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AGRIBALYSE®, the French LCI Database for agricultural products: high quality data for producers and environmental labelling★

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Abstract – AGRIBALYSE is a French research program dedicated to producing Life cycle inventories (LCI) of agricultural products, based on a strong partnership of 14 research and technical institutes. It provides a homogenous and consensual LCI database to support environmental labelling policies and to help the agricultural sector to improve its practices. The public LCI database of more than 100 products and its detailed methodology report were published in 2014. The database mainly contains LCIs for average French products, the functional unit is the product mass (kg) and the perimeter cradle-to–farm-gate. The datasets go along with a detailed methodology report and a project report, both available at: www.ademe.fr/agribalyse). Several key objectives for a follow-up project have already been identified: better estimate of uncertainties, accounting for soil carbon dynamics, impacts on biodiversity and impacts of water consumption. Enlargement of the database with additional products and products from innovative systems is also demanded, as well as stronger connections with international programs. These issues should be addressed in a future AGRIBALYSE 2 program.

Keywords: LCI database / French agricultural products / ecolabelling / ecodesign

Résumé – AGRIBALYSE®, base de données ICV (Inventaire de Cycle de Vie) pour les produits agricoles : des données de haute qualité pour les producteurs et l'affichage environnemental. AGRIBALYSE est un programme scientifique français dédié à la réalisation d'Inventaire de cycle de vie (ICV) pour les produits agricoles français, reposant sur un étroit partenariat entre 14 instituts techniques et de recherche. Il fournit une base de données d'ICV homogène et consensuelle, contribuant à renseigner l'affichage environnemental et aidant le secteur agricole à améliorer ses pratiques. Cette base publique de données d'ICV de plus de 100 produits et un rapport méthodologique détaillé ont été publiés en 2014. Cette base de données contient les ICV de produits moyens français, l'unité fonctionnelle est la masse (kg) et le périmètre « du berceau à la sortie de la ferme ». Les fichiers de données s'accompagnent d'un rapport méthodologique et d'un rapport de projet, l'ensemble est disponible en ligne sur www.ademe.fr/agribalyse. Plusieurs objectifs clés pour le suivi du projet ont déjà été identifiés : meilleure estimation des incertitudes, prise en compte du carbone organique du sol, impacts sur la biodiversité et sur la consommation d'eau. L'élargissement de la base de données avec l'ajout de produits additionnels et de produits issus de systèmes novateurs est aussi demandé, de même que des connections fortes avec les programmes internationaux. Ces points devraient trouver réponse dans le futur programme AGRIBALYSE 2.

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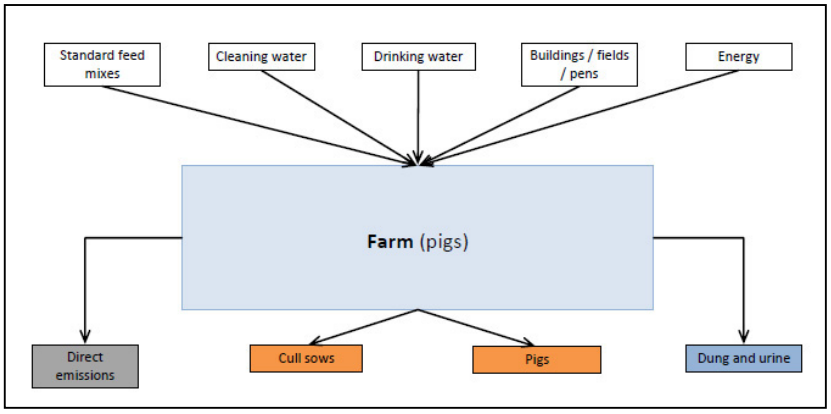

Fig. 1. Example of system boundaries for pig production.

1 Introduction

AGRIBALYSE is a French research program (2010–2013) dedicated to producing public Life Cycle Inventories (LCI) of agricultural products. A database of more than 100 products and its detailed methodological report have been published in 2014 (Koch and Salou, 2014).

AGRIBALYSE started in 2010, in response to the "Grenelle de l'Environnement" roundtables which decided on the use of Life cycle assessment (LCA) to support environmental labelling. The LCA approach was also seen as a tool to support farmers and their organisations to better identify the environmental impacts of their products and to support ecodesign strategies to improve their production systems. At the same time, a lack of LCA results and especially homogenous ones was identified concerning French agricultural productions (Ecointesys, 2008). Thus, AGRIBALYSE was launched by the French Environment and Energy Management Agency (ADEME). A strong partnership of 14 research and technical institutes (INRA, Agroscope, CIRAD, ACTA and 10 agricultural technical institutes) worked together to build a homogenous and consensual LCI database for French, as well as a few imported agricultural products.

