSE LCI data set, column 3 contains the operation time and column gives the actual fuel consumption for the process. Columns 4 and 5 are included because a given AGRIBALYSE LCI data set can be used for several processes with different fuel consumptions. Column 4 gives the fuel consumption in the AGRIBALYSE LCI data set for the "general" machinery (eg: "crushing, with shredder or chipper" LCI data set: 13.47 l/h) to which a correction is applied (column 5) to correspond to the particular process (eg: Crushing of potato vines, vine shredder: consumption 13 l/h; correction = 0.47 l/h). The sum of columns 4 and 5 multiplied by column 3 gives the consumption in column 6 (see also B.3.2.4): For an AGRIBALYSE LCI data set for an agricultural process with a non-zero value in column 5 of this table, an additional input (fuel consumption correction) is added to the unit process.

In farms in France, some machines are stored in sheds/buildings (eg: tractors, spreaders, seeders, etc.) whereas others are usually stored outdoors (tilling tools).
The machinery storage buildings are included in "agricultural process" LCI data sets. Agricultural machines such as tractors, self-propelled machines, seeders and trailers are considered to be stored in farm sheds, using the ecoinvent "shed" LCI data set. The input is calculated using the amortization period (50 years for sheds), lifetime and area occupied by the machines.
Open air storage for machinery implies land occupation. The area is included in inputs from the ecosphere, such as the flow "Occupation, heterogeneous, agricultural".

Table 159: Data collection module processes and assignment to LCI data sets, operation time, fuel consumption and type of fuel for the agricultural processes used to create the AGRIBALYSE LCI data sets

