80. LCI of food products sectors: from field data collection to the big picture

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ABSTRACT

This article deals with the construction of an LCI at the scale of agri-food sectors. It develops the methodology used to model the inventory. The methodology has been applied to two French agri-food sectors: the PDO Beaujolais and Burgundia wine sector and the PGI South West duck foie gras sector. The result of this study will allow sectors stakeholders to get an accurate snapshot of the sector's organization by the analysis of the agri-food sector inventory.

Keywords: inventory model, inventory scaling up, sector's environmental assessment, Beaujolais and Burgundia wine sector, foie gras from the French South-West area sector

1. Introduction

The ACYDU project, co-funded by the French National Research Agency (ANR), investigates the environmental, social, economic and territorial impacts of agri-food sectors. Three sectors have been investigated, in relation with emblematic French products under official quality labels: the foie gras from the South-West area (Protected Geographical Indication) sector, the Beaujolais and Burgundia wine (Protected Designation of Origin) sector and the Comté cheese (Protected Designation of Origin) sector. Various methodologies, either qualitative or quantitative, were applied to address the four types of impacts under study. Environmental impacts were assessed through attributional LCA. The specificity of the use of LCA in this specific context is the look at the agri-food sectors with a broad perspective, i.e. encompassing all steps linked with the products themselves (from agricultural stages to final consumption) but also complementary activities that belong to the sector (research, promotion, etc.). The ACYDU project outcomes are mainly directed at agri-food sectors decision makers in order to help them to identify strategic areas for improvement.
The specific objectives of this research project require to propose methodological adjustments to the product LCA and Organizational Life Cycle Assessment guidelines. Previous methodologies dealing with combining macro-economic sectors data (Input-Output transactions tables tracking purchase flows between sectors) and LCA methodologies have been developed (Lave et al., 1995; Hendrickson et al., 2005). More recently, Schmidt et al. (2007) used the multi-regional environmentally extended supply and use / Input-Output database Exiobase2 to assess the environmental impact of the global food consumption. These approaches referred, as Economic Input-Output LCA (EIO-LCA) or hybrid LCA, rely on aggregate sector-level average data that may not be representative of a specific product system. Commodity sectors in national input-output tables used in EIO-LCA are broad aggregates that cover a large number of products and do not take into account technological product specificities. As these methods did not fit the study's objectives, an ad hoc methodological approach, presented in this paper, has been developed. Challenges related to data availability and representativeness have had to be faced. Practical application is shown based on the work that has been carried out for 2 out of the 3 case studies: the PDO Beaujolais and Burgundia wine sector and the PGI South West duck foie gras sector. A critical review of this study being under process, this present paper does not show the impact assessment for the agri-food sector under study.

2. Methods

A distinctive feature of this study is the use of agri-food sectors boundaries as boundaries of the systems considered for the LCA. These boundaries have been established building on the methodological work conducted in another work package of the ACYDU project that aimed at (i) identifying the life cycle steps and (ii) defining a decision tree to be able to identify which stakeholders belong to the sector (Lempereur, 2015; Assogba, 2015).

The steps considered within the system boundary are: (i) production, transport and processing of raw materials and other inputs required for the production, transport, delivery and consumption of final products; (ii) management of waste generated over the different life cycle steps; (iii) office and travelling activities of stakeholders, including the ones belonging to the "close environment" (i.e. considered within the sector even though not involved in the production chain, such as dedicated research centers, federations, etc.). The construction of buildings and the manufacture of equipment have been excluded from the assessment as previous LCA studies have highlighted that their contribution in terms of potential environmental impacts is negligible for mass-market products.

