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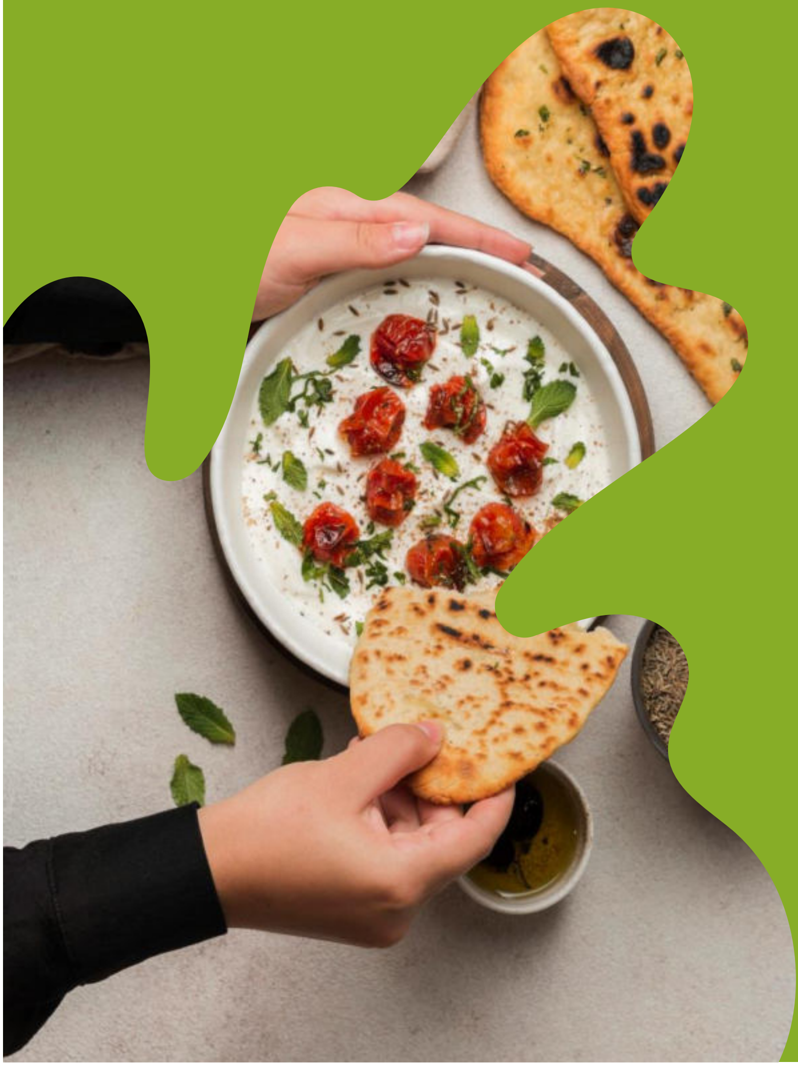
Extrapolation method

Methodological report on how to transpose a national LCA-database on food to another country?



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1. Introduction and context

a. Why is it useful to transpose a national food LCA-database to another country?

The world's food systems have a considerable impact on the environment. According to studies, they account for over a third of greenhouse gas emissions (Crippa et al., 2021 [1]), and six of the nine planetary limits established by Rockström et al. ([2]) were exceeded in 2023 (Richardson et al., 2023 [3]). This underlines the need to change our food consumption habits to reduce our environmental impact.

The EU "Farm to Fork" strategy aims to create a fair, healthy, and environmentally friendly food system with a 50% reduction in pesticide use, a 20% reduction in fertilizer use, and a 25% increase in the agricultural area dedicated to organic farming by 2030. Alongside and complementary to these agricultural objectives, this strategy places particular emphasis on improving consumer information so that they can make informed choices.

Better information enables consumers to understand the environmental impact of their food choices and make more informed decisions. Numerous private and national initiatives are flourishing in Europe to better inform consumers about the environmental impacts of food products. France, for example, is a pioneer with systems such as Planet-Score and Eco-Score, which are part of an ADEME experiment. These labelling systems aim to help consumers make greener choices and encouraging manufacturers to improve their recipes and value chains.

Environmental score calculation methods are based, in whole or in part, on environmental impact databases, more specifically food LCA databases. The use of LCA food databases is not limited to ecolabeling. They are also crucial for product eco-design, research focusing on sustainable and healthy diets (e.g. protein transition), support in the development of environmental policies and enabling companies to reduce the environmental impact of their products right from the design phase.

There are, however, still very few databases available covering all food products at a national level. Agribalyse is the exception. Over the past 10 years, France has pioneered the development of the Agribalyse database, which is the benchmark for many of these environmental calculation methods. The Netherlands also has a national database, which is much less extensive than the French (Agribalyse) and is currently being updated and expanded. Other European countries, such as Belgium and Denmark, are working on their own databases. Further away, an Australian retailer has developed a national database starting from Agribalyse ([4]). But many other countries are still in the early stages of consideration. Hence, a harmonised approach at the European level makes sense in view of the large volume of international, and even more so European, trade in food products and ingredients.

Transposing national LCA databases to other countries allows for the capitalization of existing experience and data while avoiding the creation of new, costly, and inconsistent databases. This can contribute to a more unified and effective approach to tackling the environmental challenges of the European food sector.

b. Objective of this report and context in which it was written

The Eco Food Choice project is a European project funded by the LIFE program, gathering partners from four countries (France, Spain, Germany, and the Netherlands), which aims to create conditions in Europe for the development of environmental databases for food and methodologies for environmental labelling. This will contribute to enabling the shift of European food consumption habits towards a more sustainable and healthier diet. The project started in November 2023 and will last 4 years.

The ECO FOOD CHOICE project is structured around several work packages, one of which focuses on environmental data and the development of new datasets and harmonised life cycle inventory methodology. This work package was drafted based on the observation that the current initiatives for ecolabeling face similar methodological challenges and, hence, on the need to provide guidance for methodological convergence of the already existing initiatives and of the future ones. These challenges partly lie in the methodology used to collect or estimate data to evaluate food environmental impacts.

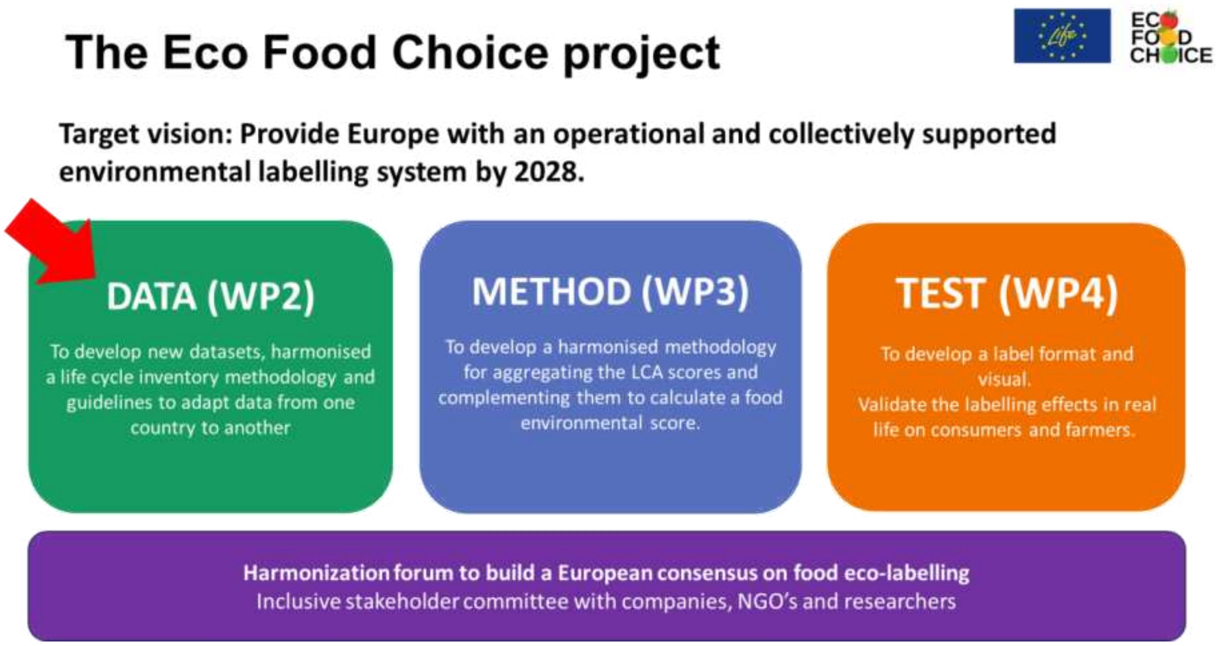

Figure 1: Eco Food Choice work package distribution

The second task of this work package (WP2) aims at providing guidance to extrapolate agricultural products data between countries. This was identified as a major point to be addressed by the project, as the use of these databases is a key solution when company-specific or region-specific data is lacking. Hence, there is a high interest in developing regional and national databases in the EU.

Since databases have already been created in Europe (such as Agribalyse), many other countries want to use these existing data to build their own databases. In this perspective, it seems appropriate and efficient to build on the experiences gathered to provide guidance on the better way to extrapolate existing data from one country to another quite efficiently, which is a way to avoid mobilising significant financial resources and time to build databases from scratch.

Whereas local data remains the preferable and most precise option to represent different local conditions in environmental labels, extrapolating data from one region to another remains a pragmatic and useful interim solution, which will be required until all EU countries have their specific databases. In addition, at database level, it is necessary to ensure a consistent methodology across countries, so integrating local data into databases isn't necessarily the best option when said data isn't consistent with each other. Thus, extrapolations carried out using a rigorous methodology may be a more appropriate choice.