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Transporting wooden posts	Harvesting, with trailer (clementine)/hr/FR	3	3.52		10.56	diesel
Breaking up soil	Harrowing, 3m harrow/hr/FR	3	14		42	diesel
Swathing (9m swather. 140 bhp tractor)	Swath, with 9m swather/hr/FR	0.18	13.75		2.48	diesel
Swathing prunings	Swath, with swather (orchard)/hr/FR	1.5	6.2		9.3	diesel
Swathing apple tree prunings	Swath, with swather (orchard)/hr/FR	1.88	6.2		11.66	diesel
Swathing carrots Aquitaine	Swath, with 1.8m swather (carrot)/hr/FR	4	14.08		56.32	diesel
Spraying fruit tree growth regulators	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	1	3.1		3.1	diesel
Applying herbicide to nursery maidens	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
Dusting peach orchards	Plant protection, spraying, with dusting machine (orchard)/hr/FR	0.1	6.00		0.6	diesel
Applying pesticides carrots Mont St Michel	Fertilizing or plant protection, with sprayer, 2500 l/hr/FR	0.5	13	-9	2	diesel
Spraying nursery maidens	Plant protection, spraying, with atomiser 800 l/hr/FR	1	6.16		6.16	diesel
Spraying using towed 2500l sprayer	Fertilizing or plant protection, with sprayer, 2500 l/hr/FR	0.08	13		1.04	diesel
Applying fertilizer to cider orchard	Fertilizing, with spreader/broadcaster, 500 l (orchard)/hr/FR	0.6	4.2		2.52	diesel
Applying manure (adding soil)	Fertilizing, solid manure (charging and spreading) with 8-10t spreader/hr/FR	1.33	8.70		11.57	diesel
Pulling fall carrots Mont St Michel	Harvesting, 1 row puller/hr/FR	12.5	8.8		110	diesel
Pulling organic carrots Normandy	Harvesting, 1 row puller/hr/FR	25	8.8		220	diesel
Grubbing up closely planted vine stocks	Grubbing of vine-stocks, with puller/hr/FR	20	22		440	diesel
Grubbing up widely spaced vine stocks	Grubbing of vine-stocks, with puller/hr/FR	10	22		220	diesel
Grubbing up trees	Rooting up trees, with tractopelle/hr/FR	8	20		160	diesel
Pulling / tailing carrots Aquitaine, towed harvester	Harvesting, 3 row puller/hr/FR	2.5	14.08		35.2	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Lifting maiden vines	Grubbing/Sorting of maiden tree, with puller/hr/FR	9.7	13.9	-1.68	118.6	diesel
Lifting scions	Grubbing/Sorting of maiden tree, with puller/hr/FR	37.5	13.86		519.75	diesel
Lifting apple scions	Grubbing/Sorting of maiden tree, with puller/hr/FR	25	13.86		346.5	diesel
Pulling up tomatoes in unheated greenhouse	Rooting up, with font fork/hr/FR	10	4.62		46.2	diesel
Grubbing up orchards	Rooting up trees, with tractopelle/hr/FR	8	20.00		160	diesel
Pulling / tailing carrots Aquitaine with self-propelled harvester	Harvesting and tailing, with complete harvester (carrot)/hr/FR	2.5	17.6		44	diesel
Lifting scions nursery	Grubbing/Sorting of maiden tree, with puller/hr/FR	37.5	13.86		519.75	diesel
Peach 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 carrots Aquitaine	Maintenance, covering with plastic, with lifter/hr/FR	0.67	13.13		8.8	diesel
Covering and uncovering carrots 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
Hoeing carrots Aquitaine	Hoeing, with 3 planches hoe/hr/FR	0.67	7.91		5.3	diesel
Hoeing organic carrots Normandy	Hoeing, with 2 row hoe/hr/FR	1	6.17	2.63	8.8	diesel
Hoeing carrots Normandy	Hoeing, with 2 row hoe/hr/FR	1.33	6.17		8.21	diesel
Hoeing maiden vines	Hoeing, with 2 row hoe/hr/FR	1.5	4.4	2.34	10.1	diesel
Whitewashing unheated greenhouse	Bleaching of greenhouse, with tractor and atomizer/hr/FR	2	6.15		12.3	diesel
Whitewashing greenhouses	Bleaching of greenhouse, with tractor and atomizer/hr/FR	10	0.45		4.5	diesel
Whitewashing greenhouse walls	Bleaching of greenhouse, with tractor and atomizer/hr/FR	1	6.15		6.15	diesel
Shredding prunings	Crushing wood, with hammer mill/hr/FR	2	9.20		18.4	diesel
Shredding apple prunings	Crushing wood, with hammer mill/hr/FR	2.5	9.20		23	diesel
Shredding potato tops using 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
Shredding straw using shredder	Crushing, with shredder or chipper/hr/FR	0.67	13.47		9.02	diesel
Shredding closely planted vine prunings	Crushing, with shredder or chipper/hr/FR	1	13.5	-1.32	12.2	diesel
Shredding vine prunings using high clearance tractor	Crushing, with shredder or chipper/hr/FR	1	13.5	-1.32	12.2	diesel
Shredding widely spaced vine prunings	Crushing, with shredder or chipper/hr/FR	0.6	13.5	-4.92	5.1	diesel
Earthing up plastic tunnel north	Earthing up, with bedder/hr/FR	2.5	7.7		19.25	diesel
Earthing up plastic tunnel south	Earthing up, with bedder/hr/FR	3.75	7.7		28.88	diesel
Earthing up potatoes using lister	Earthing up, with 2 row hoe/hr/FR	0.6	21		12.6	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Earthing up closely planted vines	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 on lorry	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
Loading organic matter	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	0.5	4.88		2.44	diesel
Loading straw organic carrots	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 carrots 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
Transporting (pot spacing)	Transporting, with conveyor/p/FR	1	0.45		0.45	diesel
Transporting (repotting)	Transporting, with conveyor/p/FR	1	0.45		0.45	diesel
Disk harrowing 4m	Soil maintenance, with cover crop 4m/hr/FR	0.5	20		10	diesel
Disk harrowing 3m	Soil maintenance, with cover crop 4m/hr/FR	0.5	20		10	diesel
2.5m chisel plow	Soil decompactation, with 4.5m chisel/hr/FR	0.8	25		20	diesel
4.5 m chisel plow	Soil decompactation, with 4.5m chisel/hr/FR	0.83	25		20.75	diesel
Soil cultivation carrots 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
Uncovering carrots Aquitaine	Maintenance, withdrawing of plastic, with lifter/hr/FR	0.67	13.13		8.8	diesel
Removing whitewash from greenhouses	Bleaching of greenhouse, with tractor and atomizer/hr/FR	6	0.45		2.7	diesel
Unbanking closely planted vines	Ploughing-back (debuttage) of vine, with inter-vine plough/hr/FR	2.8	15		42	diesel
Harrowing peach maidens	Maintenance, with rolling off device (special crops)/hr/FR	1.33	0.4	6.56	9.26	pétrol
Harrowing peach/apple maidens	Maintenance, with rolling off device (special crops)/hr/FR	1.33	0.4	6.56	9.26	pétrol
Harrowing apple maidens	Stubble ploughing, with stuble share 2.5m (orchard)/hr/FR	1.33	7.04		9.36	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Harrowing using 4m disk harrow	Stubble ploughing, with stuble share 5.5m/hr/FR	0.43	16		6.88	diesel
Harrowing using harrow attachment	Stubble ploughing, with stuble share 5.5m/hr/FR	0.31	16		4.96	diesel
Removing plastic tunnel cover north	Baring plastic (greenhouse)/hr/FR	2	6.15		12.3	diesel
Removing plastic tunnel cover south	Baring plastic (greenhouse)/hr/FR	3	6.15		18.45	diesel
Decompacting soil carrots Aquitaine	Soil decompactation, with heavy tractor/hr/FR	0.29	8.90		2.58	diesel
Decompacting soil cider apple orchard	Soil decompactation, with decompactation machine (orchard)/hr/FR	1	12.32		12.32	diesel
Decompacting soil, 5 shank subsoiler	Soil decompactation/hr/FR	0.77	17.69		13.62	diesel
Subsoiling/ripping	Preparing ground, with trenching plough/hr/FR	15	9.5		142.5	diesel
Removing straw	Distributing straw, with rotary tedder/hr/FR	8	4.63		37.04	diesel
Unrolling hail protection netting	Maintenance, with rolling off device, heavy tractor (special crops)/hr/FR	5.5	2.64		14.52	diesel
Unrolling and rolling up drip hose	Maintenance, with rolling off device, heavy tractor (special crops)/hr/FR	8	2.64		21.12	diesel
Unrolling top wire	Maintenance, with rolling off device, heavy tractor (special crops)/hr/FR	1	2.64		2.64	diesel
Unrolling training wires	Maintenance, with rolling off device (special crops)/hr/FR	12	0.4		4.8	pétrol
Applying herbicides	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	2	3.1		6.2	diesel
Applying herbicides carrots Aquitaine	Plant protection, chemical weeding, with self-propelled machine/hr/FR	0.1	12		1.2	diesel
Applying herbicides carrots Normandy	Plant protection, spraying, with sprayer, 1200 l/hr/FR	0.5	12.22	-4.22	4	diesel
Applying herbicide orchard	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	2	3.1		6.2	diesel
Applying herbicide apple orchard	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	2.5	3.1	3.06	15.4	diesel
Applying herbicide mangoes	Plant protection, weeding, with rotary beater/hr/FR	1.1	4.6	0.36	5.5	diesel
Applying herbicides manually	Plant protection, weeding, with portable swinging scythe/hr/FR	5	0.4		2	pétrol
Applying herbicide whole orchard	Plant protection, weeding, with vibrating tine/hr/FR	2.5	7.68		19.2	diesel
Applying herbicide peach orchard in rows	Plant protection, weeding, with cutter/hr/FR	1.5	7.7		11.55	diesel
Applying herbicide apple orchard in rows	Plant protection, weeding, with cutter/hr/FR	1.88	7.7		14.48	diesel
Topping using 2m rotary topper	Plant protection, weeding, with rotary beater/hr/FR	0.5	4.62		2.31	diesel
Weeding using flame weeder 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	0.8	3.1		2.48	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
	l/hr/FR					
Weeding closely planted vines	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	1	3.1	0.81	3.9	diesel
Soil disinfection carrots Aquitaine	Soil maintenance (desinfection), with spreader and heavy tractor/hr/FR	0.29	13.5		3.92	diesel
Soil disinfection carrots Normandy	Soil maintenance (desinfection) with incorporateur (carrot)/FR	1	15.80		15.8	diesel
Soil disinfection carrots Mont St Michel	Soil maintenance (desinfection) with incorporateur (carrot)/FR	1	15.80	0.7	16.5	diesel
Laying straw before manure spreading	Harvesting assistence, with trailer (carrot)/hr/FR	8	3.08		24.64	diesel
Distributing wooden posts	Maintenance, setting pillar, with elevator (special crops)/hr/FR	3	3.08		9.24	diesel
Debudding in nurseries	Maintenance, cutting buds (special crops)/hr/FR	9	0.8		7.2	pétrol
Debudding widely spaced vines	Disbudding, with trunk cleaner/hr/FR	2.4	9		21.6	diesel
Topping scions before lifting	Maintenance, pruning or cutting, with header / bunch limber/hr/FR	5.33	5.27		28.09	diesel
Topping closely planted vines using high clearance tractor	Tipping, with vine shoot tipping machine/hr/FR	1	15	-3.24	11.8	diesel
Removing carrot tops Normandy	Harvest related workleaf stripping, with leaf stripper/hr/FR	2	14.1		28.2	diesel
Removing leaves closely planted vines	Leaf thinning, with leaf stripper/hr/FR	3	5		15	diesel
Rooting up greenhouse plants	Rooting up plant/hr/FR	2	4.60		9.2	diesel
Removing straw organic carrots	Distributing straw, with rotary tedder/hr/FR	12	4.63	1.97	79.2	diesel
Haylage using bale wrapper 17 bales/hour	Harvesting, with balling machine/t/FR	1	2.09		2.09	diesel
Silage (forage harvester 600 bhp with trailer)	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
Disbudding and weeding widely spaced vines	Disbudding, with trunk cleaner/hr/FR	1.8	9	-0.9	14.6	diesel
Disbudding closely planted vines	Disbudding, with trunk cleaner/hr/FR	2.5	9	0.9	24.8	diesel
Spraying soluble nitrogen fertilizer using 2500l towed sprayer	Fertilizing or plant protection, with sprayer, 2500 l/hr/FR	0.08	13		1.04	diesel
Spreading lime	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
Spreading straw	Distributing straw, with rotary tedder/hr/FR	3	4.63		13.89	diesel
Spreading slurry, slurry tank/vacuum tank	Fertilizing, slurry, with tanker/hr/FR	1	5		5	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Spreading slurry using trailing hoses 1500-2000	Fertilizing, slurry, with tanker/hr/FR	1	5		5	diesel
Spreading fertilizer carrots Aquitaine	Fertilizing, solid manure (spreading only), with 8-10t spreader/hr/FR	0.25	8.70	-6.7	0.5	diesel
Spreading fertilizer organic carrots Normandy	Fertilizing, with spreader, 2500 l/hr/FR	0.33	13	-6.33	2.2	diesel
Spreading fertilizer carrots Mont St Michel	Fertilizing, with spreader, 2500 l/hr/FR	0.17	13	-6.53	1.1	diesel
Spreading fertilizer carrots 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
Spreading fertilizer using 2500l spreader	Fertilizing, with spreader, 2500 l/hr/FR	0.12	13		1.56	diesel
Spreading manure	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 straw organic carrots	Fertilizing, solid manure or compost (charging and spreading), with frontal bucket and 5t spreader/hr/FR	8	4.88		39.04	diesel
Spreading fertilizer vine nursery	Fertilizing, solid manure (charging and spreading) with 8-10t spreader/hr/FR	2.4	8.7	-0.63	19.4	diesel
Spreading fertilizer closely planted vines	Fertilizing, solid manure (charging and spreading) with 8-10t spreader/hr/FR	0.75	8.7	1.17	7.4	diesel
Spreading fertilizer widely spaced vines	Fertilizing, solid manure (charging and spreading) with 8-10t spreader/hr/FR	0.3	8.7	0.27	2.7	diesel
Spreading manure using 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
Laying straw organic carrots	Distributing straw, with rotary tedder/hr/FR	2	4.63	2.19	13.64	diesel
Cutting the root stock	Maintenance, pruning or cutting, with chopper blower/hr/FR	5.33	7.04		37.52	diesel
Cutting the root stock using secateurs	Maintenance, cutting buds (special crops)/hr/FR	16	0.8		12.8	pétrol
Haylage swathing using 3m tedder	Haying, with tedder/hr/FR	0.5	2		1	diesel
Mowing (7m mower, 300 bhp tractor)	Mowing, with rotary mower 7m/hr/FR	0.19	22.26		4.23	diesel
Mowing, using mower conditioner	Mowing, with rotary mower 3m/hr/FR	0.5	5.7	-3.1	1.3	diesel
Mowing, using 3m rotary mower	Mowing, with rotary mower 3m/hr/FR	0.5	5.7		2.85	diesel
Applying average fertilizer to mangoes using sprayer	Fertilizing or plant protection, with sprayer, 2500 l	0.42	5		2.1	diesel
Applying fertilizer to leaves using sprayer	Fertilizing, with spreader/broadcaster, 500 l (orchard)/hr/FR	1	4.2		4.2	diesel
Fertilizing using 1500l spin spreader	Fertilizing, with spreader, 2500 l/hr/FR	0.12	13		1.56	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Fertilizing using 500l spin 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
Supplying growing medium	Transporting of growing media, with trailer/p/FR	1	0.45		0.45	diesel
Rotary cultivator with roller	Hoeing, with rotary hoe 3m/hr/FR	1.3	11.2		14.6	diesel
Rotary cultivator carrots Mont St Michel	Soil maintenance, with rotary cultivator/hr/FR	2.5	41.2		103	diesel
Hoeing soil in nursery	Hoeing, with 2 row hoe/hr/FR	4	6.17	-1.77	17.6	diesel
Hoeing closely planted vines	Soil preparation (vine), with harrow/hr/FR	1.4	9.5		13.3	diesel
Hoeing widely spaced vines	Soil preparation (vine), with harrow/hr/FR	1	9.5		9.5	diesel
Harrowing with 4m rotary harrow	Harrowing, with rotary harrow (standard equipment)/hr/FR	0.7	14.3		10.01	diesel
Harrowing with rotary harrow and packer roller	Harrowing, with rotary harrow (standard equipment)/hr/FR	0.7	14.3		10.01	diesel
Harrowing carrots after disinfection	Harrowing, with rotary harrow (standard equipment)/hr/FR	0.33	14.3	5.4	6.5	diesel
Harrowing organic carrots Normandy	Harrowing, with rotary harrow (standard equipment)/hr/FR	1	14.3	-1.1	13.2	diesel
Harrowing carrots Mont St Michel	Harrowing, with rotary harrow (standard equipment)/hr/FR	1.33	14.3	2.17	21.91	diesel
Harrowing peach nursery	Harrowing, with rotary harrow and packer (orchard)/hr/FR	2	13.85		27.7	diesel
Harrowing peach/apple nursery	Harrowing, with rotary harrow and packer (orchard)/hr/FR	2	13.85		27.7	diesel
Harrowing apple nursery	Harrowing, with rotary harrow and packer (orchard)/hr/FR	2	13.85		27.7	diesel
Harrowing under cover	Harrowing, with rotary harrow and packer (orchard)/hr/FR	5	13.85	-6.15	38.5	diesel
Harrowing cider apple orchard	Harrowing, with small tractor (orchard)/hr/FR	1	9.20	4.88	14.08	diesel
12m chain harrow	Harrowing, with harrow 12m/hr/FR	0.11	10.8		1.19	diesel
Platform working (hour)	Maintenance, with platform self-propelled (special crops)/hr/FR	1	1.17		1.17	electricity
Tractor and compressor (hour)	Maintenance, with compressor (special crops)/hr/FR	1	3.10		3.1	diesel
Sinking posts for training wires	Maintenance, pillar installation, with post hole digger (special crops)/hr/FR	2.5	5.28		13.2	diesel
Hoeing between closely planted vines	Hoeing, with 2 row hoe/hr/FR	2.1	4.4	9.54	29.3	diesel
Hoeing between widely spaced vines	Hoeing, with 2 row hoe/hr/FR	1.2	4.4	9.54	16.7	diesel
Plowing	Ploughing (vine), with frame plough/hr/FR	1.5	8	10.8	28.2	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Plowing with 5 furrow plow	Ploughing, with 5 or 6 soc plough/hr/FR	1.33	18.75		24.9	diesel
Plowing before planting orchard	Ploughing, in orchard/hr/FR	1	16.15	-2.07	14.08	diesel
Plowing with vineyard plow - vine nursery	Ploughing (vine), with frame plough/hr/FR	1.45	8		11.6	diesel
Plowing carrots Aquitaine	Ploughing, with 8 soc plough/hr/FR	0.5	24.60		12.3	diesel
Plowing organic carrots Normandy	Ploughing, with 5 or 6 soc plough/hr/FR	1	18.75	2.35	21.1	diesel
Plowing carrots Mont St Michel	Ploughing, with 5 or 6 soc plough/hr/FR	0.67	18.75	4.39	15.5	diesel
Plowing carrots Normandy	Ploughing, with 4 soc plough/hr/FR	1	15.80		15.8	diesel
Plowing peach nursery	Ploughing, in orchard/hr/FR	2	16.15		32.3	diesel
Plowing peach/apple nursery	Ploughing, in orchard/hr/FR	2	16.15		32.3	diesel
Plowing apple nursery	Ploughing, in orchard/hr/FR	2	16.15		32.3	diesel
Subsoiling orchard	Ploughing, with 1 soc plough/hr/FR	3	24.67		74.01	diesel
Plowing widely spaced vines	Ploughing (vine), with frame plough/hr/FR	1.4	8	1.35	13.1	diesel
Plowing, 4 furrow plow	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	pétrol
Land preparation - Humid	Soil preparation, with disc harrow/hr/FR	2.5	4.24		10.6	pétrol
Land preparation post sowing	Soil preparation, with rotary tiller/hr/FR	2.5	4.24		10.6	pétrol
Land preparation pre sowing	Soil preparation, with rotary tiller/hr/FR	2.5	4.24		10.6	pétrol
Handling potato plants	Maintenance, with forklift truck/hr/FR	0.86	20.77		17.86	diesel
Flooding paddy fields (3.5h)	Flooding of paddy fields, with motor cultivator/hr/FR	3.5	0.64		2.24	pétrol
Flooding paddy fields (11h)	Flooding of paddy fields, with motor cultivator/hr/FR	11	0.64		7.04	pétrol
Flooding paddy fields (7h)	Flooding of paddy fields, with motor cultivator/hr/FR	7	0.64		4.48	pétrol
Heeling in and removing scions	Sowing or planting, maiden tree, with ditcher/hr/FR	20	7.04		140.8	diesel
Harvesting cereals using combine harvester200 bhp	Harvesting, with combine harvester/hr/FR	0.67	25.60		17.15	diesel
Earthing up organic carrots Normandy	Earthing up, with 2 row hoe/hr/FR	1.5	21.00	-3.4	26.4	diesel
Earthing up carrots Mont St Michel	Earthing up, with how (carrot)/hr/FR	1.33	6.15	4.82	14.59	diesel
Earthing up carrots Normandy	Earthing up, with how (carrot)/hr/FR	2	6.15		12.3	diesel
Digging and closing trench for drip irrigation	Tillage, preparation irrigation/hr/FR	3	7.70		23.1	diesel
Sinking posts for training	Indentation of pots, with tractopelle/hr/FR	2.66	20.00		53.2	diesel
Planting and earthing up potatoes, planter and 4 row lister	Sowing or planting and earthing up, potato, with 4-row-planter and 2 row how/hr/FR	0.9	20.00		18	diesel
Sinking training wire posts nursery	Maintenance, setting pillar for tying in (special crops)/hr/FR	2.66	3.53		9.39	diesel
Sinking training wire posts apple trees	Maintenance, setting pillar for tying in (special crops)/hr/FR	4	3.53	1.75	21.12	diesel
Layering apple trees	Sowing or planting, trees (orchard)/hr/FR	20	5.61		112.2	diesel
Planting peach rootstock	Sowing or planting, trees (orchard)/hr/FR	16	5.61		89.76	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Sinking posts for closely planted vines before tying up	Maintenance, setting pillar for tying in (special crops)/hr/FR	8	3.5	0.87	34.9	diesel
Sinking posts for widely spaced vines before tying up	Maintenance, setting pillar for tying in (special crops)/hr/FR	3	3.5	0.87	13.1	diesel
Planting potatoes using 4 row planter	Sowing or planting, potato, with 4-row-planter/hr/FR	1	17.20		17.2	diesel
Planting rootstock nursery	Sowing or planting, trees (orchard)/hr/FR	14	5.61	5.61	157.08	diesel
Planting cider apple orchard	Sowing or planting, trees (orchard)/hr/FR	1.25	5.61	1.43	8.8	diesel
Laying mulching film on two rows of vines with plastic nursery	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
Sinking stakes in nursery	Maintenance, rooting up maiden tree, with elevator (special crops)/hr/FR	8	3.52		28.16	diesel
Fitting and removing training wires in nursery	Maintenance, with rolling off device, heavy tractor (special crops)/hr/FR	12	2.64		31.68	diesel
Pushing prunings	Pushing wood, with small tractor/hr/FR	5	1.1		5.5	diesel
Preparing carrot beds Aquitaine	Soil decompactation, with cultivator/hr/FR	1	26.40		26.4	diesel
Preparing seed beds	Harrowing, with small tractor (orchard)/hr/FR	1	9.20		9.2	diesel
Preparing apple tree beds	Harrowing, with small tractor (orchard)/hr/FR	1.25	9.20		11.5	diesel
Preparing soil for planting orchard	Tillage, ploughing, tree nursery/hr/FR	0.83	7.70		6.39	diesel
Preparing soil for planting apple orchard	Tillage, ploughing, tree nursery/hr/FR	1.04	7.70		8.01	diesel
Preparing soil for drip irrigation trench	Maintenance, preparation soil for irrigation channel, with rotary hoe (special crops)/hr/FR	3	7.93		23.79	diesel
Baling hay (4t DM/ha) with round baler	Baling, with round baler (straw)/ha/FR	1	11.7		11.7	diesel
Preliminary pruning widely spaced vine	Preliminary pruning, with pruning machine/hr/FR	1.5	22		33	diesel
Preliminary pruning closely planted vine	Preliminary pruning, with pruning machine/hr/FR	2	22		44	diesel
Applying pesticide under cover using sprayer	Plant protection, spraying, with self-propelled atomiser/hr/FR	2.5	4.60		11.5	diesel
Applying pesticide using 1200l sprayer	Plant protection, spraying, with sprayer, 1200 l/hr/FR	0.11	12.22		1.34	diesel
Applying pesticide using 2500l sprayer	Fertilizing or plant protection, with sprayer, 2500 l/hr/FR	0.08	13.00		1.04	diesel
Applying pesticide using 800l sprayer attachment nursery	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	1	6.15		6.15	diesel
Minimum tillage, using 13 shank chisel plow attachment	Soil decompactation, with 4.5m chisel/hr/FR	0.63	25.00		15.75	diesel
400l sprayerattachment for vine nursery	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	1	8.8	5.58	14.4	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Spraying for rooting up	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	2	8.8	5.58	28.8	diesel
Spraying closely planted vines	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	1	8.8	3.78	12.6	diesel
Spraying widely spaced vines	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	0.5	8.8	5.13	7	diesel
Collecting forage using self-propelled harvester	Harvesting silage grass, with hay chopper and blower/hr/FR	0.5	84.00		42	diesel
Harvesting carrots Créances	Harvesting, 1 row puller/hr/FR	11	8.80		96.8	diesel
Harvesting winter carrots Aquitaine using self-propelled harvester	Harvesting, with complete harvester (carrot)/hr/FR	4	17.60		70.4	diesel
Harvesting winter carrots Aquitaine using towed harvester	Harvesting, 3 row puller/hr/FR	4	14.08		56.32	diesel
Harvesting winter carrots Mont St Michel	Harvesting, 1 row puller/hr/FR	14	8.80		123.2	diesel
Harvesting fall carrots Val de Saire	Harvesting, 1 row puller/hr/FR	15	8.80		132	diesel
Harvesting winter carrots Val de Saire	Harvesting, 1 row puller/hr/FR	17.5	8.80		154	diesel
Harvesting sugarbeet using 1 tractor for topping, lifting and loading 6 rows	Harvesting, with tractor an 6 row rooting up (beets)/hr/FR	1.3	25.00		32.5	diesel
Harvesting sugarbeet using 6 row self-propelled harvester + 1 or 2 trailers	Harvesting, with complete harvester (6 row) and trailers (beets)/hr/FR	1	40.00		40	diesel
Harvesting sugar beet with 6 row self propelled combine harvester	Harvesting, with complete harvester (beets)/hr/FR	1	40.00		40	diesel
Harvesting clementines	Harvesting, with trailer (clementine)/hr/FR	9	3.52		31.68	diesel
Lifting potatoes using harvester	Harvesting, with complete harvester (potatoes)/hr/FR	2	16		32	diesel
Harvesting cider apples using harvester	Harvesting, with harvester (fruits)/hr/FR	3	14.08		42.24	diesel
Harvesting rice	Harvesting, with combine harvester/hr/FR	0.83	25.6		21.25	diesel
Collecting and transporting carrots Créances	Harvesting assistence, with trailer (carrot)/hr/FR	11	3.08		33.88	diesel
Collecting and transporting fall carrots Mont St Michel	Harvesting assistence, with trailer (carrot)/hr/FR	12.5	3.08		38.5	diesel
Collecting and transporting winter carrots Mont St Michel	Harvesting assistence, with trailer (carrot)/hr/FR	14	3.08		43.12	diesel
Collecting and transporting fall carrots Val de Saire	Harvesting assistence, with trailer (carrot)/hr/FR	15	3.08		46.2	diesel
Collecting and transporting winter carrots Val de Saire	Harvesting assistence, with trailer (carrot)/hr/FR	17.5	3.08		53.9	diesel
Collecting and transporting carrots Aquitaine	Harvesting assistence, with trailer (21 t)/hr/FR	2.5	7.05		17.63	diesel
Collecting and transporting winter carrots Aquitaine	Harvesting assistence, with trailer (21 t)/hr/FR	4	7.05		28.2	diesel
Repotting	Repotting, with potting machine/hr/FR	1	0.45		0.45	electricity
Plowing apple orchard	Soil decompactation, with 4.5m chisel/hr/FR	0.63	25		15.75	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Turning carrots for storage Mont St Michel	Preparation of soil, with plough (before carrot harvest)/hr/FR	3	15.8	-5.23	31.71	diesel
Turning carrots for storage Aquitaine	Preparation of soil, with plough (before carrot harvest)/hr/FR	1	15.80		15.8	diesel
Removing training wires before rooting up apple orchard	Maintenance, with rolling off device (special crops)/hr/FR	6	0.4		2.4	pétrol
Trimming vines in nursery using tractor	Tipping, with vine shoot tipping machine/hr/FR	3.6	15		54	diesel
Trimming closely planted vines	Tipping, with vine shoot tipping machine/hr/FR	1.4	15		21	diesel
Trimming widely spaced vines	Tipping, with vine shoot tipping machine/hr/FR	1	15	-3.24	11.8	diesel
Rotavator carrots 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
Spader under cover	Hoeing, with rotobêche/hr/FR	7	7.70		53.9	diesel
Rolling using 3m corrugated roller	Rolling, with roller 3m/hr/FR	0.59	4.20		2.48	diesel
Rolling using 9m roller	Rolling, with roller 9m/hr/FR	0.2	15.00		3	diesel
Rolling soil before planting closely planted vines	Rolling, with roller 9m/hr/FR	1	10	-4.5	5.5	diesel
Shaking trees for harvesting	Shaking, with shaker (orchard)/hr/FR	1	8.80		8.8	diesel
Drilling using standard 4m drill	Sowing or planting, with classic seeder and harrow/hr/FR	1.3	12		15.6	diesel
Drilling carrots Aquitaine	Sowing or planting, with 3 row seeder (carrot)/hr/FR	1	7.90		7.9	diesel
Drilling organic carrots Normandy	Sowing or planting, with pneumatic seeder (carrot)/hr/FR	1.5	6.16	2.64	13.2	diesel
Drilling carrots Normandy	Sowing or planting, with pneumatic seeder (carrot)/hr/FR	2.5	6.16		15.4	diesel
Combine drill, mechanical	Sowing or planting, with classic seeder and harrow/hr/FR	0.83	16.83		13.97	diesel
Combine drill, drill, seed on demand	Sowing or planting, with pneumatic seeder and harrow/hr/FR	0.83	16.83		13.97	diesel
Sowing no till, 4m disk drill	Sowing or planting, direct seeding/hr/FR	0.42	14.29		6	diesel
Sowing grass in orchard	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
Sowing with pneumatic seed-on-demand drill	Sowing or planting, with pneumatic seeder, 6 rows/hr/FR	0.67	13.47		9.02	diesel
Removing scions from nursery	Maintenance, rooting up maiden tree, with elevator (special crops)/hr/FR	20	3.52		70.4	diesel
Removing scions from nursery	Maintenance, rooting up maiden tree, with elevator (special crops)/hr/FR	20	3.52		70.4	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Decompacting soil using subsoiler	Soil decompactation, with subsoil plow 2m/hr/FR	2	13	1.8	29.6	diesel
Subsoiling carrots Mont St Michel	Soil decompactation/hr/FR	0.67	17.69	5.44	15.5	diesel
Subsoiling carrots Normandy	Soil decompactation, with subsoil plow 2m/hr/FR	1	13.00	5.5	18.5	diesel
Subsoiling under cover	Soil decompactation, with subsoil plow 2m/hr/FR	3	13.00		39	diesel
Subsoiling using subsoiler	Soil decompactation, with subsoil plow 2m/hr/FR	2	13		26	diesel
Subsoiling for mangoes	Soil decompactation, with subsoil plow 2m/hr/FR	1.5	13	6.3	29	diesel
Pruning cider apple orchard	Maintenance, pruning or cutting, with chain saw/hr/FR	15	0.48		7.2	pétrol
Pruning cider apple orchard (trimming)	Maintenance, pruning, with angle mower/hr/FR	6	8.8		52.8	diesel
Compacting silage	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
Cutting grass in orchard	Plant protection, weeding, with rotary beater/hr/FR	0.75	4.62		3.47	diesel
Cutting grass in apple orchard	Plant protection, weeding, with rotary beater/hr/FR	0.94	4.62		4.34	diesel
Cutting grass between rows in cider apple orchard	Plant protection, weeding, with mower/hr/FR	0.9	4.7		4.23	diesel
Cutting grass between rows closely planted vines	Plant protection, weeding, with mower/hr/FR	2	4.7	4.77	18.9	diesel
Manual herbicide spraying	Plant protection, spraying, with knapsack sprayer/hr/TH	3	11.7		35.1	diesel
Manual insecticide spraying	Plant protection, spraying, with knapsack sprayer/hr/TH	3	0.5		1.5	diesel
Applying pesticide to citrus fruit to protect against fruit flies using lance sprayer	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	3	3.1		9.3	diesel
Applying pesticides to citrus fruit to protect against leaf miners and ceratitis capitata (Mediterranean fruit fly)	Plant protection, chemical weeding, with atomiser 400 l/hr/FR	1	3.1		3.1	diesel
Applying average pesticides for mangoes	Fertilizing or plant protection, with sprayer, 2500 l/hr/FR	0.42	13	-7.2	2.4	diesel
Applying pesticide under cover	Plant protection, spraying, with atomiser (greenhouse)/hr/FR	4	1.76		7.04	diesel
Applying pesticide peach orchard	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	0.5	8.80		4.4	diesel
Applying pesticide apply orchard	Plant protection, spraying, with atomiser/sprayer, 2000 l/hr/FR	0.75	8.80	-2.64	4.62	diesel
Spraying cider apple orchard	Plant protection, spraying, with trailed atomizer, 2000l/hr/FR	0.67	8.80		5.9	diesel
Applying pesticide carrots Aquitaine	Plant protection, chemical weeding, with self-propelled machine/hr/FR	0.1	12.00		1.2	diesel
Applying pesticide carrots Normandy	Plant protection, spraying, with sprayer, 1200 l/hr/FR	0.5	12.22	-4.22	4	diesel
Transporting cases for tomatoe harvest	Harvesting assistence, with trailer (carrot)/hr/FR	8	3.08		24.64	diesel
Transporting grain 140 bhp trailer 2 axle 15 t	Transporting to farm, with 2 axle trailer (15 t)/hr/FR	0.67	13.34		8.94	diesel

