Methodological guidelines for LCA of French agricultural products

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Abstract This article outlines the methodological guidelines that will be applied in the framework of the program Agri-BALYSE in order to compile life cycle inventories for about 110 French agricultural products. Special emphasis will be given on the treatment and the capture of the four main sources of variability for agricultural production systems: Variability due to differing natural production conditions, variability due to different production methods, variability due to different agricultural practices within a given production method and variability due to uncertainty of measurements. The guidelines are compiled in the Agri-BALYSE data collection guide which will be available end of summer 2011. Given the strategic importance of the Agri-BALYSE database, the data collection guide may become a national standard for LCA of agricultural products in France.

1 Introduction

1.1 The program Agri-BALYSE

The French Environment and Energy Management Agency (ADEME) is implementing a French law [1] aiming to introduce environmental labeling of consumer products by the end of 2012. The labeling scheme should be based on LCA principles together with multiple environmental criteria, i.e. not only carbon footprint.

ADEME has therefore initiated the program Agri-BALYSE to develop a public LCA-database of agricultural products in France (including a small panel of imported tropical products) by the end of 2012. Agri-BALYSE has two objectives:

- To help the agricultural practitioners and the food industry analyze and reduce the environmental impacts of their production chains;
- To supply LCA-data for the environmental labeling of food products.

The program is managed by a consortium consisting of three agricultural research institutes specialized in the environmental analysis of farming systems (INRA, ART and CIRAD) and ten technical institutes for applied agricultural research (ARVALIS, CETIOM, UNIP, IFV, ITB, CTIFL, ASTREDHOR, IFIP, ITAVI and Institut d'Elevage).

Agri-BALYSE has identified about 110 inventories (see table 1) covering the most frequently consumed agricultural products in France, on a national level (e.g. "Wheat, at farm gate, average France" or "ewe's milk, conventional, at farm gate, average France") and for important production systems (e.g. "Sunflower, irrigated, at farm gate, average France" or "Turkey, Label Rouge, at farm gate, Bretagne"). The data of 48 of these inventories will be used for the needs of the environmental labeling.

Tab.1: Overview over the inventories making part of database Agri-BALYSE

Category	Inventories	Number
Animal inventories: 43		
Beef	Beef: cow (6), calf (4), heifer (2)	12
Eggs	Eggs (4)	4
Fish	Seabream (1), trout (2)	3
Milk	Cow's milk (6), ewe's milk (1), goat's milk (1)	8
Other meat	Lamb (1), rabbit (1)	2
Pork	Pork (7)	7
Poultry	Chicken (3), duck (2), turkey (2)	7

Category	Inventories	Number
Plant inventories: 56		
Cereals, starch plants	Durum wheat (1), malting barley (1), potato (4), rice (3), soft wheat (4), starch potato (1), sweet corn (1)	15
Feeding stuff	Corn grain (1), corn silage (3), feeding barley (1), grass (4), lucerne (3), triticale (3)	15
Flowers, trees	Rose (1), tree nursery (1),	2
Fruits	Apple (3), cidre apple (1), peach (3)	7
Oil plant	Rape seed (3), sunflower (2)	5
Other plants	Fava bean (4), pea (3)	7
Sugarbeet	Sugerbeet (1)	1
Tropical plants	Coffee bean (1), small citrus fruits (1), thai rice (1)	3
Vegetables	Carrot (3), tomato (3)	6
Wine	Grape (1), red wine (1), rosé wine (1), sparkling wine (1), white wine (1)	5

2 Development of the data collection guide

2.1 Need of a common framework

Considering the diversity of the selected inventories as well as the number of organizations involved in the elaboration of the inventories, the development of a common framework for the data collection is an indispensable issue in order to ensure consistency over all products and comparability of the resulting LCA's. Based on the methodological framework of [2,3] and own experiences, the partner institutions of the program Agri-BALYSE have compiled the most important rules regarding functional unit, temporal and process related system boundaries, allocation, data quality and documentation as well as modeling principles in the "Agri-BALYSE data collection guide". As the guide is meant to help the practitioners, also structured recommendations were given regarding the handling of differences in data availability. The guide is in compliance with the international directives [4,5] and considers also the "general principles for an environmental communication on mass market products" published by the French Normalization Authority [6,7].

The stringent application of these common rules will be ensured by the mandatory use of the common IT-tool that was developed by ART and INRA on the basis of an existing data collection tool.

