Creating coherent life cycle databases for ecodesign and product declaration of agroindustrial products: how to deal with contradictory methodological requirements

Jens Lansche *, Patrik Mouron, Thomas Nemecek, Gérard Gaillard

Life Cycle Assessment Group, Institute for Sustainability Sciences, Agroscope, Zurich, Switzerland
* Corresponding author. E-mail: *jens.lansche@agroscope.admin.ch*

ABSTRACT

Existing guidelines and standards for creating LCI databases provide partly contradictory requirements which lead to initiatives that aim on harmonization. As the harmonization is still ongoing, this challenges current database projects to find a scientifically sound and applicable way to establish coherent datasets. We present a four-step approach to deal with this challenge. Based on our experiences in the two ongoing projects ACYVIA (Analyse de CYcle de Vie dans les Industries Agro-alimentaires) and WFLDB (World Food LCA Database) we draw the following conclusions: it has been shown that by following the proposed approach, most contradictory advices from different guidelines do not appear because the number of relevant guidelines can be reduced. Creating a database that allows different methodological decisions can be achieved by clearly defining and reporting all methodological decisions that are followed. For existing contradictory requirements, decision criteria are presented that can be taken into consideration to decide for one specific requirement.

Keywords: LCI database, agri-food sector, methodological guidelines, harmonization

1. Introduction

Agricultural production systems and the processing of agricultural raw materials to food products contribute significantly to several environmental impacts like global warming, eutrophication and acidification (Pardo and Zufia 2012; Ruviaro et al. 2012; Saarinen et al. 2012). Emissions from agricultural production systems show a high temporal and spatial variability which is a reason for a high variability of environmental impacts of these systems (Mouron et al. 2006; Roy et al. 2009; Nemecek et al. 2012; Rees et al. 2013). These facts together with an increasing public interest enforce the demand for LCI data in the agri-food sector in companies, science and governments in the last years. Various guidelines exist (see Table **1**) with partly contradictory requirements which causes confusion (Finkbeiner 2014). A recent review of such reference methods conclude that flexibility with respect to methodological standards is more common than prescriptive requirements are (Pelletier et al. 2014) In this context, several initiatives and projects deal with the creation on LCI databases that are either focused on the agri-food sector or cross-sectorial including agri-food related content, e.g. ACYVIA (Bosque et al. 2012), Agri-BALYSE® (Koch and Salou 2013), Asian Agri-Food database (Hayashi 2013), Australian LCI Database initiative (ALCAS 2014), Base IMPACTS® (ADEME 2014), Chilean Food and Agriculture LCA database (Emhart et al. 2013), ecoinvent (Weidema et al. 2013), ELCD (JRC 2014), World Food LCA database (Lansche et al. 2013).

This paper wants to start a discussion on the question how one can deal with the situation of existing guidelines and standards with contradictory requirements when creating an LCI database. The focus is on LCI modelling and the ideas presented are not final solutions but aim on being a starting point for further discussions. Basically, three steps are presented:

1) Categorizing the database to select the appropriate standard, guideline or tool for the purpose of the database to avoid contradictions
2) Showing an example for dealing with the requirement that a database should be applicable for different purposes
3) Developing basic principles on how to deal with remaining contradictions

Table 1. Non exhaustive list of existing guidelines and standards.

Short Title	Full title of the guideline or standard	Reference
BPX 30-323-0	Environmental communication on mass market products — Part 0: General principles and methodological framework	Afnor (2011)
PAS 2050:2011	The Guide to PAS 2050:2011: How to carbon footprint your products, identify hotspots and reduce emissions in your supply chain	BSI (2011)
PEF Guide	Product Environmental Footprint (PEF) Guide, Annex II to the Recommendations of the Commission of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organizations	EC (2013)
Envifood protocol	Environmental Assessment of Food and Drink Protocol	Envifood (2013)
MTT Guidelines	Guidelines for the assessment of the life cycle greenhouse gas emissions of food	Hartikainen et al (2012)
IDF Guide	A common carbon footprint approach for dairy – The IDF guide to standard lifecycle assessment methodology for the dairy sector	IDF (2010)
IPCC Guidelines	Guidelines fo National Greenhouse Gas Inventories -Agriculture, Forestry and other Land Use.	IPCC (2006)
ISO 14025:2006	Environmental labels and declarations - Type III environmental declarations - Principles and procedures	ISO (2006a)
ISO 14040:2006	Environmental management - Life cycle assessment - Principles and framework	ISO (2006b)
ISO 14044:2006	Environmental management - Life cycle assessment – Requirements and guidelines	ISO (2006c)
ISO 14067:2013	Carbon footprint of products—requirements and guidelines for quantification and communication.	ISO (2013)
ILCD Handbook	International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance	JRC (2010)
Shonan Guidance Principles	Global Guidance Principles for Life Cycle Assessment Databases , A basis for greener processes and products	UNEP/SETAC (2011)
Ecoinvent data quality guidelines	Overview and methodology. Data quality guideline for the ecoinvent database version 3	Weidema et al (2013)