Process	AGRIBALYSE LCI data set name	Operation time h/ha	Fuel consumption l/hour	Fuel consumption correction liters per hour	Diesel consumption per hectare	Type of fuel
Transporting grain 160 bhp 2 axle 15 t	Transporting to farm, with 2 axle trailer (15 t)/hr/FR	0.67	13.34	2	10.28	diesel
Transporting forage 110 bhp trailer 2 axle 15 t	Transporting to farm, with trailer (<15t) heavy tractor/hr/FR	0.59	12.10		7.14	diesel
Transporting forage 90 bhp forage flatbed trailer 2 axle 10-02 t	Transporting, with forage flatbed/hr/FR	0.4	9.90		3.96	diesel
Transporting maize forage 110 bhp trailer 2 axle 15 t	Transporting to farm, with trailer (<15t) heavy tractor/hr/FR	1.25	12.1		15.13	diesel
Transporting maize grain 100 bhp trailer 2 axle 12-14 t	Transporting to farm, with trailer (<15t) heavy tractor/hr/FR	1	12.1	-1.2	10.9	diesel
Transporting potatoes 135 bhp trailer 2 axle 16-18 t	Transporting to farm, with trailer (<15t) heavy tractor/hr/FR	2.5	12.1	2.9	37.5	diesel
Preparing soil before planting closely planted vines	Harrowing, 3m harrow/hr/FR	2	10		20	diesel
Preparing soil between rows (every row)	Hoeing, with 4-6m hoe (standard)/hr/FR	0.33	15		4.95	diesel
Preparing soil for changing plastic tunnel film north	Hoeing, with rotary hoe/hr/FR	1	7.7		7.7	diesel
Preparing soil for changing plastic tunnel film south	Hoeing, with rotary hoe/hr/FR	1.5	7.7		11.55	diesel
Superficial hoeing widely spaced vines	Hoeing, with rotary hoe 3m/hr/FR	1.3	13.3	0.23	17.6	diesel
Harvesting grapes from closely planted vines	Harvesting (vine), with trailer/hr/FR	2.14	30		64.2	diesel
harvesting grapes from widely spaced vines	Harvesting (vine), with trailer/hr/FR	1.6	30		48	diesel
Spring tine harrow, 3m	Harrowing, with vibrating tine cultivator (standard equipment) 5m/hr/FR	0.34	15		5.1	diesel
Spring tine harrow 5m	Harrowing, with vibrating tine cultivator (standard equipment) 5m/hr/FR	0.34	15		5.1	diesel
Spring tine harrow organic carrots	Harrowing, with vibrating tine cultivator 6m/hr/FR	1	15		15	diesel

<u>Appendix L:</u> Building the livestock feed processes

1. Method

AGRIBALYSE "feed ingredients" LCIs comre from ECOALIM project (IFIP 2016). Those LCIs provide benchmark values for « raw ingredients" (wheat, corn etc.) used by livestocks in France. Those ingredients are combined to make "composed feeds" (ex : bovine feeds), corresponding to the physiological needs of each type of animals, and evolving following their physiological phase.

The methodology to build those animal "feed ingredients" LCIs is very similar to other AGRIBALYSE crops, provided in "plant production" folder. However a few differences must be noted : including the seeds, ammoniac emission model or the way for accounting the agronomic rotation. All feeds used Ecoinvent v3.2 in background, except for a few processus (ex : fish feed), where no unit process data was available (AGRIBALYSE 2016). More methodological detail will be provided once Ecoalim project will be finalized.

For human food, it is recommended to use in priority crops in "Plant production" folder, wereas for animal feeds, users should use "Animal Feed" folder.

Transport models
Several transport models were considered.

Raw materials
All raw materials must be transported to the feed mix fabrication plant. All raw material production processes used are “at field gate” or “at factory”.
For raw materials produced in France, it was assumed that the location of the feed fabrication plant was not known. Consequently, the same means of transport and the same distances were taken into account for all raw materials, whether their production zone was known or not. The average transport distances and means of transport were defined according to Nguyen *et al* (2012).
For raw materials imported from abroad, the distances and means of transport between the place of production and France defined in GESTIM (Gac *et al*, 2010) were taken into account. The distances and means of transport to France were then added using the methodology described above.
Table 160 gives the distances and means of transport and the processes used

Table 160: Transport models for raw materials from the place of production to the feed fabrication plant

Source of RM	Means of transport	Distance transported (km)	Process	Source database
France	Road	110	Transport, lorry >32t, EURO3/RER U	ecoinvent
France	Rail	390	Transport, freight, rail/RER U	ecoinvent
Imported	Road	According to GESTIM	Transport, lorry >32t, EURO3/RER U	ecoinvent
Imported	Rail	According to GESTIM	Transport, freight, rail/RER U	ecoinvent
Imported	Sea	According to GESTIM	Transport, transoceanic freight ship/OCE U	ecoinvent

Feed mixes
Feed mixes must be transported from the feed fabrication plant to the farm where they will be consumed by the animals. The assumption described in GESTIM was used: road transport for a distance of 130 km. The process used was “Transport, lorry >32t, EURO3/RER U” (ecoinvent).