To build the LCI, a methodology deriving from both product and organizational LCA was developed and applied. According to the ISO 14044 (ISO, 2006), the functional unit is the quantified performance of a product system used as a reference unit. As this terminology does not fit with the life cycle assessment of an organization, the ISO 10072 (ISO, 2014) refers to *product portfolio* as the quantified expression of the studied system. It was chosen to use the wording *quantified expression of the studied system*. For both studied agri-food sectors, the quantified expressions of the studied systems correspond to their global activities over a 1 year period. For the PDO Beaujolais and Burgundia wine, the period considered is the wine year 2011-2012. The reference flow linked to the quantified expression of the studied system is the grape production, the wine making, the packaging, the distribution and the consumption of 237.1Ml of wine. For the PGI foie gras from French South-West sector, the period considered is the 2014 civil year, corresponding to the production of 2'645 t of raw foie gras and 4'988 t of processed foie gras and the following distribution and consumption steps (PALSO, 2014).

The LCI was built using a bottom-up approach in the sense that inventories were first built for sub-systems and then scaled-up to complete the global LCI at the agri-food sector level.

Building-up sub-inventories for each life cycle step

Each agri-food sector is composed of several organization activities. These companies can usually be classified in "organization's types" regarding their activities (for example farmers, feed manufacturers, retailers, and so on), sometimes spread over several life cycle steps (Figure 1). To deal with organizations which activities cover different life cycle steps, it is necessary to cut the organization system in different subsystems and to identify several intermediate reference flows, corresponding to the outputs of the different life cycle steps.

Primary data have been collected from the different types of organizations belonging to the defined sub-systems through questionnaires. Using annual activity data provided by participating organizations, average data have been established (i.e. average energy consumption, water consumption, amount of waste produced...). These data have been expressed per unit of the output *intermediate reference flow* of the subsystem under study (e.g: number of fattened ducks after the rearing and over-feeding step, volume of wine after the wine making step).