This article describes the main methodological choices and the general content of the database. Other articles and conference proceedings describe more specific choices and results for each product sector (animal products/crops/fruits) (Basset-Mens, *et al.*, 2014; Gac, *et al.*, Salou, *et al.*, Tailleur, *et al.*, 2014; Willmann, *et al.*, 2014). The potential use and limits of the database will be discussed in the last paragraphs.

2 Methods: modelling framework and main methodological choices

For complete and detailed information on methodological choices, please refer to the AGRIBALYSE methodological report (Koch and Salou, 2014).

2.1 General modelling framework and tools

In AGRIBALYSE, data describing agricultural practices have been provided by the technical institutes in an Excel file (called data collection tool), developed for the occasion. The data collection tool was then connected to models to calculate direct (on farm) emissions and resource use via another Excel file (called calculation chain). Indirect fluxes were then added in SimaPro, to obtain LCI and LCIA data. The characterization methods used were chosen based on the recommendation by the ILCD Handbook, the Envifood program and the ADEME-AFNOR platform (AFNOR, 2011; JRC and IES, 2011; ENVIFOOD, 2012; GT1, 2012).

2.2 System boundaries (space and time)

The perimeter considered in AGRIBALYSE LCIs is from cradle-to field-gate for crops and from cradle-to-farm-gate for animal productions. It implies that for crop production all the up-stream processes (production of inputs, field operations, etc.) are included, but none of post-harvest operations, although they might happen on the farm (storage of potatoes, drying of cereals). All operations required for the animal production phase are included (feed production, transport and storage, fattening of animals, milking, construction and maintenance of buildings and machines).

For managing manure, the distinction between animal and plant production was defined according to Gac *et al.* (2010). Emissions from storage of manure and any forms of treatment (nitrogen reduction, composting or anaerobic digestion) were allocated to the livestock production system and the emissions associated with loading, transport and spreading were allocated to the plant production system which used the manure.

To be consistent, system boundaries have been described following 9 schemes (3 for plants, 6 for animals) (Fig. 1), to cover all agricultural productions.

The reference period for LCIs was 2005 to 2009, except for perennial crops for which it was 2000–2010 to account for the production phases (seedlings, early production, full production, etc.) and alternating yield phenomenon.

2.3 System description, data sources and representativeness

Initially, AGRIBALYSE aimed to provide a representative LCI for every major French agricultural product.

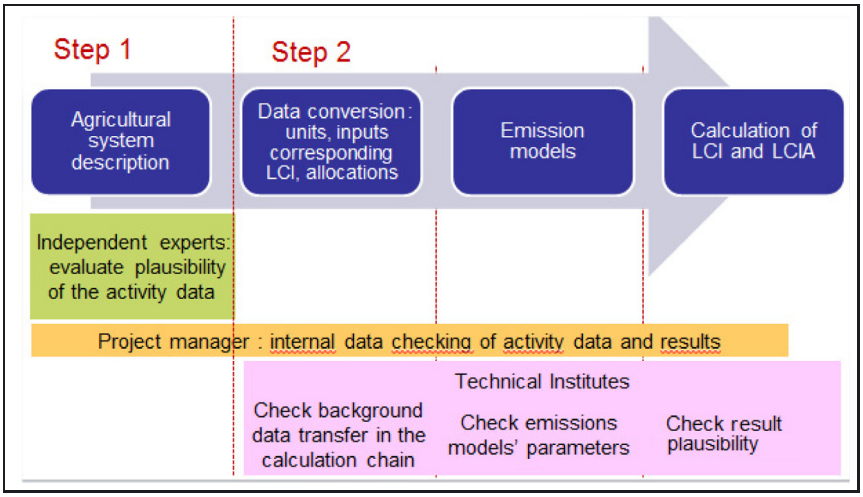

Fig. 2. Quality control scheme.

The description of production systems by the technical institutes was based on (in order of preference): statistical sources, typical cases (documented in as much detail as possible), expert opinion or individual case/estimate as the last option. The quality of the description of the production systems was a key step for the quality of the database. For many products it was not realistic to identify a single production system to represent the French average. Therefore, several production systems for the same product (variations) were often described. *E.g.* for potatoes, the following LCIs were calculated: industrial use, fresh market firm flesh, fresh market other varieties, starch potato and a national average. The national average is a weighted average based on the share of each system in the national production. For production systems that count a large number of variations, the weighted average may not be representative of the national production (*e.g.* the five dairy systems LCIs represent 21.1% of the national production of milk). For some products an average product was not meaningful (*e.g.* grapes) because each product is specific of a production system or an area of production (Beaujolais, Maconnais, etc.) and no national average could be provided. It is very important to be aware of the representativeness of each LCI when using the database.