Production on the farm
Some feed mixes are made directly on the farm, using some raw materials produced on the farm. The following assumptions were taken into account:

- No transport for the raw materials produced on the farm
- Distances and means of transport the same as those used for transport between the place of production and the feed fabrication plant for raw materials not produced on the farm

2. Feed mixes

Fabrication process

The energy required to produce the feed mixes was taken into account. The data was taken from the Tecaliman report (1995-1997 and 2009). **Table 161** gives the data used. These energy requirements were taken into account for both feed production on the farm and feed production in a factory.

Table 161: Energy requirements for producing one tonne of feed mix

Type of power	Energy (kWh)	Process	Source database
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

Building the LCIs for producing feed mixes on the farm

Several feed mixes are produced completely or partially on the farm. The LCIs were built in the same way for feed mixes produced 100% on the farm as for commercially produced feed. Only the assumptions on transport were modified (see above).

The following procedure was used for feed mixes produced partially on the farm and partly in a factory: i) feed data set built using the “produced at factory” transport model; ii) feed data set built using the “produced at the farm” transport model and iii) final feed data set built using a given percentage of each of the feed data sets already built.

Composition of feed mixes

Table 162 to Table 165 give the composition of AGRIBALYSE feed mix LCI data sets. The abbreviation OFP stands for “on-farm processed”

Table 162: Feed mix processes for pig production in AGRIBALYSE. Feed mix formulation

SimaPro process	Raw material	% composition	Comments
Sow,rapeseed meal based feed,gestating feed,conv prod, at farm gate	Soft wheat	31.3	
	Barley	30	
	Grain maize	3.3	
	Soft wheat bran	15	
	Soft wheat middlings	3.6	
	Protein peas	5	
	Rapeseed cake	3.2	
	Sunflower cake with hulls	2.2	
	Dried sugar beet pulp	3	
	Calciuim 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 maize	2.3	
	Soft wheat middlings	10.2	
	Protein peas	12.2	
	Soybean cake	3	
	Rapeseed cake	12	
	Rapeseed	0.9	
	Calciuim 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 maize	20	
	Soybean cake	15.3	
	Potato protein concentrate	3	
	Soybean concentrate	3	
	Whey powder, with lactose	10	
	Palm oil	2.6	
	Calciuim 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-Tryptophane	0.06	
Weaned piglet,rapeseed meal based feed,WP 2nd phase feed,conv prod, at farm gate	Soft wheat	60	
	Soft wheat middlings	2.8	
	Protein peas	13.8	
	Soybean cake	6.5	
	Rapeseed cake	12	
	Rapeseed	1.5	
	Calciuim 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-Tryptophane	0.03	
Pig,rapeseed meal based feed,growing feed,conv prod, at farm gate	Soft wheat	69.1	
	Soft wheat middlings	1.3	
	Protein peas	7.1	
	Rapeseed cake	15	
	Sunflower cake with hulls	4.3	

SimaPro process	Raw material	% composition	Comments
	Rapeseed	0.6	
	Calciuim carbonate	1.25	
	Salt (NaCl)	0.3	
	L-Lysine HCl	0.41	
	DL Methionine	0.02	
	L-Threonine	0.11	
	L-Tryptophane	0.01	
Pig,rapeseed meal based feed,finishing feed,conv prod, at farm gate	Soft wheat	71.7	
	Barley	8	
	Protein peas	1.9	
	Rapeseed cake	11	
	Sunflower cake with hulls	5	
	Calciuim carbonate	1.07	
	Salt (NaCl)	0.3	
	L-Lysine HCl	0.42	
	DL Methionine	0.01	
	L-Threonine	0.1	
Sow,soybean meal based feed,gestating feed,conv prod, at farm gate	Soft wheat	21.2	
	Barley	30	
	Grain maize	10	
	Soft wheat bran	15	
	Soft wheat middlings	9.2	
	Soybean cake	4.7	
	Dried sugar beet pulp	6.5	
	Calciuim carbonate	2.07	
	Dicalcium phosphate	0.24	
	Salt (NaCl)	0.4	
	L-Lysine HCl	0.13	
	L-Threonine	0.04	
Sow,soybean meal based feed,lactating feed,conv prod, at farm gate	Soft wheat	29.7	
	Barley	18.1	
	Grain maize	17.9	
	Grain maize, moist	15	
	Soybean cake	15.7	
	Calciuim 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,soybean meal based feed,WP 1st phase feed,conv prod, at farm gate	Soft wheat	41.9	
	Grain maize	20	
	Soybean cake	15.3	
	Potato protein concentrate	3	
	Soybean concentrate	3	
	Whey powder, with lactose	10	
	Palm oil	2.6	
	Calciuim 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-Tryptophane	0.06	
Weaned piglet,soybean meal based feed,WP 2nd phase feed,conv prod, at farm gate	Soft wheat	61.2	
	Barley	10	
	Soft wheat middlings	4.7	
	Soybean cake	20.5	
	Calciuim carbonate	1.03	
	Dicalcium phosphate	1.03	
	Salt (NaCl)	0.4	
	L-Lysine HCl	0.41	

SimaPro process	Raw material	% composition	Comments
	DL Methionine	0.09	
	L-Threonine	0.13	
	Soft wheat	71.4	
Pig,soybean meal based feed,growing feed,conv prod, at farm gate	Soft wheat bran	8	
	Soft wheat middlings	2	
	Soybean cake	9.3	
	Rapeseed cake	5	
	Sunflower cake with hulls	1.7	
	Calciuim carbonate	1.26	
	Salt (NaCl)	0.3	
	L-Lysine HCl	0.39	
	DL Methionine	0.03	
	L-Threonine	0.11	
Pig,soybean 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 cake	3.6	
	Rapeseed cake	5	
	Sunflower cake with hulls	3	
	Calciuim 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	100% OFP with local RM
	Barley	36.36	100% OFP with local RM
	Rapeseed cake	8.4	100% OFP
	Sunflower cake with hulls	6	100% OFP
	Calciuim carbonate	2.17	100% OFP
	Dicalcium phosphate	0.362	100% OFP
	Salt (NaCl)	0.4	100% OFP
	L-Lysine HCl	0.152	100% OFP
	L-Threonine	0.005	100% OFP
Sow,on-farm feed supply,lactating feed,conv prod, at farm gate	Soft wheat	60	100% OFP with local RM
	Barley	14.7	100% OFP with local RM
	Soybean cake	7	100% OFP
	Rapeseed cake	10	100% OFP
	Sunflower cake with hulls	4.66	100% OFP
	Calciuim carbonate	1.416	100% OFP
	Dicalcium phosphate	0.858	100% OFP
	Salt (NaCl)	0.4	100% OFP
	L-Lysine HCl	0.326	100% OFP
	L-Threonine	0.07	100% OFP
Weaned piglet,on-farm feed supply,WP 1st phase feed,conv prod, at farm gate	Soft wheat	41.9	
	Grain maize	20	
	Soybean cake	15	
	Potato protein concentrate	3	
	Soybean concentrate	3	
	Whey powder, with lactose	10	
	Palm oil	2.6	
	Calciuim 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-Tryptophane	0.06	
Weaned piglet,on-farm feed supply,WP 2nd phase feed,conv prod, at farm gate	Soft wheat	59.12	100% OFP with local RM
	Barley	15	100% OFP with local RM
	Soybean cake	18	100% OFP
	Rapeseed cake	3.44	100% OFP

SimaPro process	Raw material	% composition	Comments
	Palm oil	0.16	100% OFP
	Calciuim carbonate	1.3	100% OFP
	Dicalcium phosphate	0.988	100% OFP
	Salt (NaCl)	0.4	100% OFP
	L-Lysine HCl	0.434	100% OFP
	DL Methionine	0.084	100% OFP
	L-Threonine	0.135	100% OFP
	L-Tryptophane	0.01	100% OFP
Pig,on-farm feed supply,growing feed,conv prod, at farm gate	Soft wheat	41.86	100% OFP with local RM
	Barley	10	100% OFP with local RM
	Grain maize, moist	25	100% OFP with local RM
	Soybean cake	14	100% OFP
	Rapeseed cake	6.3	100% OFP
	Calciuim carbonate	1.384	100% OFP
	Dicalcium phosphate	0.234	100% OFP
	Salt (NaCl)	0.4	100% OFP
	L-Lysine HCl	0.332	100% OFP
	DL Methionine	0.027	100% OFP
	L-Threonine	0.089	100% OFP
	L-Tryptophane	0.004	100% OFP
Pig,on-farm feed supply,finishing feed,conv prod, at farm gate	Soft wheat	44.86	100% OFP with local RM
	Barley	10	100% OFP with local RM
	Grain maize, moist	25	100% OFP with local RM
	Soybean cake	6	100% OFP
	Rapeseed cake	12	100% OFP
	Calciuim carbonate	1.15	100% OFP
	Dicalcium phosphate	0.1	100% OFP
	Salt (NaCl)	0.4	100% OFP
	L-Lysine HCl	0.356	100% OFP
	DL Methionine	0.004	100% OFP
	L-Threonine	0.082	100% OFP
	L-Tryptophane	0.006	100% OFP
Sow,excess slurry treatment,gestating feed,conv prod, at farm gate	Soft wheat	33.4	
	Barley	24.56	
	Grain maize	6.64	
	Soft wheat bran	11	
	Soft wheat middlings	4.74	
	Protein peas	4.72	
	Rapeseed cake	1.05	
	Sunflower cake, partially dehulled	1.1	
	Sunflower cake with hulls	5.9	
	Dried sugar beet pulp	3	
	Molasses from sugarcane	0.8	
	Calciuim 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 maize	4.34	
	Soft wheat bran	5	
	Soft wheat middlings	4.96	
	Protein peas	3	
	Soybean cake	8.92	
	Rapeseed cake	8.16	
	Rapeseed	0.76	
	Molasses from sugarcane	0.12	
	Calciuim carbonate	1.542	
	Dicalcium phosphate	0.74	
	Salt (NaCl)	0.4	

SimaPro process	Raw material	% composition	Comments
	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 maize	20	
	Soybean cake	15.3	
	Potato protein concentrate	3	
	Soybean concentrate	3	
	Whey powder, with lactose	10	
	Palm oil	2.6	
	Calciuim 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-Tryptophane	0.06	
Weaned piglet,excess slurry treatment,WP 2nd phase feed,conv prod, at farm gate	Soft wheat	62.4	
	Barley	10	
	Soft wheat middlings	1.98	
	Soybean cake	17.32	
	Rapeseed cake	4.38	
	Rapeseed	0.36	
	Calciuim 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-Tryptophane	0.007	
Pig,excess slurry treatment,growing feed,conv prod, at farm gate	Soft wheat	70.44	
	Barley	0.4	
	Grain maize	0.74	
	Soft wheat bran	2	
	Soft wheat middlings	3.34	
	Protein peas	1.16	
	Soybean cake	3.64	
	Rapeseed cake	14.32	
	Sunflower cake with hulls	1	
	Rapeseed	0.14	
	Molasses from sugarcane	0.18	
	Calciuim carbonate	1.218	
	Salt (NaCl)	0.3	
	L-Lysine HCl	0.414	
	DL Methionine	0.018	
	L-Threonine	0.11	
Pig,excess slurry treatment,finishing feed,conv prod, at farm gate	Soft wheat	57.18	
	Barley	19.84	
	Grain maize	0.06	
	Soft wheat bran	2	
	Soft wheat middlings	2.76	
	Protein peas	1.82	
	Soybean cake	2.18	
	Rapeseed cake	10.98	
	Sunflower cake with hulls	0.3	
	Molasses from sugarcane	1	
	Calciuim carbonate	0.982	
	Salt (NaCl)	0.3	
	L-Lysine HCl	0.382	
	DL Methionine	0.018	
	L-Threonine	0.098	
Sow,French	Soft wheat	25.06	75% bought in and 25% OFP with

SimaPro process	Raw material	% composition	Comments
average,gestating feed,conv prod, at farm gate			local RM
	Barley	28.52	75% bought in and 25% OFP with local RM
	Grain maize	4.98	75% bought in and 25% OFP
	Grain maize, moist	10	75% bought in and 25% OFP with local RM
	Soft wheat bran	7.94	75% bought in and 25% OFP
	Soft wheat middlings	3.56	75% bought in and 25% OFP
	Protein peas	3.56	75% bought in and 25% OFP
	Soybean cake	1.7	75% bought in and 25% OFP
	Rapeseed cake	2.04	75% bought in and 25% OFP
	Sunflower cake with hulls	5.22	75% bought in and 25% OFP
	Dried sugar beet pulp	3.3	75% bought in and 25% OFP
	Molasses from sugarcane	0.6	75% bought in and 25% OFP
	Calciuim carbonate	2.096	75% bought in and 25% OFP
	Dicalcium phosphate	0.34	75% bought in and 25% OFP
	Salt (NaCl)	0.4	75% bought in and 25% OFP
	L-Lysine HCl	0.144	75% bought in and 25% OFP
	L-Threonine	0.032	75% bought in and 25% OFP
Sow,French average,lactating feed,conv prod, at farm gate	Soft wheat	32.78	75% bought in and 25% OFP with local RM
	Barley	18.46	75% bought in and 25% OFP with local RM
	Grain maize	3.26	75% bought in and 25% OFP
	Grain maize, moist	13	75% bought in and 25% OFP with local RM
	Soft wheat bran	3.46	75% bought in and 25% OFP
	Soft wheat middlings	3.72	75% bought in and 25% OFP
	Protein peas	2.26	75% bought in and 25% OFP
	Soybean cake	11.18	75% bought in and 25% OFP
	Rapeseed cake	7.38	75% bought in and 25% OFP
	Rapeseed	0.58	75% bought in and 25% OFP
	Dried sugar beet pulp	0.8	75% bought in and 25% OFP
	Molasses from sugarcane	0.09	75% bought in and 25% OFP
	Calciuim carbonate	1.504	75% bought in and 25% OFP
	Dicalcium phosphate	0.862	75% bought in and 25% OFP
	Salt (NaCl)	0.4	75% bought in and 25% OFP
	L-Lysine HCl	0.264	75% bought in and 25% OFP
	DL Methionine	0.0156	75% bought in and 25% OFP
	L-Threonine	0.0628	75% bought in and 25% OFP
	L-Tryptophane	0.0032	75% bought in and 25% OFP
Weaned piglet,French average,WP 1st phase feed,conv prod, at farm gate	Soft wheat	41.9	
	Grain maize	20	
	Soybean cake	15.3	
	Potato protein concentrate	3	
	Soybean concentrate	3	
	Whey powder, with lactose	10	
	Palm oil	2.6	
	Calciuim 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-Tryptophane	0.06	
Weaned piglet,French average,WP 2nd phase feed,conv prod, at farm gate	Soft wheat	62.4	
	Barley	10	
	Soft wheat middlings	1.98	
	Soybean cake	17.32	
	Rapeseed cake	4.38	
	Rapeseed	0.36	
	Calciuim carbonate	1.044	