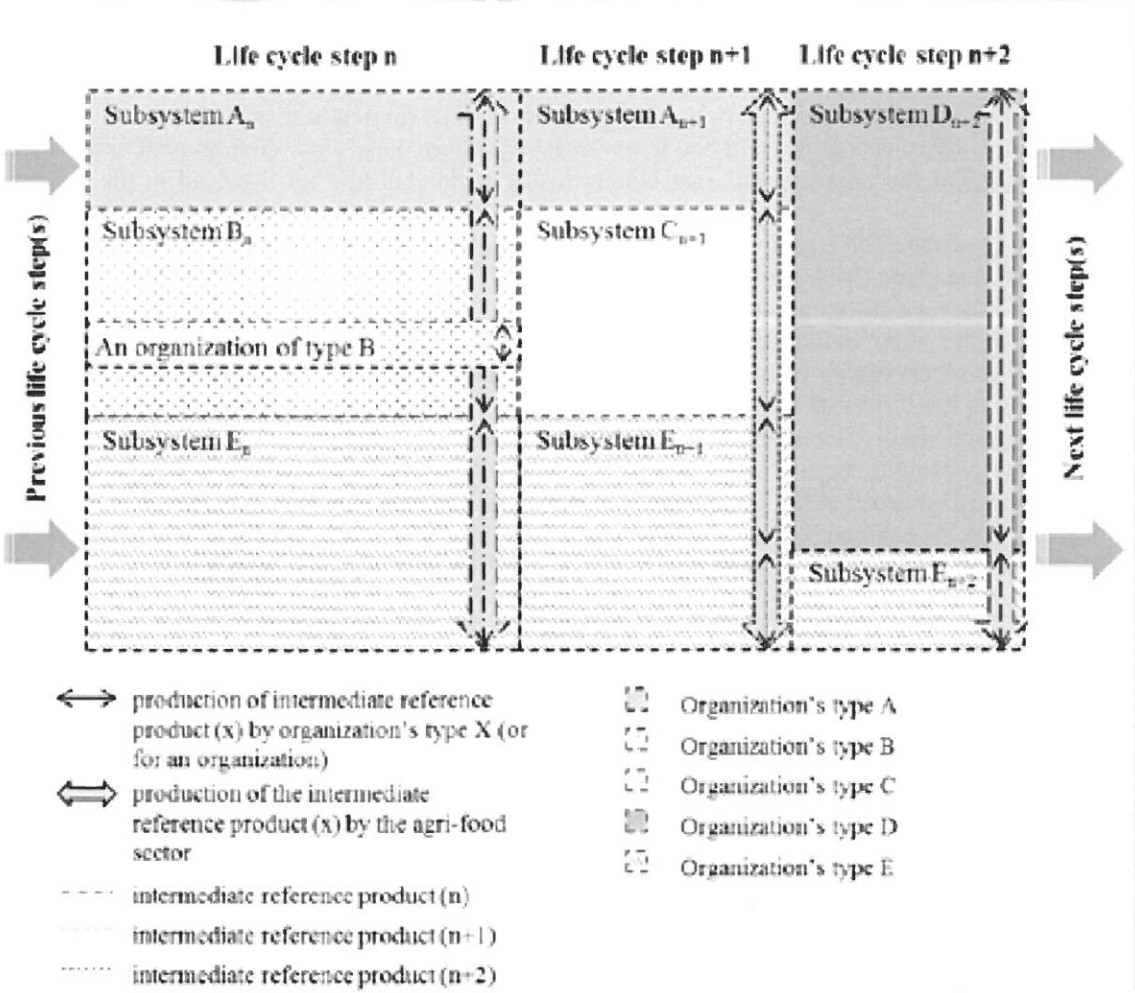

Figure 1: Graphic representation of a theoretical agri-food sector model used to build-up the life cycle inventory at the scale of the studied agri-food sector

Scaling-up the LCI at the agri-food sector level

The intermediate reference flows for the different sub-systems are used to connect the sub-systems together and build-up the inventory at the scale of the studied agri-food sector. To be able to do this scale-up, it is necessary to quantify the different intermediate reference flows for the whole studied agri-food sectors (thick vertical arrows on Figure 1) and for each organization's type (thin vertical arrows on Figure 1). In practical terms, this consists in establishing a mass balance featuring inputs and outputs flows at the sector level for the reference period. These data are then used to put together the global sector model. Primary data sources used for this task are statistics from trade associations and Customs trade data to be the most accurate. Assumptions based on sectors specialists were made to deal with unavoidable data gaps. To obtain inventories of subsystems at the sectors scale, inventories expressed per unit of intermediate reference flow (e.g. 1 fattened duck, 1 hl of wine) are multiplied by the intermediate reference flow productions of the corresponding organization's type (e.g. annual number of fattened ducks for the sector, annual volume of wine as an output of the wine making step for the sector).

3. Results

The outcome is an LCI adapted to the specific scope of the agri-food sectors under study. Figures 2 and 3 below present the life cycle steps studied for each sector, and the intermediate reference flows for each step that are used to scale-up the LCI as explained above.

Each LCI is composed of six steps: five production steps (agriculture, transformation, packaging, distribution and consumption) and one transversal step referred as "close environment" composed by the activities of the organizations that belong to the sector but are not involved in the production chain.

The LCI of the PDO Beaujolais and Burgundia wine sector begins with the production of 312 900 tonnes of wine grape (94% conventional agriculture and 6% organic) that are then transformed during the wine-making and aging step into 2 371 000 hl of wines. Different types of organizations are involved in this step: individual cellars (66% of the volume), cooperative cellars (30%) and vintners (4%). By-products (grape pomace and lees) are valorized by distilleries. Wines are then packaged. Packaging is the historical activity of the vintners who package 52% of the wines in the Beaujolais and Burgundia sector. The other 48% are packaged by cellars. Considering a loss rate of 0.3% of wine during the packaging step (CEEV, 2016), 2 363 800 hl of packaged wine are distributed, 62% in France and 38% abroad. 43% of the wines are distributed by retailers, 35% by direct sale and 22% by the cafés-hotels-restaurants. Then, considering a loss rate of 1% during the distribution and 5% during the consumption step (CEEV, 2016), 2 223 200 hl of wines are consumed (cf. Figure 2).