However, new datasets must be generated from existing ones in a relevant way, and not just according to the specific data available to the user (for instance only modify water use and not the crop yields). Extrapolation is a common and often needed practice in LCA. Beyond geographic extrapolations other kind of extrapolations are also developed in LCA, for instance technical extrapolation (from conventional to organic LCI), or scale extrapolation (from pilot/research prototype to industrial scale). This report only addresses national extrapolations.

This methodological report aims to provide guidelines on how to nationally adapt life cycle data for food products from other European countries or regions. The methodological report is meant to be generic and potentially applicable to any user wishing to extrapolate a database (or a large number of homogeneously constructed datasets) from one country to another. Extrapolation of LCIs can only be applied to disaggregated, unit process databases such as Agribalyse, ecoinvent or agrifootprint. On the other end, EF3.1 or Sphera databases can't be extrapolated due to their "system process" structure. This highlights the importance of transparent databases to maximise their potential. To a certain extent, impact extrapolation is also possible, but we don't address it in this report. To know more, refer to Agroscope works on impact extrapolation based on yield correction for instance (Roches et al., 2010 [5] ; Nemecek et al. 2012 [6]).

Specific focuses will be made throughout the report on the adaptation of data from the Agribalyse database. As part of ECO FOOD CHOICE project, 90 new datasets for food products consumed in Germany, Spain and the Netherlands will be built, based on the application of extrapolation guidelines to Agribalyse datasets. Agribalyse was chosen for this task as it is public and one of the most complete national databases. This data will then be used and analysed in the rest of the project, providing feedback and enriching the transposition methodology.

c. The process of how this method was developed

To develop this transposition method report:

- All the members of the consortium involved in this task met virtually at month 2 of the project (December 19th, 2023) to start discussing the list of structuring parameters when engaging in the process of transposition and the way to draft the transposition method;
- Then, a smaller group of consortium members worked on a hotspot analysis, a literature review and a review of existing extrapolation method (Appendix 1 to 3);
- Then, a stakeholder consultation workshop was held (April 5th, 2024) to bring together LCA experts from partner organisations in the ECO FOOD CHOICE project and gather expert opinions on the hotspot analysis and the drafted method;
- At last, the method was written and reviewed internally by two non-involved members of the consortium.

Review of existing extrapolation methods

We conducted a review of existing extrapolation methods. We examined five methods that come close to an extrapolation method, divided into two types of study:

Mass extrapolation of life cycle inventories (LCI) for agricultural products:

- Modular extrapolation of crop LCA (MEXALCA) [7]
- Construction of LCIs for organic agricultural products: Extrapolation from conventional inventories in Agribalyse. Gingko 21, 2023. [8]
- HESTIA: Storing agricultural datasets in a consistent format and filling data gaps.

Agribalyse-based mass extrapolation of life cycle inventories (LCIs) for food products:

- Adapting the Agribalyse Life Cycle Inventory database to Australia: A first step towards a comprehensive Australian food and agriculture model. Paul-Antoine Bontinck, 2022. [4]
- Adapting the Agribalyse Life Cycle Inventory database to French overseas territories: Réunion, French Guiana, Martinique, Guadeloupe. EVEA-ADEME, 2024. [9]

A deeper analysis of these studies can be found in the appendix 3, but the main lessons to be drawn from this review are as follows:

- It makes sense to focus on hotspots when extrapolating data.
- Downstream stages (i.e. all the stages after farm gate, which means food processing, packaging, transport, cooking, storage in retail and home, end of life…) are relatively simple to transpose, except for imported products and recipes for compound/complex dishes (for which data are hard to collect).
- The farm stage is more complex and crucial, with many key parameters to consider, particularly in animal production.
- Data collection is a crucial part of this process. It is also essential to qualify data quality (DQR) and ensure total transparency, notably by highlighting the importance of metadata.

Hotspot assessment

Assessing hotspots is an essential step in identifying the most relevant parameters to adapt when extrapolating life cycle inventory (LCI) data for food products from one country to another. Hotspots are the parts of the production process that have a significant environmental impact, and in our case, they vary considerably from region to region.

A hotspot analysis was conducted based on a review of existing literature and a quantitative analysis of Agribalyse data. The analysis covered both the upstream farm phases (e.g. farming practices, irrigation, fertilisers) and the post-farm phases of the life cycle (such as transport, processing and packaging). The work was carried out product category by product category to ensure accurate and relevant adaptation of the data.

The literature review addressed 51 food products within 29 INCA categories. The quantitative analysis addressed 1574 processed food products from AgriBalyse across 30 INCA categories and 70 primary foods within 12 INCA categories. Finally, similar meals with variable recipes were studied to check the sensitivity to meal composition. These analyses provided first and second rank parameters for adaptation for animal-based and plant-based primary foods and for processed foods. The analysis matched initial expectations from the consortium: Key agronomic parameters such as yield, fertilization and feed composition were confirmed as first rank for the primary products, and consumption mixes and recipes were the first rank parameters for processed food. Full details of this analysis are available in Appendix 1 and 2.

A stakeholder consultation workshop

The stakeholder workshop was held on April 5th, 2024. This workshop brought together LCA experts from partner organisations in the ECO FOOD CHOICE project to discuss the results of the hotspot assessment and gather expert opinions on three main topics:

- Key parameters to be adapted when extrapolating datasets;
- Data feasibility;
- Overall transposition methodology.

Participants contributed through oral discussions and feedback via an online collaborative platform (Miro). The conclusions of this workshop are set out in an internal detailed report.

e. Report organization

The structure of this report has been designed to guide the reader through the methodology; the usual steps involved in carrying out a life cycle assessment, providing a logical sequence from the general to the specific topics. Generic guidelines are developed in chapter 2, and then specific ones by life cycle stages in chapters 3, 4 and 5.

Chapter 2 - Generic method: this chapter is dedicated to a generic method that can be applied universally, regardless of the context or country concerned. In this chapter, we describe the fundamental principles and steps that form the basis of any transposition effort. It provides a standardized approach that guarantees consistency and reliability in the data transposition process. By starting with a broad and adaptable method, we ensure that the essential aspects of transposition are covered, paving the way for more detailed and specific guidance in subsequent chapters.

Chapters 3 to 5 - Transposition guidelines, by life cycle stages: These chapters provide detailed guidelines by life cycle stages, offering practical advice and procedures for adapting data to different countries and conditions.

Figure 2: Report organization

f. Definitions

There are various ways to transpose food LCA datasets from one country to another:

- use proxies (for instance use the French average tomato to represent the German average tomato);
- extrapolate existing LCI datasets, which means adapting some structuring parameters leaving unchanged the others (for example, adapting the electricity mixes to reflect the current mix of the respective country, adapting transportation modes and distances, and adapting agricultural practices…).

Furthermore, the choice of using proxies or extrapolating datasets may vary depending on the product or product category.

DEFINITIONS

In this report, we will use the following terms as follows:

Extrapolation of datasets: to designate the action of modifying existing datasets for a given country and adapting it for another country by modifying certain parameters.

Transposition of database: to designate the action of transposing databases / datasets from one country to another, in a generic way without specifying how to do so (using proxies and extrapolating datasets simultaneously).

2. Generic transposition method

WARNING: Life cycle inventory databases with country-specific data for food products already exist (e.g. EcoInvent, Agribalyse, World Food database, or Agri-footprint database). Some are publicly available free of charge, and some are commercial. There is a benefit in using them as a fall-back option in case country or region-specific data are not available. The user of this method is responsible for investigating where transposition of a database is allowed for the targeted purposes, and whether it comes with potential additional requirements (End User License Agreement). **In the long run it is highly advisable to invest time and resources into building publicly available and freely accessible databases with locally representative data on agricultural production practices.** Otherwise, there is a risk of high uncertainties when applying ecolabels at large scales and basing countless purchase decisions of consumers on a frail data quality basis. Meanwhile, however, **it makes good sense as a transitory solution** to extrapolate localised datasets from other regions or countries, while considering the **underlying uncertainties and consequent data quality limitations.**

NOTE: This method has been designed to be as generic as possible and to provide ideas, tools and concrete proposals on how to transpose LCA databases on food products from one country to another. However, it still needs to be tested (at the date of publication of this first version, it had not been tested). Although it is supposed to be generic, since this work is part of a European project, it is more accurate in a European context since a special effort has been made to find data sources in Europe.

a. Types of life cycle inventory covered by this method

In this section, we propose a generic method for users wishing to transpose a national food LCA database to another country, mainly in the context of consumer information, but which can also be used for eco-design purposes. This method focuses on **the transposition of LCA datasets, i.e. life cycle inventories (LCIs) on food products**, integrating all life cycle phases (inputs, agricultural production, transport, food processing, packaging, distribution, retail, consumption, end-of-life).