SimaPro process	Raw material	% composition	Comments
	Dicalcium phosphate	0.94	
	Salt (NaCl)	0.4	
	L-Lysine HCl	0.444	
	DL Methionine	0.077	
	L-Threonine	0.136	
	L-Tryptophane	0.007	
Pig,French average,growing feed,conv prod, at farm gate	Soft wheat	54.54	70% bought in and 30% OFP with local RM
	Barley	0.18	70% bought in and 30% OFP with local RM
	Grain maize	0.52	70% bought in and 30% OFP
	Grain maize, moist	15	70% bought in and 30% OFP with local RM
	Soft wheat bran	1.46	70% bought in and 30% OFP
	Soft wheat middlings	4.8	70% bought in and 30% OFP
	Protein peas	0.82	70% bought in and 30% OFP
	Soybean cake	6.38	70% bought in and 30% OFP
	Rapeseed cake	12.5	70% bought in and 30% OFP
	Sunflower cake with hulls	0.7	70% bought in and 30% OFP
	Rapeseed	0.24	70% bought in and 30% OFP
	Molasses from sugarcane	0.126	70% bought in and 30% OFP
	Calciuim carbonate	1.294	70% bought in and 30% OFP
	Dicalcium phosphate	0.036	70% bought in and 30% OFP
	Salt (NaCl)	0.3	70% bought in and 30% OFP
	L-Lysine HCl	0.388	70% bought in and 30% OFP
	DL Methionine	0.018	70% bought in and 30% OFP
	L-Threonine	0.102	70% bought in and 30% OFP
	L-Tryptophane	0.004	70% bought in and 30% OFP
Pig,French average,finishing feed,conv prod, at farm gate	Soft wheat	41.64	70% bought in and 30% OFP with local RM
	Barley	14.46	70% bought in and 30% OFP with local RM
	Grain maize	0.04	70% bought in and 30% OFP
	Grain maize, moist	15	70% bought in and 30% OFP with local RM
	Soft wheat bran	1.62	70% bought in and 30% OFP
	Soft wheat middlings	3.64	70% bought in and 30% OFP
	Protein peas	1.28	70% bought in and 30% OFP
	Soybean cake	3.72	70% bought in and 30% OFP
	Rapeseed cake	10.58	70% bought in and 30% OFP
	Sunflower cake with hulls	0.48	70% bought in and 30% OFP
	Molasses from sugarcane	0.7	70% bought in and 30% OFP
	Calciuim carbonate	1.078	70% bought in and 30% OFP
	Salt (NaCl)	0.3	70% bought in and 30% OFP
	L-Lysine HCl	0.368	70% bought in and 30% OFP
	DL Methionine	0.0122	70% bought in and 30% OFP
	L-Threonine	0.092	70% bought in and 30% OFP
	L-Tryptophane	0.0066	70% bought in and 30% OFP
Sow,pig with run syst,gestating feed,Label Rouge prod, at farm gate	Soft wheat	33.4	75% bought in and 25% OFP with local RM
	Barley	24.56	75% bought in and 25% OFP with local RM
	Grain maize	6.64	75% bought in and 25% OFP with local RM
	Soft wheat bran	11	75% bought in and 25% OFP
	Soft wheat middlings	4.74	75% bought in and 25% OFP
	Protein peas	4.72	75% bought in and 25% OFP with local RM
	Rapeseed cake	1.05	75% bought in and 25% OFP
	Sunflower cake, partially dehulled	1.1	75% bought in and 25% OFP
	Sunflower cake with hulls	5.9	75% bought in and 25% OFP

SimaPro process	Raw material	% composition	Comments
	Dried sugar beet pulp	3	75% bought in and 25% OFP
	Molasses from sugarcane	0.8	75% bought in and 25% OFP
	Calciuim carbonate	2.146	75% bought in and 25% OFP
	Dicalcium phosphate	0.238	75% bought in and 25% OFP
	Salt (NaCl)	0.4	75% bought in and 25% OFP
	L-Lysine HCl	0.164	75% bought in and 25% OFP
	DL Methionine	0.042	75% bought in and 25% OFP
Sow,pig with run syst,lactating feed,Label Rouge prod, at farm gate	Soft wheat	43.56	75% bought in and 25% OFP with local RM
	Barley	18	75% bought in and 25% OFP with local RM
	Grain maize	4.34	75% bought in and 25% OFP with local RM
	Soft wheat bran	5	75% bought in and 25% OFP
	Soft wheat middlings	4.96	75% bought in and 25% OFP
	Protein peas	3	75% bought in and 25% OFP with local RM
	Soybean cake	8.92	75% bought in and 25% OFP
	Rapeseed cake	8.16	75% bought in and 25% OFP
	Rapeseed	0.76	75% bought in and 25% OFP
	Molasses from sugarcane	0.12	75% bought in and 25% OFP
	Calciuim carbonate	1.542	75% bought in and 25% OFP
	Dicalcium phosphate	0.74	75% bought in and 25% OFP
	Salt (NaCl)	0.4	75% bought in and 25% OFP
	L-Lysine HCl	0.278	75% bought in and 25% OFP
	DL Methionine	0.017	75% bought in and 25% OFP
	L-Threonine	0.07	75% bought in and 25% OFP
Weaned piglet,pig with run syst,WP 1st phase feed,Label Rouge prod, at farm gate	Soft wheat	41.9	
	Grain maize	20	
	Soybean cake	15.3	
	Potato protein concentrate	3	
	Soybean concentrate	3	
	Whey powder, with lactose	10	
	Palm oil	2.6	
	Calciuim 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-Tryptophane	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 middlings	1.98	
	Soybean cake	17	
	Rapeseed cake	4.38	
	Rapeseed	0.36	
	Calciuim 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-Tryptophane	0.007	
Pig,pig with run syst,fattening feed,Label Rouge prod, at farm gate	Soft wheat	49.88	70% bought in and 30% OFP with local RM
	Barley	14.96	70% bought in and 30% OFP with local RM
	Grain maize	4.76	70% bought in and 30% OFP with local RM
	Soft wheat bran	4	70% bought in and 30% OFP
	Soft wheat middlings	5.04	70% bought in and 30% OFP

SimaPro process	Raw material	% composition	Comments
	Protein peas	2.4	70% bought in and 30% OFP with local RM
	Soybean cake	2.5	70% bought in and 30% OFP
	Rapeseed cake	12.66	70% bought in and 30% OFP
	Sunflower cake with hulls	0.7	70% bought in and 30% OFP
	Molasses from sugarcane	0.96	70% bought in and 30% OFP
	Calciuim carbonate	1.208	70% bought in and 30% OFP
	Salt (NaCl)	0.3	70% bought in and 30% OFP
	L-Lysine HCl	0.358	70% bought in and 30% OFP
	DL Methionine	0.0096	70% bought in and 30% OFP
	L-Threonine	0.091	70% bought in and 30% OFP
Sow,outdoor syst,gestating feed,Label Rouge prod, at farm gate	Soft wheat	33.4	75% bought in and 25% OFP with local RM
	Barley	24.56	75% bought in and 25% OFP with local RM
	Grain maize	6.64	75% bought in and 25% OFP with local RM
	Soft wheat bran	11	75% bought in and 25% OFP
	Soft wheat middlings	4.74	75% bought in and 25% OFP
	Protein peas	4.72	75% bought in and 25% OFP with local RM
	Rapeseed cake	1.05	75% bought in and 25% OFP
	Sunflower cake, partially dehulled	1.1	75% bought in and 25% OFP
	Sunflower cake with hulls	5.9	75% bought in and 25% OFP
	Dried sugar beet pulp	3	75% bought in and 25% OFP
	Molasses from sugarcane	0.8	75% bought in and 25% OFP
	Calciuim carbonate	2.146	75% bought in and 25% OFP
	Dicalcium phosphate	0.238	75% bought in and 25% OFP
	Salt (NaCl)	0.4	75% bought in and 25% OFP
	L-Lysine HCl	0.164	75% bought in and 25% OFP
	DL Methionine	0.042	75% bought in and 25% OFP
Sow,outdoor syst,lactating feed,Label Rouge prod, at farm gate	Soft wheat	43.56	75% bought in and 25% OFP with local RM
	Barley	18	75% bought in and 25% OFP with local RM
	Grain maize	4.34	75% bought in and 25% OFP with local RM
	Soft wheat bran	5	75% bought in and 25% OFP
	Soft wheat middlings	4.96	75% bought in and 25% OFP
	Protein peas	3	75% bought in and 25% OFP with local RM
	Soybean cake	8.92	75% bought in and 25% OFP
	Rapeseed cake	8.16	75% bought in and 25% OFP
	Rapeseed	0.76	75% bought in and 25% OFP
	Molasses from sugarcane	0.12	75% bought in and 25% OFP
	Calciuim carbonate	1.542	75% bought in and 25% OFP
	Dicalcium phosphate	0.74	75% bought in and 25% OFP
	Salt (NaCl)	0.4	75% bought in and 25% OFP
	L-Lysine HCl	0.278	75% bought in and 25% OFP
	DL Methionine	0.017	75% bought in and 25% OFP
	L-Threonine	0.07	75% bought in and 25% OFP
Weaned piglet,outdoor syst,WP 1st phase feed,Label Rouge prod, at farm gate	Soft wheat	41.9	
	Grain maize	20	
	Soybean cake	15.3	
	Potato protein concentrate	3	
	Soybean concentrate	3	
	Whey powder, with lactose	10	
	Palm oil	2.6	
	Calciuim carbonate	1.01	
	Dicalcium phosphate	1.33	
	Salt (NaCl)	0.3	

SimaPro process	Raw material	% composition	Comments
	L-Lysine HCl	0.56	
	DL Methionine	0.22	
	L-Threonine	0.22	
	L-Tryptophane	0.06	
Weaned piglet,outdoor syst,WP 2nd phase feed,Label Rouge prod, at farm gate	Soft wheat	62.4	
	Barley	10	
	Soft wheat middlings	1.98	
	Soybean cake	17	
	Rapeseed cake	4.38	
	Rapeseed	0.36	
	Calciuim 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-Tryptophane	0.007	
Pig,outdoor syst,fattening feed,Label Rouge prod, at farm gate	Soft wheat	49.88	70% bought in and 30% OFP with local RM
	Barley	14.96	70% bought in and 30% OFP with local RM
	Grain maize	4.76	70% bought in and 30% OFP with local RM
	Soft wheat bran	4	70% bought in and 30% OFP
	Soft wheat middlings	5.04	70% bought in and 30% OFP
	Protein peas	2.4	70% bought in and 30% OFP with local RM
	Soybean cake	2.5	70% bought in and 30% OFP
	Rapeseed cake	12.66	70% bought in and 30% OFP
	Sunflower cake with hulls	0.7	70% bought in and 30% OFP
	Molasses from sugarcane	0.96	70% bought in and 30% OFP
	Calciuim carbonate	1.208	70% bought in and 30% OFP
	Salt (NaCl)	0.3	70% bought in and 30% OFP
	L-Lysine HCl	0.358	70% bought in and 30% OFP
	DL Methionine	0.0096	70% bought in and 30% OFP
	L-Threonine	0.091	70% bought in and 30% OFP
Sow,gestating feed,organic prod, at farm gate	Barley, organic	70	70% bought in and 30% OFP with local RM
	Protein peas, organic	18	70% bought in and 30% OFP with local RM
	Soybean cake, organic	5	70% bought in and 30% OFP
	Rapeseed oil cake, organic	3	70% bought in and 30% OFP
	Salt (NaCl)	0.48	70% bought in and 30% OFP
	Calciuim carbonate	1.44	70% bought in and 30% OFP
	Dicalcium phosphate	0.96	70% bought in and 30% OFP
	Clay	0.52	70% bought in and 30% OFP
	Mineral and vitamin supplements	0.6	70% bought in and 30% OFP
Sow,lactating feed,organic prod, at farm gate	Barley, organic	30	70% bought in and 30% OFP with local RM
	Triticale, organic	28	70% bought in and 30% OFP with local RM
	Protein peas, organic	20	70% bought in and 30% OFP with local RM
	Soybean cake, organic	17	70% bought in and 30% OFP
	Salt (NaCl)	0.48	70% bought in and 30% OFP
	Calciuim carbonate	1.44	70% bought in and 30% OFP
	Dicalcium phosphate	0.96	70% bought in and 30% OFP
	Clay	0.52	70% bought in and 30% OFP
	Mineral and vitamin supplements	0.6	70% bought in and 30% OFP
Weaned piglet,WP	Soft wheat, organic	20	90% bought in and 10% OFP with