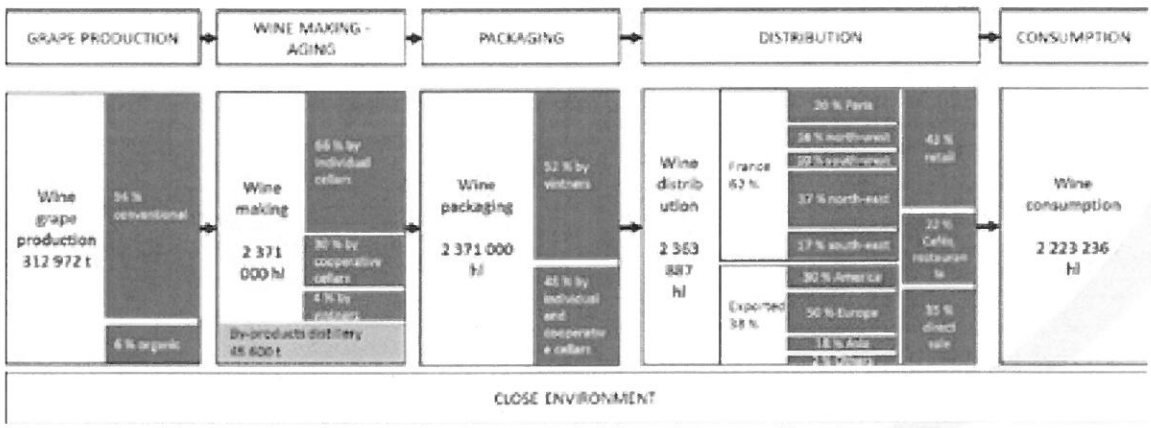

Figure 2: Model of product flows in the PDO Beaujolais and Burgundia wine sector

The LCI of the PGI South West duck foie gras sector starts with the raising of ducklings, followed by the overfeeding step, leading to about 24 616 360 fattened ducks ready for slaughtering. Once the foie gras has been taken out after cutting, raw foie gras is either commercialised raw or transformed into a range of different products. Putting together sector data in order to complete the global sector mass balance pointed out the importance of the product flows that are downgraded as non PGI along the production chain. Indeed, some intermediate products leave the PGI production chain along the process, because of compliance issues regarding the PGI specifications or commercial opportunities. The analysis of available statistics for the PGI South West duck foie gras sector suggests that 8.5% of fattened ducks get out of the PGI production chain before slaughtering. Further downgrading occurs after slaughtering. In the present LCA, the issue has been dealt with by allocating to the PGI foie gras sector all inputs and outputs arising upstream from the downgrading. In the end, 7 633 tonnes of foie gras products (either raw or transformed) are commercialised under the PGI label. In order to take into consideration the potential environmental impacts related to the packaging, it has been necessary to establish the breakdown of the different types of packaging (i.e. glass containers, plastic containers, metal cans…) for the various products. Assumptions were necessary since available sector data did not include such information. Market data for the PGI foie gras sector show that 96% of products are sold in France and 4% exported (PALSO, 2014). A loss rate of 1% over the distribution step has been considered (Figure 3).