As environmental labelling systems involve data of different granularity/precision, depending on access to primary data/traceability by the operator implementing them, different levels of data are considered in this transposition method regarding the agricultural stage, which proves to be the most crucial:

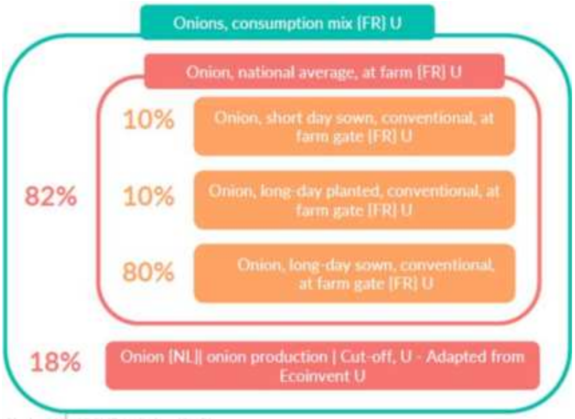

Figure 3: Different levels of granularity regarding agricultural LCIs

- **LCIs representing an agricultural product, at farm gate**, with a specific production system and agricultural practices (example: *Onion, short day sown, conventional, at farm gate {FR}*)
- **LCIs representing an agricultural product representative of the average (or majority) production method in a given country** (example: *Onion, national average, at farm gate {FR}*)
- **LCIs representing an agricultural product representative of the average product consumed in a given country** (*Onion, consumption mix {FR}*).

Regarding the inclusion of organic products: Organic production systems can be quite different from "conventional" ones; this method mainly focuses on the transposition of food products LCIs from a country to another, taking into account differences in farming practices between countries (i.e. no heated greenhouse in Spain whereas vegetables in a heated greenhouse is important in Netherlands). However, at the agricultural stage, this method mainly focuses on conventional products, whereas the transposition of conventional products into non-conventional ones (for instance organic products) is a different exercise ; there is great diversity of organic production and non-conventional farming methods in Europe and it is even more difficult to obtain representative statistical data. However, the method proposed is suitable to transpose "a French organic product" to a Spanish organic product" considering the European harmonization of organic farming specifications. Readers interested in the transposition of conventional products datasets at farm gate to organic products datasets at farm gate can refer to Gingko21, 2023 [8].

b. The main steps to consider

In this method, we propose a three-stages approach, as described in the following diagram:

- **Stage #1: define goal and scope** of the transposition work, and **take stock of the data available (i.e. gather most appropriate data)**;
- **Stage #2: define the way to transpose, collect the necessary data, and carry out the transposition work;**
- **Stage #3: analyse the data, interpret them** and adjust if necessary.

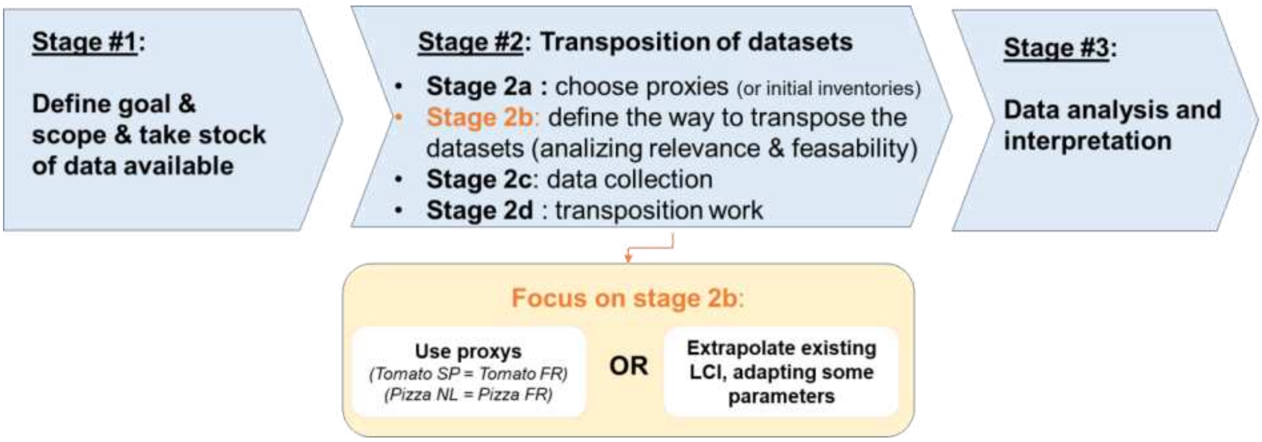

Figure 4: Proposed method to transpose a food-LCA database from one country to another

c. Stage #1: Define the goal and scope of the transposition work, and achieve the state of the art of the existing data

In a similar way to an LCA study, we are proposing an initial step of **definition of the Goal & Scope of the transposition work**, to ensure that the methodological choices will be relevant to its intended use, and transparent. This stage involves:

- To define the purpose of the study: clearly state the intended use of the transposition work (ecolabelling, ecodesign, analysis of food systems, prospective studies…).
- To specify the system boundaries: determine what processes and life cycle stages will be included in the study (e.g. from cradle-to-grave? at farm gate? at consumer plate?).
- To establish the functional unit and ensure the functional unit is relevant to the purpose of the study. Regarding ecolabelling, the functional unit for example may be a unit of mass of food product (kg of product), a unit of sale, a portion consumed, or even other units. Indeed, if the functional unit chosen is not aligned with the functional unit of the data that is intended to be transposed, keep in mind that the functional unit conversion will introduce additional uncertainties.

In light of these factors, the next step will be to **take stock of the data available**. In Europe, the public LCA databases for agricultural and food products identified at the time of writing this method are as follows:

- Ecoinvent (since 2005, annual update), developed by The Ecoinvent association, which contains data for all sectors (energy, transports, end of life…) and main agricultural products LCIs (animal production and crops), for entire world, Europe and some country-specific data.
- World Food Database (developed by Quantis in 2012, regular updates), which contains data for main agricultural products (animal production and crops) and some food products, entire world, Europe and some country-specific data. WFLDB contains copies of ecoinvent data.
- Agrifootprint (since 2014, regular updates), developed by Blonk, which contains agricultural (animal production and crops) and food products for the entire world and some country-specific data.
- GFLI, developed the GFLI association, gathering the major feed and livestock industries, is a specialized LCA database on feed, including data from different geographical regions around the world.
- Agribalyse (since 2013, regular updates, approximately every two years) developed by ADEME, with scientific and technical support of the REVALIM scientific interest group (INRAE and French technical institutes for agriculture and food industry), which is the most comprehensive database on food at national level. Agribalyse contains copies or adapted LCIs of World Food Database and EcoInvent.
- Environmental Footprint (referred to hereafter as "EF") Database that contains datasets that are compliant with EF methods, but currently only accessible to data providers. The EF database is currently being redefined: a new version is under development and terms of uses are not yet known.
- Hestia project that stores agricultural datasets mainly from academic research in a consistent format.

- Sphera, who offer their data in system processes (i.e. aggregated, non-transparent) and according to a highly integrated model (service integrating software, database and consulting services), mainly targeting large companies.
- Other national databases are also currently being planned/realised, but are not yet available, particularly in the Netherlands, Denmark and Belgium.

WARNING: Even if it is possible to use more than a single source of data as the data of origin, it is advisable to do so sparingly and cautiously, because the mixed use of different databases inevitably generates inconsistency (due to differences in the methodological choices). It is also stated by the consortium that using ecoinvent, World Food Database, or Agribalyse seems fine for transposition of datasets, but Agrifootprint does not encompass capital goods, and is thus not recommended to use in this context (especially for productions involving greenhouses) .

Next, the objectives and scope of the study will be cross-referenced with the assessment of existing data to **define the best sources of original data to use and transpose** in each specific transposition study. This choice must take into account:

- The structuring methodological choices, assumptions and limitations such as scope limitations, functional unit, and allocation procedures.
- The analysis of the contextual differences between the region/country of the original data and the context in which the new database will be produced: what are the potential consequences and points of attention regarding the transposition work? This concerns both the consumption patterns (example: consumption of seafood very different across European countries) and the production practices (agricultural practices mainly: for instance, breeding conditions).

Finally, when extrapolating a whole national database to another country, an important step will be **to determine which product will be part of the transposed new database, and amongst those, which ones will be the subject of a specific attention**, regarding their relative contribution in food diets in the specific country (in terms of consumption volumes and environmental impacts), the upcoming markets (like plant protein products), and the state of the art of existing datasets. In doing so, we recommend adopting a systematic and transparent approach, and justifying the choices made.

In a national or international database, aiming for completeness involves focusing on hotspots and doing some simplification for secondary parameters. For instance, Agribalyse developers have opted for full scope (producing data for all foodstuffs consumed by French consumers). Agribalyse database contains around 2500 food products at consumer plate and 200 agricultural life cycle inventories (vegetables, crops, feed and animal production). This means necessary simplification of "secondary parameters" or data. And so, Agribalyse datasets are more precise regarding hotspots, such as agricultural processes and "emblematic" products or with significant consumption volumes (i.e. fresh tomatoes versus industrial tomatoes) and even different versions depending on contrasting farming practices (i.e. heated greenhouse tomatoes, versus open-field tomatoes). On the other hand, the Agribalyse database includes a lot of proxies, which means that behind different food items, same datasets are used sometimes (for example, orange and grapefruits "at farm" are modelled with the same "orange LCI dataset" today).

NOTE: The multiple ways to use "proxies" in food LCA databases

Different kinds of proxies can be used in a food LCA database.

- proxies at the food item level. *Example: strawberries yogurt = vanilla yogurt*

- proxies at processing plant level. *Example: process for canning peas = process for canning carrots*.