SimaPro process	Raw material	% composition	Comments
feed,organic prod, at farm gate			local RM
	Barley, organic	10	90% bought in and 10% OFP with local RM
	Triticale, organic	21.5	90% bought in and 10% OFP with local RM
	Protein peas, organic	10	90% bought in and 10% OFP with local RM
	Faba beans, brown, organic	10	90% bought in and 10% OFP with local RM
	Soybean cake, organic	20	90% bought in and 10 OFP
	Potato protein concentrate	5	90% bought in and 10% OFP
	Calciuim carbonate	1.26	90% bought in and 10% OFP
	Dicalcium phosphate	0.84	90% bought in and 10% OFP
	Salt (NaCl)	0.42	90% bought in and 10% OFP
	Clay	0.455	90% bought in and 10% OFP
	Mineral and vitamin supplements	0.525	90% bought in and 10% OFP
Pig,growing feed,organic prod, at farm gate	Soft wheat, organic	20	60% bought in and 40% OFP with local RM
	Barley, organic	10	60% bought in and 40% OFP with local RM
	Triticale, organic	27	60% bought in and 40% OFP with local RM
	Protein peas, organic	25	60% bought in and 40% OFP with local RM
	Soybean cake, organic	15	60% bought in and 40% OFP
	Calciuim carbonate	1.08	60% bought in and 40% OFP
	Dicalcium phosphate	0.72	60% bought in and 40% OFP
	Salt (NaCl)	0.36	60% bought in and 40% OFP
	Clay	0.39	60% bought in and 40% OFP
	Mineral and vitamin supplements	0.45	60% bought in and 40% OFP
Pig,finishing feed,organic prod, at farm gate	Soft wheat, organic	20	60% bought in and 40% OFP with local RM
	Barley, organic	15	60% bought in and 40% OFP with local RM
	Triticale, organic	27	60% bought in and 40% OFP with local RM
	Protein peas, organic	25	60% bought in and 40% OFP with local RM
	Soybean cake, organic	10	60% bought in and 40% OFP
	Calciuim carbonate	1.08	60% bought in and 40% OFP
	Dicalcium phosphate	0.72	60% bought in and 40% OFP
	Salt (NaCl)	0.36	60% bought in and 40% OFP
	Clay	0.39	60% bought in and 40% OFP
	Mineral and vitamin supplements	0.45	60% bought in and 40% OFP

Table 163: Feed mix processes for poultry and rabbit production in AGRIBALYSE. Feed mix formulation

SimaPro process	Raw material	% composition
Reproductive,reproductive feed, at farm gate	Soft wheat	25.652
	Grain maize	37.517
	Soybean cake	19.115
	Calciuim carbonate	8.846
	Protein peas	1.319
	Soybean oil	0.597
	Soybean, extruded	0.733
	Rapeseed	1.313
	Dicalcium phosphate	0.474

SimaPro process	Raw material	% composition
	Salt (NaCl)	0.315
	Sunflower seed	0.11
	DL Methionine	0.113
	Rapeseed cake	0.767
	Sunflower seed	0.987
	Sunflower cake, partially dehulled	0.382
	Cornmeal	0.081
	Rapeseed oil	0.069
	L-Lysine HCl	0.004
	L-Tryptophane	0
	Other: alfalfa protein concentrate	1.1
	Other: Natuphos 5000 (phytase)	0.006
	Other COV + Xynalase (phytase)	0.5
Poulette,poulette feed,conv prod, at farm gate	Soft wheat	41.651
	Grain maize	31.351
	Soybean cake	19.684
	Triticale	0.861
	Calciuim 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 cake	0.182
	DL Methionine	0.184
	L-Lysine HCl	0.105
	L-Threonine	0.01
	Cornmeal	0.092
	Barley	0.113
	Rapeseed	0.101
	Soybean, extruded	0.024
	Other: Phytase (Naphtulos and VOC 0.5%)	0.51
Laying hen,laying hen feed,organic prod, at farm gate	Soft wheat, organic	16.4
	Grain maize, organic	25
	Rapeseed cake, organic	1
	Sunflower cake, organic	10
	Protein peas, organic	3
	Soybean cake, organic	8.8
	Soybean, organic	5.8
	Triticale, organic	6
	Oats, organic	2
	Soft wheat bran, organic	3
	Corn gluten feed	4
	Sunflower seed, organic	1
	Dried alfalfa, organic	3
	Calciuim carbonate	8
	Other	3
Laying hen,outdoor laying hen feed,conv prod, at farm gate	Soft wheat	21
	Grain maize	35
	Sunflower cake	3
	Soybean cake	20
	Oats	5
	Soft wheat bran, organic	3
	Corn gluten feed	1
	Calciuim carbonate	10
	Other	2

SimaPro process	Raw material	% composition
Laying hen,laying hen feed,conv prod, at farm gate	Soft wheat	25.652
	Grain maize	37.517
	Soybean cake	19.115
	Calciuim carbonate	8.846
	Protein peas	1.319
	Soybean oil	0.598
	Soybean, extruded	0.733
	Dicalcium phosphate	0.474
	Salt (NaCl)	0.315
	Sunflower seed	1.097
	DL Methionine	0.113
	Rapeseed cake	0.767
	Sunflower cake, partially dehulled	0.382
	Cornmeal	0.081
	Rapeseed oil	0.069
	L-Lysine HCl	0.004
	L-Tryptophane	0
	Rapeseed	1.313
	Other: alfalfa protein concentrate	1.1
	Other: phytase (Natuphos 5000 and VOC 0.5% + xynalase)	0.506
Broiler,broiler feed,conv prod, at farm gate	Soft wheat	25.75
	Grain maize	38.32
	Soybean cake	20.99
	Corn gluten feed	3.08
	Soybean, extruded	2.04
	Triticale	0.44
	Soybean oil	1.47
	Protein peas	0.31
	Calciuim carbonate	0.85
	Rapeseed cake	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-Tryptophane	0.001
	Rapeseed	0.64
	Rapeseed oil	0.25
	Sunflower cake with hulls	0.136
	Other: alfalfa protein concentrate	0.09
	Other: phytase (Natuphos 5000 and VOC 0.5% + xynalase)	0.51
Future reproductive,future reproductive feed, at farm gate	Soft wheat	41.651
	Grain maize	31.351
	Soybean cake	19.684
	Triticale	0.861
	Calciuim 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 cake	0.182

SimaPro process	Raw material	% composition
	DL Methionine	0.184
	L-Lysine HCl	0.105
	L-Threonine	0.01
	Cornmeal	0.092
	Barley	0.113
	Rapeseed	0.101
	Soybean, extruded	0.024
	Other: Phytase (Naphtulos and VOC 0.5%)	0.51
Broiler,broiler feed,Label Rouge prod, at farm gate	Soft wheat	41.651
	Grain maize	31.351
	Soybean cake	19.684
	Triticale	0.861
	Calciuim 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 cake	0.182
	DL Methionine	0.184
	L-Lysine HCl	0.105
	L-Threonine	0.01
	Cornmeal	0.092
	Barley	0.113
	Rapeseed	0.101
	Soybean, extruded	0.024
	Other: Phytase (Naphtulos and VOC 0.5%)	0.51
Broiler,broiler feed,organic prod, at farm gate	Soft wheat, organic	10
	Grain maize, organic	39
	Triticale, organic	8
	Protein peas, organic	2.5
	Faba beans, brown, organic	2.5
	Soft wheat bran, organic	3
	Sunflower cake, organic	5
	Soybean, organic	5
	Soybean cake, organic	14.5
	Salt (NaCl)	0.3
	Cornmeal	2.5
	Potato protein concentrate	2.5
	DL Methionine	0.2
	L-Lysine HCl	0.1
	L-Threonine	0.01
	Other ingredients	4.89
Turkey,reproductive feed,conv prod, at farm gate	Soft wheat	35.286
	Soybean cake	28.245
	Grain maize	16.428
	Protein peas	3.901
	Soybean oil	2.65
	Soybean, extruded	3.406
	Rapeseed	4.754
	Calciuim carbonate	0.783
	Dicalcium phosphate	0.663
	DL Methionine	0.296
	Salt (NaCl)	0.298
	L-Lysine HCl	0.224
	L-Threonine	0.054

SimaPro process	Raw material	% composition
	Cornmeal	0.699
	Palm oil	0.167
	Rapeseed oil	0.353
	Rapeseed cake	0.583
	Sunflower seed	0.4
	Other: alfalfa protein concentrate	0.3
	Other: Phytase (Natuphos 5000 and VOC 0.5% + xynalase)	0.51
Turkey,turkey feed,conv prod, at farm gate	Soft wheat	35.286
	Soybean cake	28.245
	Grain maize	16.428
	Protein peas	3.901
	Soybean oil	2.65
	Soybean, extruded	3.406
	Rapeseed	4.754
	Calciuim carbonate	0.783
	Dicalcium phosphate	0.663
	DL Methionine	0.296
	Salt (NaCl)	0.298
	L-Lysine HCl	0.224
	L-Threonine	0.054
	Cornmeal	0.699
	Palm oil	0.167
	Rapeseed oil	0.353
	Rapeseed cake	0.583
	Sunflower seed	0.4
	Other: alfalfa protein concentrate	0.3
	Other: Phytase (Natuphos 5000 and VOC 0.5% + xynalase)	0.51
Turkey,turkey feed,Label Rouge prod, at farm gate	Soft wheat	35.286
	Soybean cake	28.245
	Grain maize	16.428
	Protein peas	3.901
	Soybean oil	2.65
	Soybean, extruded	3.406
	Rapeseed	4.754
	Calciuim carbonate	0.783
	Dicalcium phosphate	0.663
	DL Methionine	0.296
	Salt (NaCl)	0.298
	L-Lysine HCl	0.224
	L-Threonine	0.054
	Cornmeal	0.699
	Palm oil	0.167
	Rapeseed oil	0.353
	Rapeseed cake	0.583
	Sunflower seed	0.4
	Other: alfalfa protein concentrate	0.3
	Other: Phytase (Natuphos 5000 and VOC 0.5% + xynalase)	0.51
Duck,future reproductive feed,conv prod, at farm gate	Soft wheat	44.166
	Grain maize	27.613
	Soybean cake	15.001
	Protein peas	1.551
	Cornmeal	0.957
	Soybean oil	1.275

SimaPro process	Raw material	% composition
	Rapeseed cake	3.606
	Calciuim carbonate	1.186
	Soft wheat bran	0.488
	Dicalcium phosphate	0.535
	Salt (NaCl)	0.311
	Soybean	0.61
	DL Methionine	0.101
	L-Lysine HCl	0.105
	Sunflower cake	1.105
	Rapeseed	0.486
	Rapeseed oil	0.2
	Palm oil	0.025
	Barley	0.169
	Other: phytase (Natuphos 5000 and VOC 0.5% + xynalase)	0.51
Duck,PAG feed,conv prod, at farm gate	Soft wheat	44.164
	Grain maize	27.6
	Soybean cake	15
	Calciuim carbonate	1.2
	Protein peas	1.6
	Soybean oil	1.3
	Soybean, extruded	0.6
	Rapeseed	0.5
	Dicalcium phosphate	0.5
	Salt (NaCl)	0.3
	Sunflower cake	1.044
	DL Methionine	0.1
	Rapeseed cake	3.6
	Cornmeal	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
	Other: Natuphos 5000 (phytase)	0.01
	Other VOC + Xynalase (phytase)	0.5
Duck,fattening feed,conv prod, at farm gate	Grain maize, moist	100
Duck,duck feed,conv prod, at farm gate	Soft wheat	44.164
	Grain maize	27.6
	Soybean cake	15
	Calciuim carbonate	1.2
	Protein peas	1.6
	Soybean oil	1.3
	Soybean, extruded	0.6
	Rapeseed	0.5
	Dicalcium phosphate	0.5
	Salt (NaCl)	0.3
	Sunflower cake	1.044
	DL Methionine	0.1
	Rapeseed cake	3.6
	Cornmeal	0.957
	Rapeseed oil	0.2
	L-Lysine HCl	0.1
	Palm oil	0.025

SimaPro process	Raw material	% composition
	L-Threonine	0
	Other: Natuphos 5000 (phytase)	0.01
	Other VOC + Xynalase (phytase)	0.5
	Barley	0.2
	Soft wheat bran	0.5
Rabbit,maternity feed,conv prod, at farm gate	Sunflower cake	20
	Dried alfalfa	17.95
	Dried sugar beet pulp	13.96
	Soft wheat bran	10.01
	Barley	9.97
	Rapeseed cake	5
	Soft wheat	6.64
	Other: Citrus	4.58
	Soybean	3.78
	Molasses from sugarcane	3
	Protein peas	1.14
	Soybean oil	0.53
	Other: VOC	0.5
	Calciuim carbonate	0.39
	Dicalcium phosphate	0.23
	Soybean cake	0.81
	DL Methionine	0.01
	Untreated straw	1.499
	Rapeseed oil	0.001
Rabbit,fattening feed,conv prod, at farm gate	Sunflower cake	20
	Dried alfalfa	17.95
	Dried sugar beet pulp	13.96
	Soft wheat bran	10.01
	Barley	9.97
	Rapeseed cake	5
	Soft wheat	6.64
	Other: Citrus	4.58
	Soybean	3.78
	Molasses from sugarcane	3
	Protein peas	1.14
	Soybean oil	0.53
	Other: VOC	0.5
	Calciuim carbonate	0.39
	Dicalcium phosphate	0.23
	Soybean cake	0.81
	DL Methionine	0.01
	Untreated straw	1.499
	Rapeseed oil	0.001

Table 164: Feed mix processes for cattle, sheep and goat production in AGRIBALYSE. Feed mix formulation

SimaPro process	Raw material	% compositi on	Comments
Bovine feed,BV40, at farm gate	Soft wheat	2.4	GESTIM data
	Grain maize	5.2	GESTIM data
	Oats	0.1	GESTIM data
	Barley	5.8	GESTIM data
	Corn gluten feed	0.8	GESTIM data
	Soft wheat bran	6.9	GESTIM data