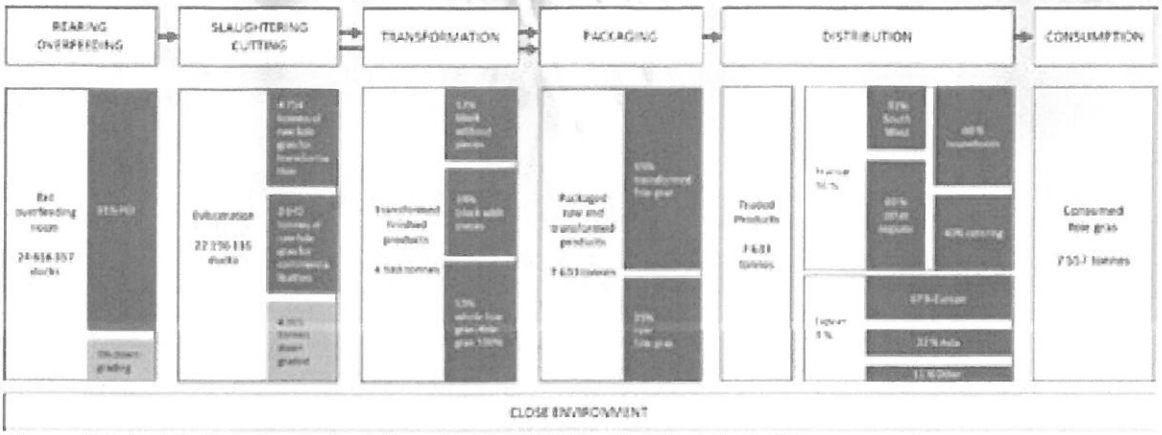

Figure 3: Model of main product flows in the PGI South West duck foie gras sector

Both case studies use the same approach to complete the LCI of the different sub-systems for each of the life cycle steps. For the **agricultural** step, LCI from the French AGRIBALYSE database (version 1.3) have been used (Koch et al., 2015; and more recent updates). For the foie gras case study, inventory data for rearing and over-feeding is based on the work on the PGI production system described in Deneufbourg et al., 2016. The **transformation** step (covering wine making and aging on one hand; slaughtering, cutting and transformation on the other hand) considers: transport of raw materials and inputs to the industrial site, energy and water consumption, consumption of ingredients and process inputs, consumption of cleaning products, transport of by-products to the valorization site (and valorization itself for the wine sector), treatment of waste. A lot of effort focused on the collection of primary data for this step. A sample of organizations (17 organizations from wine sector and 14 from foie gras sector) has been selected, based on technological representativeness. The **packaging** step is composed by: upstream transport of transformed products and other inputs, energy and water consumption, consumption of inputs (mainly primary and secondary packaging), consumption of cleaning products, treatment of waste. The **distribution** step includes: transport of packaged products up to the point of sale, storage by the retailer and storage at the point of sale, end of life of the secondary packaging. The **consumption** step is composed of: transport from the sale's outlet, storage at the consumption place, energy, water and inputs consumption for the preparation of the products, end of life of the primary packaging. The "**close environment**" considers impacts linked to business travels and office work (energy and water consumption). The ecoinvent database version 3.1 was used as the main source of background data.

Multifunctionality has been managed in different ways. For the wine case study, no allocation has been used. The sub-sector in charge of wine byproducts valorization (distillation) has been defined as part of the wine sector. System expansion has been used. For the foie gras case study, this question arises in relation with the rearing/overfeeding and slaughtering steps since these steps result in foie gras production but also other meat parts (magret, strips of breast…) and by-products that are valorized in other sectors (feathers, feet, blood…) (Figure 4). Economic allocation has been applied in the reference scenario, based on economic data concerning the sales price at the slaughterhouse after cutting provided by a sample of companies. An allocation factor of 55% has therefore been applied for foie gras.