-proxies at the ingredient level i.e. agricultural product or processed agricultural product. *Example: duck = chicken.*

- proxies at the agricultural product regarding the origin. *Example: Moroccan tomato = Spanish tomato*

WARNING: conditions of use of "native" datasets

Developing and updating LCA data requires considerable resources and expertise, which has an impact on the conditions for accessing and using the data. Data users must always ensure that their use of the data complies with the rules laid down by the owners of the native data. To the best of our knowledge, today, only the Agribalyse database can be used freely, including for commercial purposes. However, since Agribalyse is based on ecoinvent background data, Agribalyse data can only be used in LCA software if you have an ecoinvent licence.

d. Stage #2: Transposition of datasets

Stage 2a – Choose proxies or initial inventories (inventories from which the extrapolation is made)

Whether or not the inventory is adapted (proxy), the step of choosing the best starting inventory (or severals) is a very important one. To find the best proxies amongst existing LCIs, we recommend having a systematic approach that specifies:

- The priority between databases, when using several databases, to ensure the best consistency in the overall database.
- The choices made regarding the farming practices, when there are several choices for a same product, especially for the key parameters developed above (yields, pesticides, fertilizers, greenhouse, irrigation and fuel use).
- The choices made regarding geographical and temporal representativeness: wherever possible, it is advisable to look for a neighbouring country (with similar soil and climate conditions); if not, use European or global data.
- For agricultural products without a corresponding LCA dataset, the choice regarding the proxies: the genetic proximity and the proximity of the growing methods and environment (same soil, same growing seasons, etc.) must be taken into account.

For some products, moving away from the specific agricultural product may be relevant on a case-by-case basis. *For instance, in Agribalyse database, there is no French mustard LCI, and the vast majority of mustard consumed in France comes from Canada. In ecoinvent, there is an LCI for mustard produced in India, which does not seem appropriate for French consumption, since the production* *methods in India and Canada are very different. In this specific case, on the advice of an expert, it was decided to choose a 'Canadian rapeseed' proxy (spring rapeseed with the same cycle length as mustard, same genetic family) rather than 'Indian mustard'.*

To avoid methodological bias, we recommend avoiding mixing data from different databases, or failing that, only mixing databases that are methodologically similar. Having said that, regarding agricultural inventories, it seems difficult to stick to a single database. In this case, we recommend defining an order of priority in the choice of original data.

Suggested method to transpose a database or a large number of datasets and application to Agribalyse database

Since LCA databases are built like "Russian dolls", involving different LCIs for each finished food product (agricultural LCI, processing LCI, transport LCI, etc.), in the case of transposing data on finished food products (i.e. "products at consumer plate"), and in the interests of efficiency, it seems appropriate to proceed as follows:

1/ start from a single database of food products, to avoid methodological bias and select the finished products to be retained in the extrapolated database, and identify any gaps (new products to be reconstructed)

2/ extrapolate the LCIs for all post-farm operations, i.e. transport, processing, packaging, distribution, retail and home use (cooking, storage) by defining the list of parameters to be modified, depending on the feasibility and resources / time available (various degrees of granularity possible). See chapter 5 for guidelines.

3/ for on-farm operations (plant and animal production), identify the best proxies for each agricultural product actually produced in the country in question, mixing databases if necessary, but setting up prioritisation rules and justifying them (e.g. give priority to DB A, if not relevant take data from DB B). Then, define the list of parameters to be modified, depending on the feasibility and resources / time available (various degrees of granularity possible). See chapter 3 and 4 for guidelines.

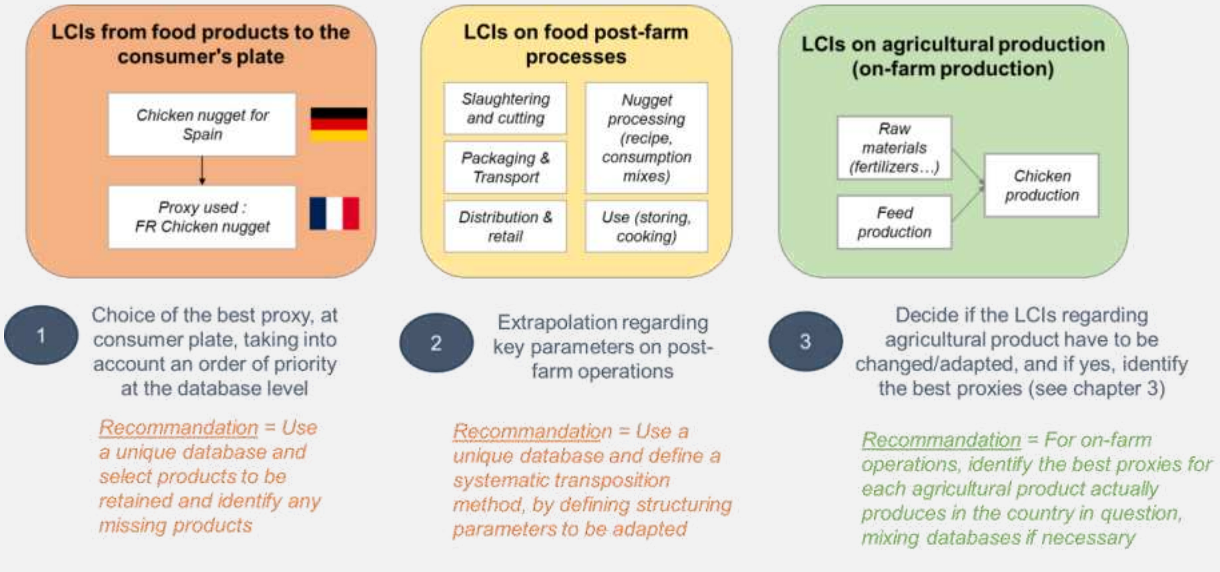

Figure 5: Suggested method to transpose a database or a large number of datasets

Stage 2b – Define the way to transpose datasets

There are multiple ways to transpose LCIs from a country to another:

- Use a proxy considered as acceptable.
- Choose an existing LCI (considered as the best proxy for this specific product) and adapt the parameters to build an adapted/extrapolated LCI.
- Build a completely new dataset based on regional data: this is out of the scope of this method. However, at a database level, it is possible that for some specific products where extrapolated data are sorted out as irrelevant, building of new inventories will be necessary.

At a database level, it is possible to mix different approaches, depending on the products considered, based on the relevance (i.e. the level of environmental importance of each specific product), and feasibility (i.e. regional data availability). However, an overall coherence must be sought at the scale of a database. For example, if it is decided to adapt the energy mix for one of the life-cycle phases that carries a significant environmental burden, or for a specific product category, it would seem appropriate to do so for all life-cycle phases and for all products, including those with the lowest impact, as this does not require the collection of additional data.

For food products, the agricultural stage is often the hotspot, and it is therefore advisable to pay greater attention to it, and refine the data with regional data, when possible (which could be very difficult in some cases). However, in a certain number of cases, particularly concerning imported products (for instance imported chicken from Brazil), it will be more difficult to have access to regional data in order to fine-tune the data. If possible, it is advised to refine the adaptation of agricultural products, concentrating efforts on the most impacting products (for instance, adapt the feed for the animal production systems).

Three criteria must be taken into account to choose the way to transpose a dataset (between extrapolation or keep a proxy as is):

- The importance of each specific product in terms of environmental impact;
- The importance of each specific product in the diets of the specific country that the work is done for;
- The variability of the environmental impact amongst countries (that will rely on the soil and climate conditions and production methods, and the genetic proximity, i.e. the varieties used).

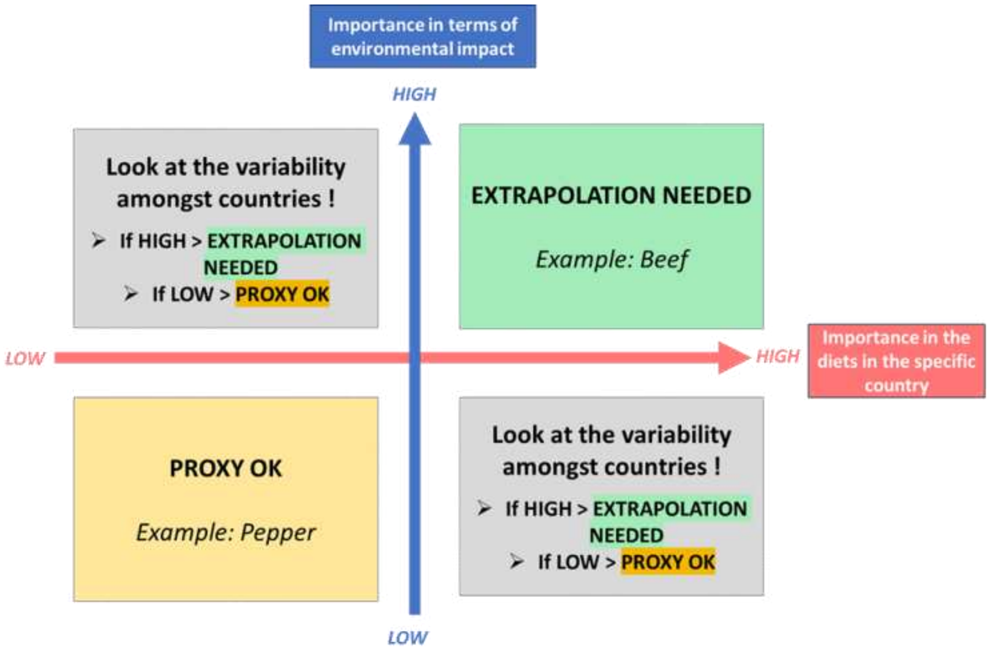

Figure 6: Decision support-diagram for choosing the transposition method

This decision support-diagram includes a degree of uncertainty linked to data collection. Some data may not be available or may be very difficult to obtain.