2.4 Allocation

Allocation rules follow the international recommendations (ISO, 2006a, 2006b). The allocation method must always be meaningful for all co-products implicated. For crop production, most of the co-products are generated in the processing step, which is not included in the AGRIBALYSE program. No allocation between different product qualities was applied at field-gate (*e.g.* export quality versus local market quality for imported fruits). For crops, an important work has been implemented to allocate organic N fertilizer and P and K mineral fertilizers within cropping sequences (Koch and Salou, 2014, Annexe D). For animal production, a so-called bio-physical allocation method was implemented, based on Dollé and Gac (2012) for milk. At first, allocation was avoided by decomposing the system in animal classes based on their production phase. Then, for the animal classes where allocation was required (ex: dairy cow in production phase), allocation was based on the metabolic energy required to produce each co-product (calf, milk). The impacts of the animal classes producing a single product were fully allocated to this product. For data imported from pre-existing databases (*e.g.* ecoinvent v2, INRA Rennes internal database), such as for animal feed components, the allocation choice made in the pre-existing database (mostly economic allocation) was not modified.

2.5 Models for the calculation of the direct emissions

AGRIBALYSE identified the most appropriate calculation methods for all direct emissions and resource consumptions, while pre-existing datasets (mainly ecoinvent v2) were used for calculating indirect emissions (up-stream ex: inputs production, material, etc.).

Finding appropriate models to estimate direct emissions for each pollutant substance was one of the main challenges. According to the AGRIBALYSE set of rules, such models should not require input data that are too difficult to collect, should have been published, should have been validated for France (or tropical conditions for the tropical crops) and should be recognized internationally. The priority was given to inter-product consistency, with the idea of having specific models for each emission mechanism used across the entire database rather than having specific models for each product or type of product. The list of models used is available in the methodological report (Koch and Salou, 2014).

2.6 Quality control

The quality control was performed in two steps: control of agricultural system data and control of LCI data (Fig. 2). Quality control of agricultural system descriptions was performed by independent experts. LCI results were controlled by experts of the technical institutes involved in the program,

Table 1. List of AGRIBALYSE product groups and number of variants per product group.

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

both at the level of the calculation tools and regarding the plausibility of the results. More than 160 system description sets were checked with unqualified acceptance in 30% of cases, minor revisions in 50% of cases and major revisions in 20% of cases. More than 500 suggestions for improvement or comments on technical data and sources were taken into account to meet the recommendations of the experts. The quality control of the LCI results allowed the correction of calculation errors, the detection of anomalies, it ensured coherence and improved the credibility of the results. Performing a quality control on both the system description data and the LCI data sets significantly contributed to the quality of the AGRIBALYSE database.

3 Results

The outcomes of AGRIBALYSE are a public LCI database, a methodological report (Koch and Salou, 2014) and a final report describing the project organization and main lessons learnt (Colomb *et al.*, 2014). The database is available in several formats with various levels of detail depending on the user's requirements:

- Factsheets: a simplified version in PDF format presenting most common and most robust impact indicators. The factsheets are freely available and do not require an LCA software.
- The AGRIBALYSE_vIMPACTS database (system processes, and Ecospold_V1 formats): containing aggregated LCI data sets considered by the AGRIBALYSE consortium to be sufficiently reliable to be used for a product environmental labelling approach (robustness, representativeness). An LCA software is required to analyse these data.
- The AGRIBALYSE_vcomplete database (unit processes, Ecospold_V1 format). These data are intended primarily for ecodesign projects and provide the results in a transparent format. An LCA software is required to analyse these data.

Ecospold formats are suitable for LCA specialists as the data can be used in current LCA software.

The reports and summary factsheets are available on line (www.ademe.fr/agribalyse), while the full database is available on demand to ADEME. Finally, a short document "Advices for proper use of AGRIBALYSE results" (AGRIBALYSE, 2014) highlights the critical points when using and interpreting the data. The publication of data and the efforts made to ensure transparency, with several formats to respond to different needs has been an important time investment, but should contribute to a large and appropriate use of the datasets.

The products included in the database are 28 crop and 18 animal products (Tab. 1). For several products a number of variants exist.

4 Discussion and perspectives

4.1 Improvement needs and perspectives

AGRIBALYSE proposes a comprehensive database and a detailed and coherent methodological framework.

For further work several methodological improvements have been identified. The main issues to be resolved are the modelling of changes in soil and biomass carbon stocks (due to farmer practices and land use change), of the impact on biodiversity, and the impact of water consumption.