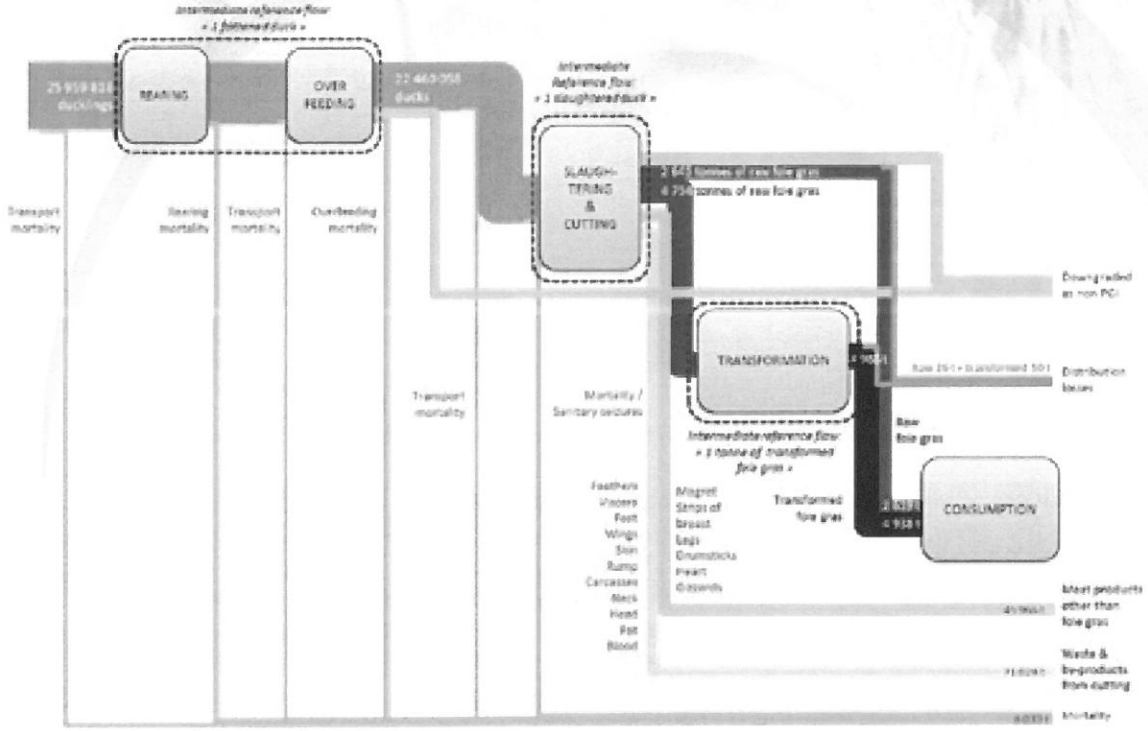

Figure 4: Model of input and output flows in the PGI South West duck foie gras sector featuring byproducts

4. Discussion

Establishing a LCI at a food sector scale starting from primary data collected in individual organizations is a complex task. The quantification of flows, first at the sub-system scale and then at the global scale of the sector for each life cycle step requires substantial research and data compilation work. In addition, despite efforts to ensure representativeness, the data collection for this type of project depends on volunteer organizations that are interested in this exercise. Assessing the representativeness of the different organizations is also a difficult task, especially in agri-food sectors characterized by a large number of small organizations. As a matter of fact, whereas 17 organizations took part to the study for the Beaujolais and Burgundia sector, they only represent 9% of the wine produced. Another issue that had to be faced was that adjustments in the collected primary data were necessary in order to build up the sectors LCI. For instance, in the wine sector, the activities of a given organization often cover several life cycle steps (viticulture, wine making-aging and packaging). Data collected for these organizations (e.g. energy and water consumption) had therefore to be allocated to several steps while only global data were provided.

Several areas for further work can also be identified. For example, additional work could be carried out to explore different ways of addressing downgrading issues for products under registered designation such as PDO or PGI. The methodology that was chosen to deal with the downgrading of PGI foie gras along the production chain implies that the potential environmental impacts of the sector are maximized. Indeed the number of ducks that is taken into account for the upstream steps is as a consequence of the chosen approach well above the number of ducks that would actually be required based on the final quantity of PGI foie gras placed on the market. Allocation issues between products and by-products could also be further studied.

It is also believed that the conducted work has tackled some interesting methodological issues that are not so often investigated in LCA. The presented methodology was developed based on two case studies. It ought to be applied to other food sectors in order to check its repeatability.

5. Conclusions

This work has led to the development of a methodology that can provide a useful framework for LCA practitioners that would like to study the potential environmental impacts of agri-food sectors. However the construction of an LCI that fits the boundaries of an agri-food sector remains a difficult exercise given the extensive data requirements.

The thorough mass balance of input and output product flows at a sector level and the resulting global LCI can be useful to agri-food sectors' decision-makers in order to get an accurate snapshot of the sectors' organization together with an assessment of the potential environmental impacts.

This work can therefore be used to better understand the environmental significance of agri-food sectors and be a basis to explore the consequences of possible changes in the sectors to improve the overall environmental performance.

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