2.2 Main challenges

The implementation of a LCA database for agricultural products faces several specific challenges. One may distinguish two groups of main issues, namely: (a) methodological topics like the definition of an appropriate granulometry or the structuring of the unit processes and (b) scientific questions, mainly the choice of the appropriate methods for the estimation of direct environmental emissions and resource use (i.e. field emissions associated with the application of fertilizers etc.). The program Agri-BALYSE decided to address these issues separately and to focus first on the methodological challenges, as listed in table 2. The problem of the "granulometry" originates from the multitude of production methods for a given product, the large variability of agricultural practices within a given production method and the yearly changing natural production conditions.

Tab.2: Overview over the major methodological challenges

Challenge	Approach / method of solution
Varibility of the natural production conditions	Definition of the temporal reference period and collection of information on the distribution of the data
Avoiding artificial differences in the results due to different assumptions conerning the natural production conditions	Central definition and collection of the main parameters conerning the natural production conditions
Large diversity of products with special requirements (e.g. annual and perennial systems, tropical production systems)	Creation of ideotypes of data collection sheets for the main product groups; Recommendations for the structuring of the unit processes
Multitude of farming systems (i.e. conventional and organic farming)	Introduction of declinations, that is differentiation by sub-inventories
Diversity of agricultural practices	Provision of the different agricultural practices and their frequency of application
Distortion in the results due to including and excluding of inputs	Systematic rules on setting of the system boundaries
Multi-output system	Allocation rules for co-products and crop rotation systems
Different data availability according to product	Consequent data quality assessment of all data provided

3 Facing the variability of agricultural production systems

In agricultural production systems there are four main sources of variability, namely

- Variability due to differing natural production conditions
- Variability due to different farming systems
- Variability due to different agricultural practices within a given production method
- Variability due to uncertainty of measurements

3.1 Variability due to differing natural production conditions

As one of the objectives of the program Agri-BALYSE is the provision of LCA-data for the environmental labeling, comparability is a major concern. The natural production conditions influence the agricultural practices (e.g. dosage of PK-fertilizers due to different soil qualities) and the yields (e.g. its dependency on the altitude) on the one hand and the direct field emissions on the other hand (e.g. precipitation and its influence on leaching, soil erosion, etc). The following choices were judged appropriate to capture the variability of the natural production conditions (see 1 and 2) and to avoid artificial differences in the results (see 3):

1) Defining the temporal reference period: The collected data for all inputs should reflect the conditions of the last five years, that is 2005-2009. For perennial crops subjected to the phenomena of biennial bearing (i.e. alternance of yields of fruit crops as apple or plum) this period has to cover the last ten years (i.e. 2000-2009).
2) Collecting information on distribution: For each input data further information should to be provided in order to estimate the distribution. This information will be collected by indicating the minimum and maximum value of the reference period or - if judged more appropriate by the data collectors - by specifying the corresponding standard deviation.
3) Using identical data on crop-independent issues as weather information, soil quality etc. for all inventories: In order to avoid "artificial" differences due to differences in the underlying data on natural production conditions, all input data that is not directly dependent on the product will be collected centrally. The central collected data will be used later for the calculation of direct environmental emissions.

3.2 Multitude of farming systems

Agricultural products may be produced using different "production methods", covering the gradient intensive-extensive (fertilisation, mechanisation, irrigation etc.) as well as different farming systems ("conventional","organic", "red label"). In plant production, the main difference lies in the nature and the quantity of the applied inputs (e.g. chemical fertilizers and pesticides in conventional systems and organic fertilizers and biological pest control in organic systems); whereas for animal production systems additional differences exist with respect to the access of animals to the outdoors which is often required for organic production.
In order to reflect the manifold production systems existing in France, the program Agri-BALYSE differentiates between *products* as wheat or beef meat and *declinations of a product* (or "sub-inventories", e.g. wheat from conventional production and wheat from organic production). As a principle, each product should encompass at least two declinations. All data will be collected on the level of the declinations. The final aggregation to the LCA of the corresponding product will be performed by weighting the different declinations by their frequency of application (the weighting criteria being dependent on the product, like the cultivated surface for cereals or the shares of stocks for beaf meat).

3.3 Diversity of agricultural practices

The third important source of variability is the diversity of agricultural practices that farmers may carry out within a given production method. To treat a mildew attack one may use several fungicides or active substances just as well as one could till using a five-furrow reversible plough or a two-furrow single side plough, which both affects the working time and the power of the tractor. Moreover regional particularities may influence the practices applied (for example irrigation of corn in the more arid southern regions).
Considering the diversity of agricultural practices is important for Agri-BALYSE, because its inventories should reflect the reality of the agricultural production systems and not only the most frequently applied or the "best available technology". Of course, declination or building of sub-inventories could be a possible or viable approach to catch also this kind of variety. To avoid of the risk of an exploding number of inventories with probably often insignificant differences in the environmental impacts, the diversity of agricultural practices is captured "inside of an inventory" by providing the different practices applied as well as their quota / frequency.