ADVICE: Prioritising the major issues, striking a balance between feasibility and relevance: because this is a transposition / extrapolation method, the key point is the balance between the complexity of the extrapolation and the relevance of the adaption of the variables (fertilizer, yield, pesticides, manure management…). In many cases, the data are available, but data collection and transposition work are time consuming. A main common mistake in LCA is to use too much time for a non-relevant parameter and don't have enough time to go deep on a relevant parameter. A key principle in this kind of work is to match relevance with time availability and prioritise the parameters to be adapted, and the products on which to focus.

When several LCIs exist for the same product in the same country, it may be appropriate to reconstruct 'national averages' by estimating the majority production methods and their relative shares. For example, if a Spanish onion is approximated by a French onion, it may be appropriate to rework the French mix, removing inventories of production methods that do not exist in the country. See a fictitious example below regarding onion consumption mix.

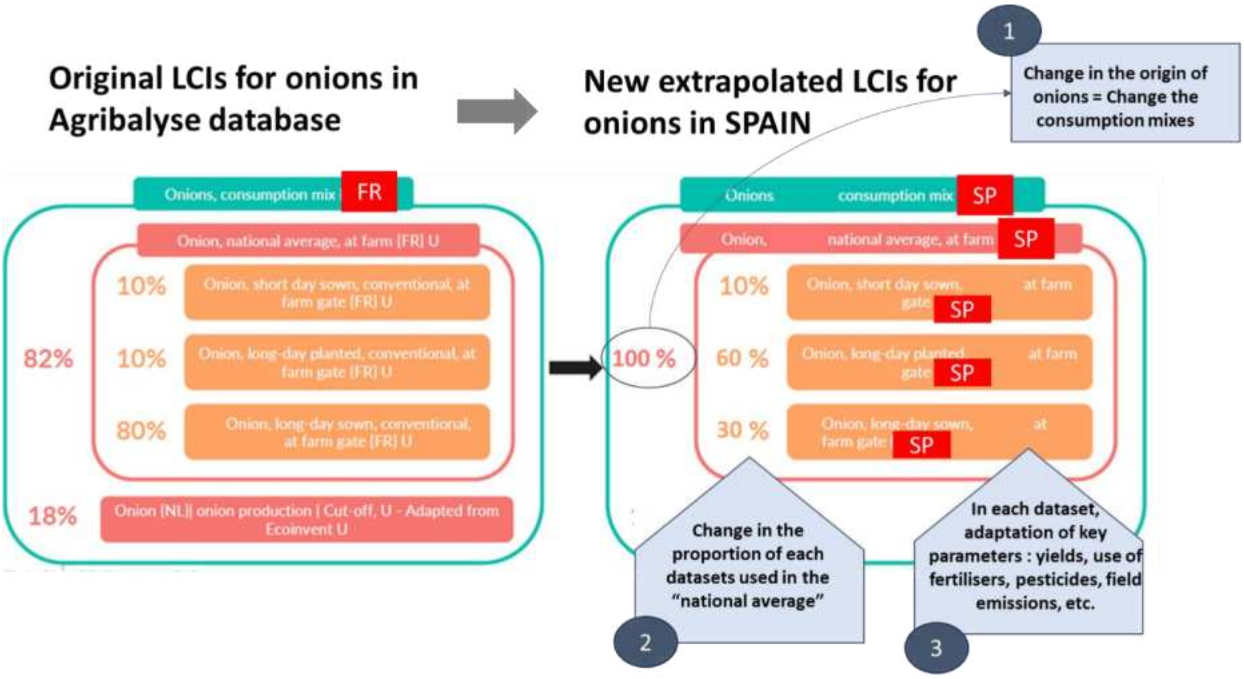

Figure 7: Example for the transposition of a French onion consumption mix to a Spanish one, including change in the datasets used and the extrapolation of some datasets

In short, it does not seem easy to recommend a «systematic approach» for all product categories, and for all types of geographic situations. The approach proposed is therefore a general approach that needs to be adapted on a case-by-case basis, depending on the type of product, data availability, goal and scope...

Stage 2c – Data collection

Data will be collected from relevant sources (public statistics, experts) for each product and category, following the guidelines framed in chapters 3, 4 and 5. For missing and hard-to-collect data, it is recommended to look for the best available alternatives (generic data, proxies, extrapolations, etc.).

In most cases, we can rank data reliability as follows (in descending order):

1. **Statistics**: Statistics data are permanent collection of data from a public or private organisation based on a methodological report that describes in detail how the data was produced. The data is available to the public or internally within the organisation. Statistics can be available/mobilised at different levels (national or regional averages, averages for a group of products, etc.). Statistic data might however incorporate some representativeness limitations (ex: sample focusing on big compagnies) or even methodological bias, especially when they touch upon politically sensitive topics.

2. **Supported expert opinion** (cross-referenced with field data or literature): Expert opinion data is data that emerges from a coordinated and documented process that incorporates the experience of several experts on a consensual basis. The experts may draw on several sources of data, i.e. statistics, field data, case histories, estimates or a mix of all four, usually associated with their experience. The documentation should contain: (1) the names of the experts, (2) the dates of the meetings, (3) a list of the data sources used, (4) a detailed description of the system for which the data is valid and (5) an indication of the accuracy of the data (e.g. "good", "with a lot of variances" or "very vague"). If the data is not effectively documented, then the data is an estimate.

3. **Field data (company data or literature),** not cross-checked with expert opinion

4. **Unargued expert opinion, estimation.**

In practice, the choice between data sources will be made on a case-by-case basis, to always comply with the general rule (e.g. in some cases 'expert opinion' is more relevant than statistics). If several data sources are possible, the choice of data source should be explained.

Stage 2d -Transposition work

To maintain data consistency, it is recommended that the new inventories' background data (electricity, heat, infrastructure, etc.) be adapted using the same data as the original database used for the transposition. Today ecoinvent is by far the most widely used general background databases. In the years to come, this could change, depending in particular on what the European Commission may propose with the new EF base.

For the transposition of many datasets, it is strongly recommended to mobilise computer coding skills to automate and make reliable the extrapolation of many inventories, through Brightway for example which is an open-source software package for life cycle assessment (LCA) written in Python.

As a final step, the quality of datasets must be assessed. The quality of inventory data affects the credibility of the LCA results. A method must be defined to score a Data Quality Ratio (DQR) for each inventory.

NOTE – TRANSPARENCY AND QUALITY OF DATA

To guarantee the reproducibility and transparency of data collection and to enable the validation of the data collected, the data collected must be documented in the metadata, in particular: author and contact of the inventory, time representativeness, geographic representativeness, technology representativeness.

In addition, a data quality rating system needs to be developed and is crucial to the successful use of the data. In the context of a database for a country located in Europe, this system must be in line with the PEF approach (Guide for EF compliant datasets, Version 2.0 [10]), while being adapted to the scope of food products. This is the case for Agribalyse's DQR system, which takes into account the following indicators: Precision (P), Temporal Representativeness (TiR), Geographical Representativeness (GR) and Technological Representativeness (TeR).

FOCUS ON HESTIA: HESTIA is a project that aims at scaling up the data and modelling detailed production practices and environmental impacts of agricultural products (https://www.hestia.earth/). In addition to providing a data format to harmonise agri-environmental data between researchers and supply-chains, it provides open-source models to gap fill missing data, estimate emissions and resources uses, using geospatial datasets and lookup tables. For agricultural inventories, these open-source models can be potentially useful for transposing inventories from one geographical context to another. (e.g. find out how to modify the value of a key parameter using Hestia data and models).

e. Stage #3: Data analysis and interpretation

After the building of the new extrapolated LCIs, impacts results of these new LCIs must be analysed and compared to relevant LCIs, at least the original LCIs, but also, if possible, data contained in literature such as meta-analysis.

To do so, an impact assessment method must be chosen relating to the objectives of the study. For ecolabelling purposes, we recommend the European impact method EF 3.1, with a specific attention to the indicators particularly sensitive for food production (climate change, water scarcity, land use, eutrophication and ecotoxicity).

In addition, it would also be interesting to compare the results with an endpoint LCA impact method, such as LC Impact, Impact World + or Recipe.

Lastly, interpreting the results is necessary to ensure robustness, and the correction of any errors in inventories. When doing so, limitations of the new inventories must be highlighted (to help the future users of these data, and to enhance to which extent the new inventories are relevant, and to which extend they are not).

In this stage, we recommend that the new inventories be critically reviewed by external experts, to ensure that the inventories defined are relevant/representative of production methods in a given context, particularly in cases where the experts working on extrapolation are not specialists in the production contexts of the countries concerned.

f. Application to Agribalyse datasets within ECO FOOD CHOICE project

Within ECO FOOD CHOICE project, 90 new datasets for food products consumed in Germany, Spain and The Netherlands will be built, based on the application of extrapolation guidelines to Agribalyse datasets.

Agribalyse was chosen for this task as it is one of the most comprehensive national databases. This data will then be used and analysed in the rest of the project, providing feedback and enriching the methodology for transposing data from one country to another.

APPLICATION TO AGRIBALYSE

Stage #1 – Goal & Scope: Before carrying out the transposition phase, it is important to bear in mind the methodological choices behind the Agribalyse database. A summary of the main methodological assumptions regarding Agribalyse data is presented in Appendix 4.

Stage #2 - Transposition Work

The test of this transposition method will be applied on 30 Agribalyse datasets. The chosen products are still under discussion now of the writing of this report; this will be defined in the follow steps of ECO FOOD CHOICE project.