2. Methods

The following methodological procedure is a proposition on how a coherent database could be created given the various guidelines and methodological recommendations as illustrated in Table **1** above. We suggest a procedure with the following main steps:

- Step 1: Categorizing the database as "general database" or "specific database". For categorizing a database we propose to use specifications for the geography, application, and sector that are addressed given in Table **2**.
- Step 2: Identify the most relevant guidelines (from Table **1**) related to the database.
- Step 3: Identify the methodological options that are crucial for the database. Options for LCI occur e.g. for system boundary choice, direct emission modeling, allocation methods, end-of-life modeling, data source choices and the kind of dataset documentation.
- Step 4: Decide which options to use in order to meet the criteria according to Table **2**.

This four-step procedure is applied to two ongoing database projects that are:

- WFLDB (World Food LCA Database): This project is developing datasets for selected agricultural primary products as well as food and beverage products produced in the most relevant countries that supply the global market.
- ACYVIA (Analyse de CYcle de Vie dans les Industries Agro-alimentaires): This project addresses environmental product declaration of food transformation processes at national-level in France.

Table 2. Categorizing food databases

Criteria	General database	Specific database
Geographical specification	Global, multi-national	National, regional
Application addressed	Ecodesign and Environmental product declaration (EPD)	Ecodesign or Environmental product declaration (EPD)
Sectorial specification	Agriculture and food industry	Agriculture or food industry

3. Results

Categorizing databases

The two database projects WFLDB and ACYVIA can be clearly categorized with as "General database" and "Specific database", respectively (Table **3**). Table 2 shows also that the two project differ very much in the order of guidelines that are most relevant for each project. For ACYVIA the BPX guidelines are of the highest importance defining methods for LCI modelling, system boundaries, allocation, end-of-live modelling whereas the ILCD entry-level is of importance regarding the method for data quality assessment and the selection of external reviewers. As a consequence, in case of the ACYVIA database practically no methodological options are left since BPX defines them all for EPD in France. In contrast, for WFLDB due to the wide range of geographical, sectorial applications a number of methodological decisions according to ISO 14044/ 44 have to be taken. In practice this means that for each methodological issue one option has to be chosen. Such choices need to be described in the documentation of the database. But whatever option is chosen, it might be that for a certain database user and for certain applications this methodological option is not the one that suits well. Therefore we model a methodological option in a reversible way, that means, the user will have the opportunity to calculate backwards and to apply another methodological option that fits to the desired application. This is e.g. the case when economic allocation is applied.

In the following we will illustrate for the case of modelling "heavy metal uptake by crops" what is meant by reverse modelling:

Table 3. Categorizing WFLDB and ACYVIA database and associated relevant guidelines

	WFLDB **General database**	**ACYVIA** **Specific database**
Geographical specification	Global	National
Application addressed	Ecodesign and EPD	EPD
Sectorial specification	Agriculture and food industry	Food industry
Guidelines (order of importance)	1. ISO 14040/ 44 2. ILCD handbook 3. ENVIFOOD 4. Others	1. BPX 30-323-0 2. ILCD entry-level 3. ISO 14040/ 44 4. Others

Reverse modelling of heavy metal uptake by crops

In crop production heavy metals (e.g. Cadmium) will be imported to the field by inputs such as mineral fertilizers. On the field the plant is taking up nutrients but also heavy metals that will be exported from the field with the harvested crop. In case the whole life cycle (i.e. from cradle to grave) is assessed the amount of heavy metal exported by the crop is of interest since this might cause toxicological problems at another place (e.g. waste water treatment after consumption and digestion). But if the LCA addresses only the crop production on the field (i.e. cradle to gate) the uptake of heavy metal could lead to unrealistic "credits" and therefore want to be excluded from the assessment. We suggest to model heavy metal in that way that the uptake to the plant can be set to zero, if needed.