SimaPro process	Raw material	% composition	Comments
	Molasses from sugarcane	1.3	GESTIM data
	Dried sugar beet pulp	2.5	GESTIM data
	Linseed oil	0.1	GESTIM data
	Protein peas	0.0	GESTIM data
	Dried alfalfa	1.0	GESTIM data
	Groundnut cake	1.8	GESTIM data
	Rapeseed cake	32.6	GESTIM data
	Soybean cake	13.1	GESTIM data
	Sunflower cake	13.3	GESTIM data
	Soybean	0.1	GESTIM data
	Calciuim carbonate	13.0	GESTIM data
Bovine feed,CMV 5-25-5, at farm gate	Monocalcium phosphate	10.0	
	Dicalcium phosphate	19.16	
	Calciuim carbonate	59.41	
	Calciuim carbonate	2.0	
	Selenium	0.44	
	Iodine	0.02	
	Zinc	0.19	
	Copper	0.72	
	Cobalt	0.09	
	Vitamins	1.31	
	Molasses from sugarcane	6	
Bovine feed,MAT18, at farm gate	Soft wheat	4.8	GESTIM data
	Grain maize	16.1	GESTIM data
	Oats	0.7	GESTIM data
	Barley	6.7	GESTIM data
	Corn gluten feed	8.8	GESTIM data
	Soft wheat bran	29.1	GESTIM data
	Molasses from sugarcane	3.5	GESTIM data
	Dried sugar beet pulp	4.8	GESTIM data
	Linseed oil	0.5	GESTIM data
	Protein peas	0	GESTIM data
	Dried alfalfa	0.2	GESTIM data
	Groundnut cake	1.2	GESTIM data
	Rapeseed cake	11.9	GESTIM data
	Soybean cake	7.6	GESTIM data
	Sunflower cake	0.7	GESTIM data
	Soybean	0.1	GESTIM data
	Calciuim carbonate	3.3	GESTIM data
Bovine feed,Melo, at farm gate	Triticale, organic	52.0	Datasheet produced by Yann Pitois (CIVAM Bio 53) Cereal mix harvested on the farm - No transport
	Oats, organic	6	Datasheet produced by Yann Pitois (CIVAM Bio 53) Cereal mix harvested on the farm - No transport
	Protein peas, organic	42	Usually vetches (27%) + peas (16%) but not specified in the table and therefore treated as peas - Datasheet produced by Yann Pitois (CIVAM Bio 53) Cereal mix harvested on the farm - No transport
Bovine feed,suckler feed, at farm gate	Skimmed milk powder	20	Expert opinion, Idele and Syndicat de la Vitelerie
	Whey powder, lactose free	18	Expert opinion, Idele and Syndicat de la Vitelerie
	Whey powder, with lactose	29	Expert opinion, Idele and Syndicat de la Vitelerie
	Tallow	6	Expert opinion, Idele and Syndicat de la Vitelerie
	Lard	6	Expert opinion, Idele and Syndicat de la Vitelerie
	Palm oil	4	Expert opinion, Idele and Syndicat de la Vitelerie
	Coconut oil	4	Expert opinion, Idele and Syndicat de la Vitelerie
	Potato starch	3	Expert opinion, Idele and Syndicat de la Vitelerie
	Gluten wheat feed	3	Expert opinion, Idele and Syndicat de la Vitelerie
	Soybean protein (powder)	4.5	Expert opinion, Idele and Syndicat de la Vitelerie
	L-Lysine HCl	0.3	Expert opinion, Idele and Syndicat de la Vitelerie -

SimaPro process	Raw material	% composition	Comments
			formulation of mineral and vitamin supplement used by Idele Le Rheu experimental station
	DL Methionine	0.1	Expert opinion, Idele and Syndicat de la Vitelerie - formulation of mineral and vitamin supplement used by Idele Le Rheu experimental station
	Calciuim carbonate	0.5	Expert opinion, Idele and Syndicat de la Vitelerie - formulation of mineral and vitamin supplement used by Idele Le Rheu experimental station
	Vitamins	1.6	Expert opinion, Idele and Syndicat de la Vitelerie -in practice 1.5% mineral and vitamin supplement and prebiotic + 0.2% silica (but silica is not available as an ingredient)
Calf,fiber diet, at farm gate	Soft wheat	35	Expert opinion, Idele and Syndicat de la Vitelerie
	Barley	20	Expert opinion, Idele and Syndicat de la Vitelerie
	Protein peas	10	Expert opinion, Idele and Syndicat de la Vitelerie
	Untreated straw	5	Expert opinion, Idele and Syndicat de la Vitelerie
	Grain maize	30	Cake or meal-Expert opinion, Idele and Syndicat de la Vitelerie
Calf,suckler feed, at farm gate	Skimmed milk powder	20	Expert opinion, Idele and Syndicat de la Vitelerie
	Whey powder, lactose free	17	Expert opinion, Idele and Syndicat de la Vitelerie
	Whey powder, with lactose	30	Expert opinion, Idele and Syndicat de la Vitelerie
	Tallow	8.	Expert opinion, Idele and Syndicat de la Vitelerie
	Lard	8	Expert opinion, Idele and Syndicat de la Vitelerie
	Coconut oil	4	Expert opinion, Idele and Syndicat de la Vitelerie
	Flour, soft wheat, low grade	3	Pregelatinized wheat starch (or flour, but it must be soluble)- Expert opinion, Idele and Syndicat de la Vitelerie
	Gluten wheat feed	3	Expert opinion, Idele and Syndicat de la Vitelerie
	Soybean protein (powder)	4.5	Soybean concentrate -Expert opinion, Idele and Syndicat de la Vitelerie
	L-Lysine HCl	0.3	Expert opinion, Idele and Syndicat de la Vitelerie - formulation of mineral and vitamin supplement used by Idele Le Rheu experimental station
	DL Methionine	0.1	Expert opinion, Idele and Syndicat de la Vitelerie - formulation of mineral and vitamin supplement used by Idele Le Rheu experimental station
	Calciuim carbonate	0.5	Expert opinion, Idele and Syndicat de la Vitelerie - formulation of mineral and vitamin supplement used by Idele Le Rheu experimental station
	Vitamins	1.6	Expert opinion, Idele and Syndicat de la Vitelerie - in practice 1.5% mineral vitamin supplement and prebiotic + 0.2% silica (but silica is not available as an ingredient)
Caprine,replacement goat,CL 25 % feed, at farm gate	Soft wheat	3.8	GESTIM data
	Grain maize	12.7	GESTIM data
	Oats	0.5	GESTIM data
	Barley	5.3	GESTIM data
	Corn gluten feed	6.9	GESTIM data
	Soft wheat bran	23	GESTIM data
	Molasses from sugarcane	2.8	GESTIM data
	Dried sugar beet pulp	3.8	GESTIM data
	Linseed oil	0.3	GESTIM data
	Protein peas	0.1	GESTIM data
	Dried alfalfa	0.3	GESTIM data
	Groundnut cake	2	GESTIM data
	Rapeseed cake	19.5	GESTIM data
	Soybean cake	12.5	GESTIM data
	Sunflower cake	1.1	GESTIM data
	Soybean	0.2	GESTIM data
	Calciuim carbonate	3.3	GESTIM data
	Magnesium	1	GESTIM data

SimaPro process	Raw material	% composition	Comments
	Vitamins	0.1	GESTIM data
	Dried citrus pulp	0.8	GESTIM data
Caprine,in milk goat,CL 25 % feed, at farm gate	Soft wheat	3.8	GESTIM data
	Grain maize	12.7	GESTIM data
	Oats	0.5	GESTIM data
	Barley	5.3	GESTIM data
	Corn gluten feed	6.9	GESTIM data
	Soft wheat bran	23	GESTIM data
	Molasses from sugarcane	2.8	GESTIM data
	Dried sugar beet pulp	3.8	GESTIM data
	Linseed oil	0.3	GESTIM data
	Protein peas	0.1	GESTIM data
	Dried alfalfa	0.3	GESTIM data
	Groundnut cake	2	GESTIM data
	Rapeseed cake	19.5	GESTIM data
	Soybean cake	12.5	GESTIM data
	Sunflower cake	1.1	GESTIM data
	Soybean	0.2	GESTIM data
	Calciuim carbonate	3.3	GESTIM data
	Magnesium	1	GESTIM data
	Vitamins	0.1	GESTIM data
	Dried citrus pulp	0.8	GESTIM data
Ovine,purchased concentred feed, at farm gate	Soft wheat	4.8	GESTIM data
	Grain maize	16.1	GESTIM data
	Oats	0.7	GESTIM data
	Barley	6.7	GESTIM data
	Corn gluten feed	8.8	GESTIM data
	Soft wheat bran	29.1	GESTIM data
	Molasses from sugarcane	3.5	GESTIM data
	Dried sugar beet pulp	4.8	GESTIM data
	Linseed oil	0.5	GESTIM data
	Protein peas	0	GESTIM data
	Dried alfalfa	0.2	GESTIM data
	Groundnut cake	1.2	GESTIM data
	Rapeseed cake	11.9	GESTIM data
	Soybean cake	7.6	GESTIM data
	Sunflower cake	0.7	GESTIM data
	Soybean	0.1	GESTIM data
	Calciuim carbonate	3.3	GESTIM data

Table 165 : Feed mix processes for fish farming in AGRIBALYSE. Feed mix formulation

SimaPro process	Raw material	% composition
Small trout,fattening feed 1,conv prod, at farm gate	Fish meal, North Atlantic	20.1
	Fish meal, South America	20.1
	Soybean protein (powder)	10.1
	Blood meal	10.6
	Fish oil from scraps (Europe)	12.9
	Gluten wheat feed	17
	Corn gluten feed	0.9
	Vitamins	0.3
	Fish oil, North Atlantic	8
Small trout,fattening feed 2,conv prod, at farm gate	Fish meal, South America	20.9
	Fish meal, North Atlantic	22
	Fish oil, North Atlantic	18.8
	Rapeseed cake	9
	Faba beans, white	12
	Gluten wheat feed	9
	Rapeseed oil	5
	L-Lysine HCl	3.3

SimaPro process	Raw material	% composition
Small trout,fattening feed 3,conv prod, at farm gate	Fish meal, South America	30.5
	Fish meal, North Atlantic	30.5
	Fish oil, North Atlantic	13.9
	Protein peas	12.6
	Gluten wheat 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
	Fish meal, North Atlantic	10.2
	Fish oil, North Atlantic	11.6
	Rapeseed cake	3
	Faba beans, white	9.9
	Gluten wheat feed	13.8
	Rapeseed oil	16.9
	L-Lysine HCl	0
	Soybean cake	18.9
	Vitamins	5.5
Large trout,fattening feed 1,conv prod, at farm gate	Fish meal, South America	8.5
	Fish meal, North Atlantic	8.5
	Gluten wheat feed	2
	Soybean protein (powder)	9.3
	Soybean concentrate	16.5
	Fish oil, North Atlantic	14
	Corn gluten feed	15
	Rapeseed oil	14
	Vitamins	0.5
	L-Lysine HCl	0.6
	Flour, soft wheat, low grade	11.1
Large trout,fattening feed 2,conv prod, at farm gate	Fish meal, South America	11.1
	Fish meal, North Atlantic	11.1
	Fish protein concentrate	10
	Soybean protein (powder)	16.2
	Fish oil, North Atlantic	10.5
	Gluten wheat feed	17.7
	Soybean concentrate	15.4
	Rapeseed oil	0.9
	Rapeseed cake	0.9
	Vitamins	0.2
	Fish oil from scraps (Europe)	6
Large trout,fattening feed 3,conv prod, at farm gate	Fish meal, South America	18.5
	Fish meal, North Atlantic	18.5
	Rapeseed cake	10
	Soybean protein (powder)	12
	Fish oil, South America	9
	Rapeseed oil	9
	Cornmeal	5
	Gluten wheat feed	10
	Vitamins	0.5
	Protein peas	2
	Soybean concentrate	5.5
Large trout,fattening feed 4,conv prod, at farm gate	Fish meal, South America	22
	Fish meal, North Atlantic	22
	Gluten wheat feed	1
	Rapeseed oil	0.5
	Soybean protein (powder)	0.5
	Fish oil, North Atlantic	0.6
	Gluten wheat feed	17
	Corn gluten feed	0.5
	Protein peas	0.5
	L-Lysine HCl	0.2
	Vitamins	0.2
	Fish meal from scraps (Europe)	10

SimaPro process	Raw material	% composition
	Fish oil from scraps (Europe)	20
	Soybean protein (powder)	5
Sea bass or sea bream,fattening feed 1,conv prod, at farm gate	Fish meal, South America	40.7
	Fish meal, North Atlantic	20.4
	Fish oil, North Atlantic	5.2
	Soybean cake	8.5
	Faba beans, white	24.7
	Vitamins	0.5
Sea bass or sea bream,fattening feed 2,conv prod, at farm gate	Fish meal, South America	42
	Fish meal from scraps (Europe)	16
	Fish oil from scraps (Europe)	6.4
	Corn gluten feed	6
	Soybean cake	10
	Rapeseed cake	11
	Fish protein concentrate	8
	Vitamins	0.5

3. Forage

The LCI data sets built for AGRIBALYSE (see Appendix G) were used as raw material for forage. As the LCI data sets for plant production included losses in the field, only the losses during storage and distribution of forage were taken into account for livestock production. **Table 166** gives the loss rates used, depending on the type of forage and the type of use.

Table 166: Loss rates used to calculate the quantities of forage distributed, expressed as a percentage of the yield at farm gate (meaning field loss are implicitly accounted for). For pastures, losses comparing pasture yield/harvesting yield are accounted for.