Stage #3 – Data analysis and interpretation

This section will be completed later in the project, once the new transposed LCIs have been produced.

3. Transposing crop production inventories, at farm gate

a. Hotspots to consider

The diagram below summarises the hotspots to be considered when extrapolating plant production life cycle inventories, distinguishing between first-rank parameters (the most important/relevant from an environmental point of view to be adapted), and second-rank parameters. These parameters were identified by analysing hotspots along the food chain, by product category (see appendices 1 and 2) and discussed through the expert workshops. Indeed, the characterisation method strongly influences the «contribution level». Indeed, by using the «EF single score», it is likely that pesticides for instance do not pop up as a «hot spot» due to low (eco)tox weighting. Same reasoning can go on water/irrigation.

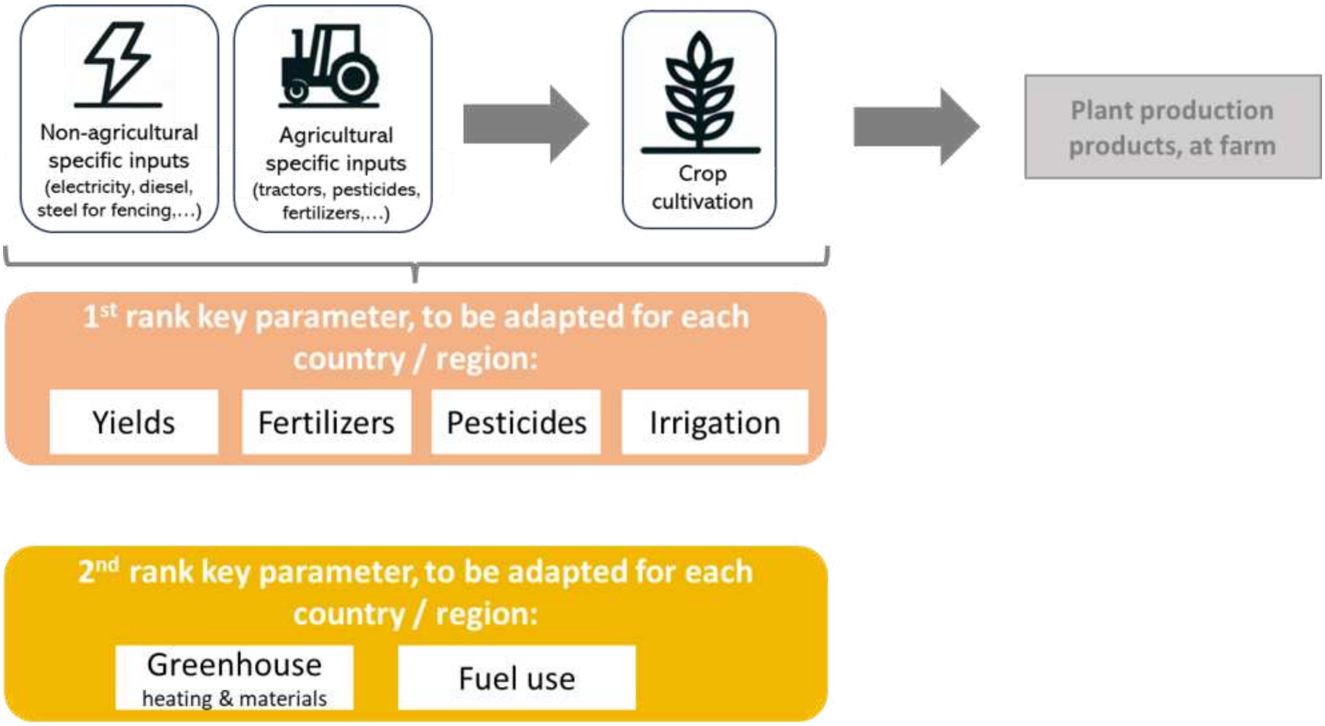

Figure 8: hotspots to consider when modelling plant production LCIs

b. Guidelines on the parameters to be adapted as a priority

Yields (1st rank-parameter)

Yield data per area and per crop is a key parameter with a strong influence on impact results that should be adapted, particularly when climatic conditions and cropping practices differ greatly from one country to another. Moreover, this data is easily accessible, through national statistics for example.

Fertilizers (1st rank-parameter)

Fertilizers, production and particularly the emissions due to application, are identified as a hotspot in plant-based production. The type and the amount of fertilizer used varies depending on the crop, soil characteristics, and country. These kinds of data (type and amount of fertilizers) are feasible to collect, even though in lot of countries, they are accessible globally over a given area (via sales data), and difficult to allocate to a particular crop.

In addition, fertilisation is rationalised on a rotational basis, which means that some practical issues and challenges may arise regarding the allocation of inputs into crop rotation over multiple years. Particularly organic fertiliser (e.g. manure), is applied to improve the quality of the soil and not specifically as nutrient application for one specific crop. In Agribalyse, it was decided that the quantities of nitrogen supplied in mineral form are directly available to the crop receiving them, whereas in the case of organic nitrogen, only a fraction is directly available to the crop receiving the input (the rest is allocated equally between all the crops in the rotation).

At last, we draw attention to the fact that a consistency check should be carried out, as far as possible, to ensure that the nitrogen balance is consistent across the different adaptations (yield and fertilizer adaptation).

Pesticides (1st rank-parameter)

Pesticides are identified as a hotspot in plant-based production. The type and the amount of pesticides used varies depending on the crop, annual weather conditions, and country. These kinds of data (type and amount of pesticides) are available but most of the time the data is available globally over a given area (via sales data), and difficult to allocate to a particular crop, even if legislation can help (maximum amount by substances allowed by crops for example). Nevertheless, recent datasets for pesticides inventories for many crops for many countries have been built by the Technical University of Denmark or DTU (Yuyue Zhang, 2024, [15]).

Irrigation (1st rank-parameter)

Irrigation is considered a potential hotspot for some plant-based foods, particularly in countries with water scarcity issues. Water use and irrigation energy resulting from irrigation need to be adapted to the location of the cultivation.

Regarding irrigation energy, a proxy of energy per water quantity could be assumed as a default, paying attention to irrigation practices (for example, flood irrigation is way less energy-consuming).

At last, it seems important to consider the different water sources (surface and groundwater), including increased use of alternative sources (e.g. desalinated water, reused water, inter-basin water transfers) to supply agriculture. The combination of water sources and technologies (including infrastructures and energy) results in a regional water supply mix (WSmix) for each specific use (agriculture, domestic…). It is relevant that Life Cycle Inventory (LCI) does include these mixes when modelling processes, if not it leads to a poor representation of water supply systems and related environmental impacts (Leão and al., 2017, [11]).

Greenhouse production (2nd rank-parameter)

Greenhouse heating is a hotspot in products grown in greenhouses, and it could vary per climate zone and crop type. It is important to adapt energy when the crop is cultivated in a heated greenhouse that is not in the South/Mediterranean countries (as the vast majority of southern European greenhouses are unheated [14]), using a good estimate per greenhouse crop to account for crop differences, differentiating when the heating is fuelled with fossils versus renewables if possible.

Greenhouse materials are not a critical hotspot, but accounting for materials' variability and structures used in each country could be useful. Indeed, plastic greenhouses have more impact (because of steel use as well) than glass greenhouse if the yield is high (for all large crops from temperate glass horticulture: tomatoes, zucchini, bell pepper, ...). Also plastic pollution (water/soil) should be integrated in LCA in the future, giving more importance to this aspect. A recent report from PRE Consultants and Wageningen University and Research [12], written in the context of the development of a methodology for calculating the environmental footprints of horticultural products, provide guidance on adapting greenhouse materials.

Fuel use (2nd rank-parameter)

For plant production, both human and feed purposes , diesel use is often quite an important data point, potentially variable between countries, but data gathering is difficult. As a first step, it may be useful to identify the crops (in the country under consideration) that require fewer inputs (and therefore fewer associated tractor hours) than in the country of origin, or for which no-till farming techniques are particularly well developed.

Besides, it is easier to know the hours per each tool used than the total fuel consumption. If such data exists, tools to transform this data could be used.

Example of a Spanish tool: https://www.mapa.gob.es/es/ministerio/servicios/informacion/plataforma-de-conocimiento-para-el-medio-rural-y-pesquero/observatorio-de-tecnologias-probadas/maquinaria-agricola/calculo-tractor-aperos.aspx

In the absence of primary data, it is relevant to use a modelling approach based on yield dependence, like the extrapolation method Mexalca.

c. Guideline regarding data sources

As for general considerations regarding data sources, refer to chapter 2 – section d.

When extrapolating plant production life cycle inventories, we recommend the following data sources prioritization:

Parameter to be adapted by country/region	Data sources	Remarks
Yields	Statistics (national / regional) per specific crops. If not available: FAOStat or Eurostat	As far as possible, reference period = 5 years preceding the inventory creation period
Fertilizers	Statistics (national / regional) per specific crops (public statistics, or private one like certification organisms). If not available: supported expert opinion.	As far as possible, reference period = 5 years preceding the inventory creation period
Pesticides	Statistics (national / regional) per specific crops (public	As far as possible, reference period = 5 years preceding the inventory creation period

	statistics, or private one like certification organisms). Data from Yuyue Shang, 2024: [15] If not available: supported expert opinion.	
Irrigation	Statistics (national / regional) per specific crops. If not available: expert opinion, literature, and field data. Advised literature regarding water use: Crop Water Footprint data (Mialyk and al. 2024 [16]) Advised literature regarding water supply mixes: Leão and al., 2017, [11].	As far as possible, reference period = 5 years preceding the inventory creation period
Greenhouse heating and materials	Statistics (national / regional) per specific crops. If not available: expert opinion, literature and field data. Advised literature regarding greenhouse materials: recent report from PRE Consultants and Wageningen University [12]	As far as possible, reference period = 5 years preceding the inventory creation period
Fuel use	Statistics (national / regional) per specific crops. If not available: expert opinion, literature and field data. Advised literature regarding fuel use ?	As far as possible, reference period = 5 years preceding the inventory creation periods

d. Application to Agribalyse within Eco Food Choice Project

APPLICATION TO AGRIBALYSE

In a future version of this report, the extrapolation choices made for the new inventories to be built for Spain, Germany and the Netherlands, based on Agribalyse inventories, will be detailed here.