4. Discussion

We proposed a first approach how one can deal with the situation of guidelines and standards with contradictory requirements when creating an LCI database. The three criteria (geography, application, economic sector) for categorizing databases have been sufficient for the two projects WFLDB and ACYVIA but its sufficiency and applicability need to be proved in practice with other databases.

If contradictions remain, we propose to develop a hierarchy of basic principles that support to make appropriate methodological decisions in respect to LCI modelling. Such criteria can be:

- scientific nature of the requirement
- internal consistency of the database
- acceptance by stakeholders

The ideas presented have to be further developed and tested more comprehensively in practice.

5. Conclusion

By categorizing databases, relevant guidelines can be selected. This helps to identify the relevant methodological options. By following this approach, most contradictory advices from different guidelines do not appear because the number of relevant guidelines can be reduced for each individual database.

6. References

ADEME (2014). "Base IMPACTS ® - Base d'indicateurs d'impacts ACV pour l'affichage environmental des produits de grande consommation." Retrieved 30.04.2014, 2014, from http://www.base-impacts.ademe.fr/.

Afnor (2011). Environmental communication on mass market products — Part 0: General principles and meth-od-ological framework (BPX 30-323-0). La Plaine Saint-Denis Cedex, France, Association Française de Normalisation. BPX 30-323-0.

ALCAS (2014). "AusLCI The Australian National Life Cycle Inventory Database ". Retrieved 30.04.2014, 2014, from http://alcas.asn.au/AusLCI/index.php/Home.

Bosque, F., O. Réthoré, S. Kerner, H. Bortoli, L. Peano, S. Humbert, G. Gaillard and J. Lansche (2012). ACYVIA: creation of a public LCI/LCIA database of the French food industry. 8th International Conference on Life Cycle Assessment in the Agri-Food Sector, Saint-Malo, France, INRA.

BSI (2011). The Guide to PAS 2050:2011: How to carbon footprint your products, identify hotspots and reduce emissions in your supply chain. London, British Standards Institution.

EC (2013). Product Environmental Footprint (PEF) Guide, Annex II to the Recommendations of the Commission of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organizations, COM (2013) 179. Luxembourg, Official Journal of the European Union, Legislation (L 124), Volume 56, Publications Office of the European Union.

Emhart, C., A. Florenzano, C. Loyola and J. Bengtsson (2013). Chilean Food and Agriculture LCA Database using UNEP/SETAC Shonan Guidance Principles. The 6th International Conference on Life Cycle Management (LCM 2013), Gothenburg.

Envifood (2013). Environmental Assessment of Food and Drink Protocol, Version 1.0. E. F. S. C. P. R. Table.

Finkbeiner, M. (2014). "Product environmental footprint—breakthrough or breakdown for policy implementation of life cycle assessment?" The International Journal of Life Cycle Assessment 19(2): 266-271.

Hartikainen, H. K., Juha-Matti; Pulkkinen, Hannele; Saarinen, Merja; Silvenius, Frans; Usva, Kirsi (2012). Guidelines for the assessment of the life cycle greenhouse gas emissions of food. Helsinki, Finland, MTT Agrifood Research Finland, Responsible food chain – better consumer wellbeing.

Hayashi, K. (2013). LCA Agri-food Asia Initiative. P. Mouron. Zurich, Switzerland, Hayashi, Kiyotada.

IDF (2010). A common carbon footprint approach for dairy – The IDF guide to standard lifecycle assessment methodology for the dairy sector. Brussels, International Dairy Federation (I.N.P.A).

IPCC (2006). Guidelines fo National Greenhouse Gas Inventories -Agriculture, Forestry and other Land Use. IGES, Japan, Institute for Global Environmental Strategies (IGES), Hayama, Japan on behalf of the IPCC.

ISO (2006a). Environmental labels and declarations - Type III environmental declarations - Principles and procedures. Geneva, Switzerland. ISO 14025:2006.