Type of grass	Loss at harvesting (in the field)	Losses during storage (% of yield at farm gate)	Losses on collection and distribution (% of yield at farm gate)	Total losses (% of yi farm gate)
Meadow without clover				
Hay	15	2.3	5.75	8.05
Silage	5	13.26	10.2	23.46
Haylage	5	7.14	5.1	12.24
Meadow with clover				
Hay	25	2.5	6.25	8.75
Silage	3	22.66	10.3	32.96
Haylage	7	10.7	5.35	16.05
Alfalfa				
Hay		2.62	6.55	9.17
Silage		9.064	10.3	19.364
Haylage		3.159	5.85	9.009
Maize				
Silage		13	1	14

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Appendix M: Allocations used for AGRIBALYSE

1. Pig production

The allocations for piglets and cull sows were calculated on the basis of the quantity of feed required to produce each of two co-products. The allocations are given in **Table 167**.

Table 167: Percentage of each type of feed used in the maternity class required for the fabrication of each of the two co-products

Co-product	Piglet feed	Gestation feed	Lactation feed
Cull sow	100%	75%	40%
Piglet	-	25%	60%

Table 168: Allocations for pig production

Co-product N°	Co-product	Allocation
Axxx-132.169.171	Cull sow - conventional, fed rapeseed meal - Brittany or generic	68.19% of maternity class impacts
Axxx-133.170172	Cull sow - conventional, fed soybean meal - Brittany or generic	68.19% of maternity class impacts
Axxx-134.171173	Cull sow - conventional, on farm feed supply/locally supplied pigs - Poitou Charente	68.38% of maternity class impacts
Axxx-135.172174	Cull sow - conventional, excess slurry treatment - 100% purchase - Brittany	68.97% of maternity class impacts
Axxx-136.173175	Cull sow - conventional -France	68.19% of maternity class impacts
Axxx-137.174a176	Cull sow - Label Rouge, litter – France (run system)	68.27% of maternity class impacts
Axxx-137.174b177	Cull sow - Label Rouge, litter – France (outdoor system)	68.83% of maternity class impacts
Axxx-138.175178	Cull sow - organic - France	68.58% of maternity class impacts

2. Rabbit production

The allocations for cull does and kits were calculated on the basis of the quantity of feed required to produce each of two co-products (**Table 169**). The maternity class impacts are allocated as:

- Cull doe: 56.44%
- Kit: 43.56%

Table 169: Percentage of each type of feed used in the maternity class required for the fabrication of each of the two co-products

Co-product	Gestation	Lactation
Cull doe	75%	40%
Kit	25%	60%

3. Cattle, sheep and goat production

The feed was allocated pro rata for the energy required for maintenance. The equations proposed in IPCC (2006b) were used.

Net energy required by the animal for maintenance (cattle/sheep/goats)

$$NE_m = Cf_i \times (weight)^{0.75}$$

Where:

- NE_m is the net energy required by the animal for maintenance (MJ/day)
- Cf_i is a coefficient which depends on the animal category (MJ/day/kg), see **Table 170**
- Weight is the live weight of the animal (kg)

Table 170: Coefficients for calculating the net energy required for maintenance

Animal	Coefficient (MJ/day/kg)
Cattle- outside lactation period	0.322
Cattle- during lactation period	0.386
Cattle - bull	0.37
Sheep-lamb under one year	0.236
Sheep over one year	0.217

Net energy required for activity (cattle)

$$NE_a = C_a \times NE_m$$

Where:

- NE_a is the net energy required by the animal for activity (MJ/day)
- C_a is the coefficient for the animal's feeding situation, see **Table 171**
- EN_m is the net energy required by the animal for maintenance (MJ/day)

Net energy required for activity (sheep/goats)

$$NE_a = C_a \times (weight)$$

Where:

- NE_a is the net energy required by the animal for activity (MJ/day)
- C_a is the coefficient for the animal's feeding situation, see **Table 171**
- Weight is the live weight of the animal (kg)

Table 171: Activity coefficient for the animal's feeding situation

Animal	Definition	C_a
Cattle: C_a without size		
Stall	Animals are confined to a small area and expend very little energy to acquire feed	0
Pasture	Animals are confined in areas with sufficient forage and expend an average amount of energy to acquire feed	0.17
Grazing large areas	Animals graze in open range land or hilly terrain and expend significant energy to acquire feed	0.36
Sheep: C_a MJ/day/kg		
Housed ewes enclosure	Animals are confined due to pregnancy in the final quarter (50 days)	0.009
Grazing flat pasture	Animals walk up to 1000 m per day and expend very little energy to acquire feed	0.0107
Grazing hilly pasture	Animals walk up to 5000 m per day and expend significant energy to acquire feed	0.024
Housed fattening lambs	Animals are housed for fattening	0.0067

Net energy required by the animal for growth (cattle)

$$NE_g = 22.02 * \left(\frac{BW}{C * MW}\right)^{0.75} * WG^{1.097}$$

Where:

- NE_g is the net energy required for growth (MJ/day)
- BW is the live body weight of the animal (kg)
- C is a coefficient of 0.8 for females, 1.0 for steers and 1.2 for bulls
- MW is the mature body weight of an adult animal (kg)
- WG is the daily weight gain (kg/day)

Net energy required by the animal for growth (sheep/goats)

$$NE_g = \frac{WG \times \left(a + 0.5b \times \left(BW_i + BV_f\right)\right)}{Duration\ of\ presence}$$

Where:

- NE_g is the net energy required by the animal for growth (MJ/day)
- WG is the weight gain, PVf – PVi, (kg/day)
- BWi is the body weight on weaning (kg)
- BWf is the live weight at slaughter (kg)
- a, b are constants, see Table 172

Table 172: Coefficients for calculating the energy required for growth (sheep)

Category of animal	a (MJ/kg)	b (MJ/kg)
Rams	2.5	0.35
Castrated males	4.4	0.32
Ewes	2.1	0.45

Energy requirement during lactation (cattle)

$$NE_l = milk \times (1.47 + 0.40 \times fat)$$

Where:

- NE_l is the net energy required for lactation (MJ/day)
- Milk is the quantity of milk produced (kg/day)

Fat is the fat content of the milk (% of weight)

Energy requirement during lactation (sheep/goats)

$$EN_l = milk \times EV_{milk}$$

Where:

EN_l is the net energy required for lactation (MJ/day)

Milk is the quantity of milk produced (kg/day)

EV_{milk} is the energy value to produce 1 kg of milk = 4.6 MJ/kg, equivalent to a milk fat content of 7% in weight

Energy requirement for gestation (cattle/sheep/goats)

$$NE_g = C_{gestation} \times NE_s$$

Where:

NE_g is the net energy required for gestation (MJ/day)

$C_{gestation}$ is the gestation coefficient, see **Table 173**

NE_s is the net energy required by the animal for maintenance (MJ/day)

Table 173: Coefficients for calculating the energy required for gestation

Category of animal	$C_{gestation}$
Dairy cattle	0.10
Sheep	
Single birth	0.077
Double birth (twins)	0.126
Triple birth or more (triplets)	0.150

Net energy required to produce wool (sheep)

$$NE_{wool} = \left(\frac{EV_{wool} \times Production_{wool}}{period}\right)$$

Where:

NE_{wool} is the net energy required to produce a year of wool (MJ/day)

EV_{wool} is the energy value of each kg of wool produced = 24 MJ/kg

$Production_{wool}$ is the average wool production per sheep over the period (kg/period)

Table 174 gives the allocations for cattle, sheep and goats.

Table 174: Allocations for cattle, sheep and goat production in AGRIBALYSE

LCI data set	Ax class	Biophysical allocation co-products (%)				Other allocations		
		Milk	Calf/lamb	Wool	Cull Ax	Co-product	Key (%)	Type
Cow milk, conventional, lowland milk system, silage maize more than 30%, at farm gate – Cull cow, conventional, lowland milk system, silage maize more than 30%, at farm gate atelier	Dairy cattle - Dairy cows in production	96.44	3.56					
	Dairy cattle - Calf (birth -"1 week")					Replacement calf	50.81	by mass
	Dairy cattle - Calf (birth -"1 week")					Beef calf	49.19	by mass
Cow milk, conventional, lowland milk system, silage maize 10 to 30%, at farm gate – Cull cow, conventional, lowland milk system, silage maize 10 to 30%, at farm gate	Dairy cattle - Dairy cows in production	96.79	3.21					
	Dairy cattle - Calf (birth -"1 week")					Replacement calf	49.34	by mass
	Dairy cattle - Calf (birth -"1 week")					Beef calf	50.66	by mass
Cow milk, conventional, lowland milk system, silage maize 5 to 10%, at farm gate- Cull cow, conventional, lowland milk system, silage maize 5 to 10%, at farm gate	Dairy cattle - Dairy cows in production	95.81	4.19					
	Dairy cattle - Calf (birth -"1 week")					Replacement calf	49.34	by mass
	Dairy cattle - Calf (birth -"1 week")					Beef calf	50.66	by mass
Cow milk, organic, lowland milk system, silage maize 5 to 10%, at farm gate- Cull cow, organic, lowland milk system, silage maize 5 to 10%, at farm gate	Dairy cattle - Dairy cows in production	96.17	3.83					
	Dairy cattle - Calf (birth -"1 week")					Replacement calf	37.41	by mass
	Dairy cattle - Calf (birth -"1 week")					Beef calf	62.59	by mass
Cow milk, conventional, highland milk system, grass fed, at farm gate - Cull cow, conventional, highland milk system, grass fed, at farm gate	Dairy cattle - Dairy cows in production	95.57	4.43					
	Dairy cattle - Calf (birth -"1 week")					Replacement calf	29.29	by mass
	Dairy cattle - Calf (birth -"1 week")					Beef calf	70.71	by mass
Sheep milk, conventional, Roquefort system, at farm gate-	Milk ewe - Lambs (0-weaning)		100					
	Milk ewe - Replacement gimmer 0-1 yr			1.36	98.64			
	Milk ewe - Ewe in production	88.71	9.28	2.01				
Goat milk, conventional, intensive forage area, at farm gate	Milk goat - Goats in production	90.30	9.70					
Lamb, conventional, indoor production system, at farm gate	Sheep for meat - Lambs 0-weaning					replacement	16.66	by mass
	Sheep for meat - Lambs 0-weaning					lamb for meat	18.34	by mass
	Sheep for meat - Lambs weaning-sale		100					
	Sheep for meat - Replacement			2.32	97.68			

	gimmers weaning-1yr			
	Sheep for meat - Replacement gimmers 1yr-2yrs		1.56	98.44
	Sheep for meat - Sheep in production	98.80	1.42	

4. Grassland / hay – grazed grass

As the LCI data sets for cut grass (hay, haylage, silage) cover mixed production systems (including grazing/cutting), there must be an allocation between the main product (cut grass) and the co-product (grazed grass). Mass allocation was used using generic values (yield of main product divided by the sum of the yields of the main product and the co-product, see column 3, **Table 175**). This was used for the inputs for the main product and the co-product. Harvesting (cutting, swathing, baling, transport, etc.) was allocated 100% to cut grass, because the work involved in harvesting is entirely for the cut grass (cf last column, **Table 175**).

Table 175: Allocation for products and co-products for the 17 grass LCI data sets

LCI data set / crop	Allocation	Generic allocation[1]
Grazed grass, permanent meadow, without clover, Auvergne, on field	No, grazing only	100%
Baled grass, permanent meadow, without clover, Auvergne, at farm	Yes, by mass	3.58/(2.41+3.58) = 60%
Grass silage, horizontal silo, permanent meadow, without clover, Auvergne, at farm	Yes, by mass	3.58/(2.41+3.58) = 60%
Baled hay, permanent meadow, without clover, Auvergne, at farm	Yes, by mass	4.18/(2.41+4.18) = 63%
Grazed grass, permanent meadow, without clover, Northwestern region, on field	No, grazing only	100%
Baled grass, permanent meadow, without clover, Northwestern region, at farm	Yes, by mass	3.55/(4.92+3.55) = 42%
Baled hay, permanent meadow, without clover, Northwestern region, at farm	Yes, by mass	4.22/(4.96+4.22) = 46%
Grazed grass, temporary meadow, without clover, Northwestern region, on field	No, grazing only	100%
Baled grass, temporary meadow, without clover, Northwestern region, at farm	Yes, by mass	17.16/(17.88+17.16) = 49%
Baled hay, temporary meadow, without clover, Northwestern region, at farm	Yes, by mass	20.88/(17.88+20.88) = 54%
Grazed grass, permanent meadow, with clover, Northwestern region, on field	No, grazing only	100%
Baled grass, permanent meadow, with clover, Northwestern region, at farm	Yes, by mass	3.29/(4.92+3.29) = 40%
Baled hay, permanent meadow, with clover, Northwestern region, at farm	Yes, by mass	4.87/(4.92+4.87) = 50%
Grazed grass, temporary meadow, with clover, Northwestern region, on field	No, grazing only	100%
Baled grass, temporary meadow, with clover, Northwestern region, at farm	Yes, by mass	18.2/(19.68+18.2) = 48%
Grass silage, horizontal silo, temporary meadow, with clover, Northwestern region, at farm	Yes, by mass	17.72/(17.88+17.72) = 50%
Baled hay, temporary meadow, with clover, Northwestern region, at farm	Yes, by mass	4*5.87/(17.88+4*5.87) = 57%

1) Yield in t per hectare per assement period for LCI data set

5. Clementines

When the clementines have been harvested, they are graded by quality into two grades: clementines for export and clementines for local market. Economic allocation was used with the value defined by multiplying the quantities of the grades by their respective prices. The allocation for clementines for export was 86% (**Table 176).**

Table 176: Allocation for product and co-product for the Clementine data set

Grade	Yield	Price	Allocation
Clementines, export, SN – Average	330.6 t	3,000 Dirham/t	991,800/1,147,100= 86%
Clementines, local market	115.3 t	1,000 Dirham/t	115,300/1,147,100= 14%

6. Coffe

Economic allocation was done between coffee grain and pulp (in full production phase) : 4% of the impacts were allocated to pulp.

ADEME

The Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME) is a government organization agency under the Ministry of Ecology, Sustainable Development, Transport and Housing, the Ministry of Higher Education and Research and the Ministry of the Economy, Finance and Industry. It is involved in the implementation of government policies for the environment, energy and sustainable development.

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