4. Transposing animal production inventories, at farm gate

a. Hotspots to consider

The diagram below summarises the hotspots to be considered when extrapolating animal production life cycle inventories, distinguishing between first-rank parameters (the most important/relevant from an environmental point of view to be adapted), and second-rank and third-rank parameters. These parameters were identified by analysing hotspots along the food chain, by product category (see appendices 1 and 2).

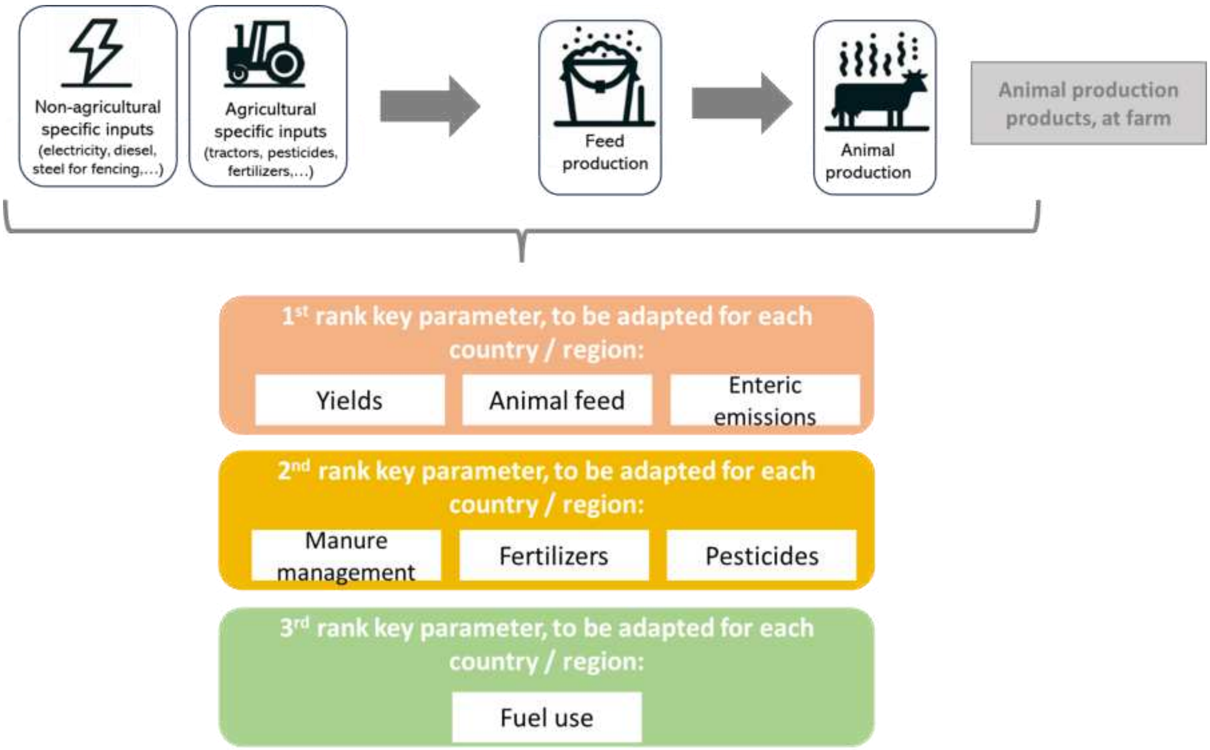

Figure 9: hotspots to consider when modelling animal production LCIs

WARNING REGARDING SEAFOOD PRODUCTS: It is important to note here that the figure 9 above is relevant for agricultural products, but hotspots are quite different for fish / seafood.

- Within cultivated fish and seafood (aquaculture), yields, feed composition are first rank parameters, and ideally additional data on feed composition should be adapted such as country of origin or fertilization.
- Within wild-caught fish and seafood, fuel consumption (diesel and its associated emissions) during fishing, and transport across the supply chain is the first rank parameter; ideally packaging and perhaps infrastructure (ships) could be adapted. Biodiversity impacts of fishing are also very diverse depending on geographical areas, and extrapolation would need to account for this dimension. Sea biodiversity indicators are however still at a "research stage" and not available in LCI databases.

b. Guidelines on the parameters to be adapted as a priority

Yields (1st rank-parameter)

As for plant products, yield data per year and per production for animal-based products is a key parameter with a strong influence on impact results that should be adapted, particularly when farming practices differ greatly from one country to another. By "yields" we refer to growing speed of the animals and the associated losses. This data is easily accessible, through national statistics for example, but this parameter hides different sub-parameters, such as the feed conversion ratio, which is a key parameter for animal production.

Animal feed and fodder (1st rank-parameter)

Animal feed and fodder composition, including feed additives (micronutrients) is a key parameter with a strong influence on impact results that should be adapted, particularly when farming practices differ greatly from one country to another. The feeds are in many cases traded worldwide and some databases provides data for most commodities. Besides, for certain feed products, there is a high variability of practices (and thus impacts) between countries (for instance soybean which can be a source of deforestation in some parts of the world and not in others), and between databases (depending on modelling choices). This means that not only feed composition is important, but also origin, and modelling choices of the feed (for instance, impact of Brazilian soy is very different between ecoinvent and GFLI).

An extra step is adjusting farming practices of each feed type, but regional data can be difficult to obtain. For animal feed produced in the country of extrapolation (i.e. domestic feed), the same rules as for plant products intended for human consumption (refer to chapter 3) can be applied. For imported feed produced, finding the best proxy representative of agricultural practices in the importing country may be sufficient. As much as possible, consistency between feed and yield should be ensured as those aspects are very strongly correlated: ie yield should not be strongly modified without changing feeds and vice versa. To a lesser extent, changing the feed ration (ex : ingested volume, switch from cereals to grassland) can also change enteric and manure emission. Therefore it is important to ensure the overall consistency of the final LCA.

Enteric emissions (1st rank-parameter)

Enteric emissions are identified as a hotspot for animal products. Enteric emissions are usually model based, so models could be adapted for extrapolation, focusing on the animal feed composition for each specific husbandry and country.

Manure management (2nd rank-parameter)

Manure management emissions are identified as a potential hotspot for animal products, and the high variability in manure management practices across countries should be reflected. These practices depend on local policy preferences, local natural variables (like temperature), costs, and practicality. Manure management is usually model based, so the models could be used for adjustment, focusing on the differences in the model's parameters depending on the management processes.

Fertilizers and pesticides (2nd rank-parameter)

See above. These parameters concern animal feed and have a major influence on the impact of animal products.

Fuel use (3rd rank parameter)

See above. This parameter concerns animal feed and has a major influence on the impact of animal products.

c. Guideline regarding data sources

As for general considerations regarding data sources, refer to chapter 2 – section d. Specific recommendations regarding data sources when modelling animal production:

Parameter to be adapted by country/region	Data sources	Remarks
Yields	Statistics (national / regional) per specific crops. If not available: FAOStat or Eurostat	As far as possible, reference period = 5 years preceding the inventory creation period
Animal feed	Feed statistics (national / regional). If not available: expert opinion, literature, and field data.	As far as possible, reference period = 5 years preceding the inventory creation period
Enteric emissions and manure management	Statistics (national / regional) per specific crops. If not available: expert opinion, literature and field data.	As far as possible, reference period = 5 years preceding the inventory creation period

Regarding crops yields, fertilizers, pesticides and fuel use: see chapter 3 above.

d. Application to Agribalyse within Eco Food Choice Project

APPLICATION TO AGRIBALYSE

In a future version of this report, the extrapolation choices made for the new inventories to be built for Spain, Germany and the Netherlands, based on Agribalyse inventories, will be detailed here.

5. Transposing food item production inventories, at consumer plate (including food processing, packaging, distribution, retail, preparation, end of life)

a. Hotspots to consider

The diagram below summarises the hotspots to be considered when extrapolating food products life cycle inventories, focusing on post-farms operations, and distinguishing between first-rank parameters (the most important/relevant from an environmental point of view to be adapted), and second-rank and third-rank parameters. These parameters were identified by analysing hotspots along the food chain, by product category (see appendices 1 and 2).