ISO (2006b). Environmental management - Life cycle assessment - Principles and framework. Geneva, Switzerland, International Organization for Standardization. ISO 14040:2006.

ISO (2006c). Environmental management - Life cycle assessment – Requirements and guidelines. Geneva, Switzerland, International Organization for Standardization (ISO). ISO 14044:2006.

ISO (2013). Carbon footprint of products—requirements and guidelines for quantification and communication. Geneva, Switzerland, International Organization for Standardization (ISO). ISO 14067:2013.

JRC (2010). International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. Luxembourg.

JRC (2014). "ELCD - European reference Life Cycle Database." Retrieved 30.04. 2014, 2014, from http://eplca.jrc.ec.europa.eu/ELCD3/index.xhtml.

Koch, P. and T. Salou (2013). AGRIBALYSE®: Rapport Méthodologique – Version 1.0. E. ADEME. Angers, France, ADEME.

Lansche, J., G. Gaillard, T. Nemecek, P. Mouron, L. Peano, X. Bengoa, S. Humbert and Y. Loerincik (2013). The World Food LCA Database project: towards more accurate food datasets. The 6th International Conference on Life Cycle Management (LCM 2013), Gothenburg.

Mouron, P., T. Nemecek, R. W. Scholz and O. Weber (2006). "Management influence on environmental impacts in an apple production system on Swiss fruit farms: Combining life cycle assessment with statistical risk assessment." Agriculture, Ecosystems & Environment 114(2–4): 311-322.

Nemecek, T., K. Weiler, K. Plassmann, J. Schnetzer, G. Gaillard, D. Jefferies, T. Garcia-Suarez, H. King and L. Mila i Canals (2012). "Estimation of the variability in global warming potential of worldwide crop production using a modular extrapolation approach." Journal of Cleaner Production 31: 106-117.

Pardo, G. and J. Zufia (2012). "Life cycle assessment of food-preservation technologies." Journal of Cleaner Production 28: 198-207.

Pelletier, N., K. Allacker, R. Pant and S. Manfredi (2014). "The European Commission Organisation Environmental Footprint method: comparison with other methods, and rationales for key requirements." The International Journal of Life Cycle Assessment 19(2): 387-404.

Rees, R. M., J. Augustin, G. Alberti, B. C. Ball, P. Boeckx, A. Cantarel, S. Castaldi, N. Chirinda, B. Chojnicki, M. Giebels, H. Gordon, B. Grosz, L. Horvath, R. Juszczak, Å. Kasimir Klemedtsson, L. Klemedtsson, S. Medinets, A. Machon, F. Mapanda, J. Nyamangara, J. E. Olesen, D. S. Reay, L. Sanchez, A. Sanz Cobena, K. A. Smith, A. Sowerby, M. Sommer, J. F. Soussana, M. Stenberg, C. F. E. Topp, O. van Cleemput, A. Vallejo, C. A. Watson and M. Wuta (2013). "Nitrous oxide emissions from European agriculture – an analysis of variability and drivers of emissions from field experiments." Biogeosciences 10(4): 2671-2682.

Roy, P., D. Nei, T. Orikasa, Q. Xu, H. Okadome, N. Nakamura and T. Shiina (2009). "A review of life cycle assessment (LCA) on some food products." Journal of Food Engineering 90(1): 1-10.

Ruviaro, C. F., M. Gianezini, F. S. Brandao, C. A. Winck and H. Dewes (2012). "Life cycle assessment in Brazilian agriculture facing worldwide trends." Journal of Cleaner Production 28: 9-24.

Saarinen, M., S. Kurppa, Y. Virtanen, K. Usva, J. Makela and A. Nissinen (2012). "Life cycle assessment approach to the impact of home-made, ready-to-eat and school lunches on climate and eutrophication." Journal of Cleaner Production 28: 177-186.

UNEP/SETAC (2011). Global Guidance Principles for Life Cycle Assessment Databases , A basis for greener processes and products, ‘Shonan Guidance Principles’. Paris, France, UNEP/SETAC Life Cycle Initiative.

Weidema, B., C. Bauer, R. Hischier, C. Mutel, T. Nemecek, J. Reinhard, C. Vadenbo and G. Wernet (2013). Overview and methodology. Data quality guideline for the ecoinvent database version 3. St. Gallen, Swiss Centre for Life Cycle Inventories.