The methods and models for calculating emissions (nitrate, phosphorus, trace metals, etc.) may also be modified to take better account of the specific characteristics of crops, agricultural and animal production practices and soil-climate characteristics. For France, IPCC tiers 2 models for GHG emissions should be ready soon and could significantly modify the results. It will be therefore important to update the database and use the best models available.

The LCI database could also be enlarged, by including new products (ex: fishery products, other vegetables, more imported products, etc.) and new product variations (regional products, Protected Geographical Indication products, quality label products, etc.) could be included to strengthen the representativeness of the database. For a proper comparison of products, it would be necessary to better quantify the uncertainty of the LCI data. The quality of the data was assessed using the ecoinvent pedigree matrix and ILCD criteria. Data for tropical products and for less studied production systems (with less data available, like organic systems) hold the largest uncertainty.

The future AGRIBALYSE database will probably allow the inclusion of LCI data proposed by third parties. This would mean that a procedure should be established to examine whether the proposed LCI data have been produced in accordance with the AGRIBALYSE methodology and quality assurance standards. This will be a complex task that will have to be tackled. Finally, the database being based on ecoinvent v2 datasets, the relevance of updating to ecoinvent v3 should be assessed.

4.2 Contribution to environmental labelling and eco-conception

The LCI data needed for the implementation of environmental labelling will depend on the labelling scheme. The companies will need reliable background data (such as AGRIBALYSE) and tools to implement ecolabelling schemes.

By the end of 2013, a French parliamentary report on environmental footprinting highlighted the interest of consumers for environmental labelling of food products; it also identified several specific methodological issues for the food sector (Errante and Saddier, 2013). It advocates that, in France, environmental labelling should become a voluntary but regulated process in the future. The volunteer companies should apply a common methodology and communication framework, which would be defined by public institutes and would limit the risk of green-washing or incomplete analysis. No clear time frame for this development was given, but the will to implement environmental labelling was reaffirmed. The European Union is also currently carrying out an experimentation on the Product environmental footprint (PEF) to determine the appropriateness and feasibility of implementing environmental labelling at the European scale. AGRIBALYSE data could be used for this experiment.

Thus the AGRIBALYSE LCI database is a key element for the environmental labelling of food products. It is however not sufficient as it does not include processing, marketing and end of life stages. The processing steps for food products are currently analysed in ACYVIA, another French LCI database program, that should provide results by the end of 2016. Both data from AGRIBALYSE and ACYVIA will feed ADEME "IMPACTS" LCI database, which should be the official multisectorial database supporting the French ecolabelling schemes.

AGRIBALYSE helps to guide the farming sector towards more ecoefficient agricultural systems. By providing a comprehensive method for future LCA studies of agricultural products, it will allow more comparable results and clearer conclusions. By November 2014, the database had been downloaded by 97 institutions (200 individual licences provided), research and technical institutes, agro-food companies, consultancies working on ecodesign. The data have also been integrated in some LCA computer tools. The database is used for instance in French Ecoalim research project which tries to identify animal feeding strategies with lower environmental impact. Data have also been used for policy studies, for instance in a study for the Swiss government comparing the impacts of Swiss and imported products, in order to define an appropriate agricultural and environmental strategy. Last but not least, the LCI data can be used to explore the impacts of human diets.

4.3 AGRIBALYSE II

ADEME has decided to launch a follow up program for AGRIBALYSE. The general goals, providing data for environmental labelling and supporting ecodesign are still considered to be very relevant and will be conserved. The main goals for this program will be to (a) help users to produce LCI data following the AGRIBALYSE methodology, (b) update and maintain the data, (c) augment the database with LCIs of new key products, (d) promote and include methodological improvements from the LCA field.

Thus, AGRIBALYSE II should be a platform coordinating several thematic projects on dataset production and methodology improvements that would feed the database. The platform should be strongly connected to other European and international database projects.

5 Conclusion

The AGRIBALYSE partnership produced a consensual and homogenous LCI database for French agricultural products. By its ambition and innovativeness it also consisted in a major learning process for the partners involved. Nevertheless it must be stressed that the amount of work and skills required for such program has been considerable.

The database is now used by many French and international organisations: research and technical institutes, agro-food companies, consultancies, etc. These data are publicly available and can be used in many projects dealing with sustainable production system, eco-labelling, diet studies, agricultural policy strategies, etc. For the future, several methodological issues remain to be implemented in the AGRIBALYSE methodology (dynamics of soil carbon stocks, water consumption, impacts on biodiversity) and the characterisation of uncertainty should be improved. Really understanding LCIA results requires understanding of the impact assessment methods including complex scientific models, thus efforts on communication means should be continued.

To conclude, we can say that AGRIBALYSE has been an excellent pilot program that now needs to be connected and enriched with other initiatives.

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