3.4 Avoiding distortions due to including and excluding of inputs

In Agri-BALYSE, the minimal requirements regarding system boundaries and functional unit are defined as follows:

- *Process related system boundaries*: Considering that Agri-BALYSE has to provide LCA-data for environmental labelling, all inventories have to cover the stages from cradle to farm gate in order to be usable for the subsequent transforming stages such as food processing or transport and distribution to the points of sale. Downstream processes are therefore excluded.
- *Temporal system boundaries:* Plant production inventories consider primarily single product systems and not whole crop rotation systems. Nevertheless, important issues at the crop rotation level (as for example: effects on the soil organic matter content or basal dressing of K and P) are intended to be taken into account by applying corresponding allocation rules. The temporal system boundaries encompass the period starting after the end of the preceding crop and lasting until the end of the exploitation of the crop considered. This rule applies to all kind of crops, annual, perennial or short cycle crops.
  For animal productions systems the temporal system boundary is always set to one calendar year, due to the modeling approach by age classes. If the production cycle is inferior to one year (e.g. poultry), the data has to be provided for as many production cycles as may be produced in one year.
- As a principle, the *cut-off* criterion is set to zero, which means that inclusion or exclusion of input or output flows are not defined by quantity considerations, but by explicit enumeration of the processes (see table 3).

Tab.3: Included and excluded processes in Agri-BALYSE LCI

Animal systems	Plant systems
Included are (direct data collection)	
• Feedstuff, including water • Litter/straw • Breeding of the genitors or bought animals • Work processes (Milking, feeding, manure removal) including the production of the infrastructure (machines, buildings hangars), its maintenance and demolition • Water for the cleaning of the buildings • Different materials	• Production of seeds • Production of fertilizers • Production of pesticides, as well as the dilution water • Field work processes including the production of the infrastructure (machines, buildings, hangars), its maintenance and demolition • For tropical production systems: animal traction including their feeding • Irrigation • Journeys of seasonal workers • Different materials (fence posts, cords)
Included are (by calculation)	
• Emissions due to the activity of the animals (rumination, excretion)	• Direct field emissions due to fertilization, application of pesticides, irrigation etc.
Not included are:	
• Accommodation and alimentation of workersOther buildings that are not strictly used for agricultural purposes • Minor working tools (hay-forks, scissors, etc), working clothes and utilities such as ear protectors • Veterinary products and treatments • Artificial insemination of animals • Agents or insects for the biological pest control or for the pollinators	

3.5 Data quality

Uncertainty in the provided data is a common issue in all fields of LCA. Literature provides several approaches to handle uncertainty by defining measures of data quality [2,4,5]. In Agri-BALYSE data quality will be evaluated at two levels:

1) Overall data quality of the inventory or data set respectively according to the guidelines of the ILCD handbook (pp. 323-332 in [4]).
2) Data quality of an individual input data based on the quality-pedigree-matrix [8].

In order to harmonize the data quality assessment across all data collectors, the assignment of the data quality to a given input data will be based on the corresponding data source for which data quality has to be evaluated just once.
If multiple data sources are available for a given input data, the general rule "to choose the data with the best quality" has to be applied. The data availability is very heterogenic for the different products and often the data provided will rely on expert's advice. Agri-BALYSE has implemented minimal requirements for expert's advice in order to make them as transparent as possible, namely:

- Name of the experts,
- Dates of the meeting(s),
- List of the documents used as basis for the advice,
- Precise definition for which situation the advice applies,
- Estimation of the data quality by assessing the values "good", "with a great variance" and "very uncertain".

4 Conclusions and outlook

As the details above show, Agri-BALYSE has implemented well-designed measures to capture the different sources of variability in the input data for agricultural LCIs. The data collection guide provides more guidance in order to enable a harmonized data collection (e.g. definition of the functional unit, basic allocation rules, instructions regarding the modeling of the inventories for perennial products). Starting with April 2011, the partner institutions of Agri-BALYSE will apply the guide and collect the data for the first set of inventories. By the end of July 2011, after a critical review of the practicability and feasibility of the instructions in the guide, the Agri-BALYSE data collection guide will be available for the public (in French only).
Simultaneously, the second part of methodological guidelines has to be worked out: Starting with May 2011, Agri-BALYSE will address the scientific questions, namely the choice of the appropriate calculation models as well as the fixation of the allocation rules for crop rotation systems, and summarise the choices taken in a comprehensive methodological report.

5 References

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