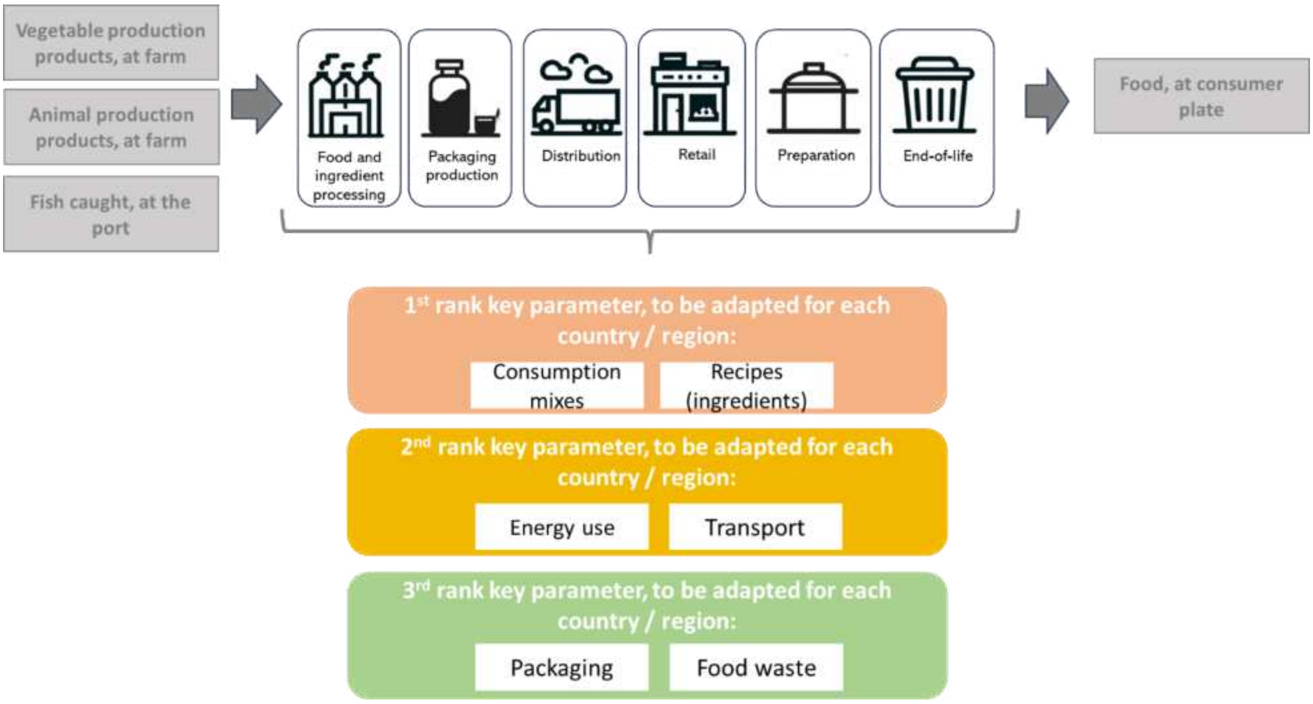

Figure 10: hotspots to consider when modelling food products (after agricultural/aquaculture and fishing phase)

In the case of plant-based foods, impacts were found to be more spread through the life stages. On the other hand, for animal-based food, the weight of the agricultural phase is often very dominant, compared to other impacts in the life stages. For plant-based food, some hotspots could be found in transportation (for fruits and vegetables), for preparation at consumer's house (for food products that need to be boiled or cooked in the oven like pasta or pizza), and packaging for beverages (milk, fruit juice) that can come in glass packaging.

b. Guidelines on the parameters to be adapted as a priority

Consumption mix (1st rank-parameter) and national average production

Origin of raw agricultural product consumed by consumer in each country is a key element that has a strong influence on impact results. Indeed, it is particularly important to adapt the "consumption mixes" for products that are massively imported (such as oil cakes used in animal feed and lot of fruits). To avoid collecting data that is too laborious, a cut-off point can be defined, as was done in Agribalyse (cut-off at 70% meaning that the origin detailed by country has been researched to reach a minimum of 70% of the total product consumed in the country).

Recipes (1st rank-parameter)

Composition of food items (ingredients and relative proportions) is a key element that has a strong influence on impact results. However, for the majority of products, we can assume that industrial recipes do not vary much from one country to another. As a result, if data is not available (which could be the case, as companies do not tend to be willing to share recipes), we recommend adjusting only the products that use meat (because, in this case, adaptation will have a particular impact); or check for a sample of products, in particular animal products, whether the composition of the initial LCI seems relevant.

Energy use (2nd rank-parameter)

Energy use is not the most important key parameter, but as energy mixes are easy to adapt, we recommend adapting the energy mix (country-specific) but not the energy used for each process. Specific attention could be taken when using cooling agents, which could have a potential GHG impact and there can be variability across countries (due to different ways to implement European regulation, different market dynamics and capacities). Greater attention must be paid regarding energy use for greenhouse cultivation in cold countries that need heating.

Transport (2nd rank-parameter)

Transport is usually an important hotspot, and has different components: the import, sometimes over long distances, of agricultural and food products from a country of production to the country of consumption, but also transport within the same country between the manufacturing plant, the distribution platform and the shop where it is purchased by the consumer.

Even if the transport is not the most important key parameter, since default data could be estimated with robust rules without the need for national primary data, it is appropriate to adapt it. As far as possible and to be consistent we recommend adjusting a minima transport of foodstuffs linked to imports at the same time as consumption mixes (considering the different countries of origin).

For some product categories or some specific territories where imports are high, particular attention could be paid to fragile products with a short shelf life (fruit and vegetables), which are more likely to travel by air.

Packaging (3rd rank-parameter) & packaging waste

The packaging is not identified as a hotspot unless for glass packaging (for instance for drinks) or for products sold in unit doses with small quantities (ex: teabags, candies) or containing ingredients with relatively low impact. It therefore seems appropriate to check the packaging material used for each product (e.g. in Agribalyse, spices are packaged in glass because this is the main container for spices sold on the French market: is this the case in other countries?). By default, it seems acceptable in most cases to keep original data, as there is no high variability across countries (in the weight of wine bottles, for example, across countries). However, the user of the method may need to pay particular attention to this point, especially when it is established that the packaging for a specific product category differs greatly from one country to another, due to consumer habits (milk is typically sold in plastic bottles of 1 gallon in US, and in 1L tetra pack/bottles in FR) and regulations (major changes are underway in the regulations governing plastics in Europe, for example), or for products where packaging is known to account for a significant proportion of the impact (beverages, over-packaged products such as coffee capsules or biscuits, etc.).

Food waste (3rd rank-parameter)

Food waste and loss are considered a relevant parameter, playing a big role in some product categories (mostly vegetables and fruits). Accounting for food waste could be relevant for some stages like agriculture, households, transportation, and storage; hence, it could affect the results. Data gathering could be difficult, but within Europe, a suggestion would be to use European statistics (EU default values exist, but also country-specific values for some countries). Waste structure differs a lot between "industralised countries", with strong infrastructure and reliable "cold chain", where losses happen mostly at the consumer stage. On the opposite, in developing countries waste are more important along the production chain, but usually reduced at the consumer level. If extrapolation is applied to "developing countries", a specific attention should be given to adapt properly waste ratios.

c. Guideline regarding data sources

As for general considerations regarding data sources, refer to chapter 2 – section d. Specific recommendations regarding data sources when modelling food products:

Parameter to be adapted by country/region	Advised data sources	Remarks
Consumption mixes (=origin of agricultural products)	National and European statistics (Eurostat) FAOStat: Data should be used with caution and compared with other sources, since many foodstuffs transit through certain countries and are therefore included in the statistics.	As far as possible, reference period = 5 years preceding the inventory creation period
Recipes (=ingredients)	These data could be hard to collect, as few national statistics exist (public or private). Open Food Facts can be a relevant source of information.	As far as possible, reference period = 5 years preceding the inventory creation period Or latest data (no great yearly fluctuations)
Energy use	National or European statistics (Eurostat) regarding the source of energy used (energy mixes). Regarding the energy consumption (for cooling, freezing, lighting and heating and at distribution	As far as possible, reference period = 5 years preceding the inventory creation period

	and retail), PEF guidelines provide default values.	Or latest data (no great yearly fluctuations)
Transport	European statistics (Eurostat) By default, we recommend to use the default values of transport distances defined in the PEF guidelines.	As far as possible, reference period = 5 years preceding the inventory creation period Or latest data (no great yearly fluctuations)
Packaging	National statistics (public or private). Open Food Facts can be a relevant source of information : example of the data collection campaign "Plein pot sur les emballages [17]" in France in 2023 European statistics regarding the end of life of packaging (composting - recycling - incineration - landfill) to each country for all packaging materials (glass - cardboard - plastic)	As far as possible, reference period = 5 years preceding the inventory creation period Or latest data (no great yearly fluctuations)
Food waste	National or European statistics (Eurostat [18]). Default values for food losses are defined by food category in PEF guidelines (see annex F of the Organisation Environmental Footprint methods [13]) To find out more, the European Commission has set up a framework for monitoring Member States' food waste levels, one of the aims of which is to track changes in food waste levels, including levels of food waste on their territory. The first food waste data reporting exercise was carried out in 2022 based on 2020 data. Ongoing projects: Wastewise, and FOLOU	As far as possible, reference period = 5 years preceding the inventory creation period Or latest data (no great yearly fluctuations)

d. Application to Agribalyse within Eco Food Choice Project

APPLICATION TO AGRIBALYSE

In a future version of this report, the extrapolation choices made for the new inventories to be built for Spain, Germany and the Netherlands, based on Agribalyse inventories, will be detailed here.

6. Conclusions & perspectives

National food LCI databases are needed to support the development of ecolabelling at scale. Considering the diversity of food products and the limited number of public LCI data available, rigorous extrapolation approach is a cost effective, and sometime the only realistic approach, to build large number of new national datasets and address ecolabelling needs. Extrapolation is a common practice by LCA practitioners, but little formalised guidance is available until today.

In coming months, 90 new datasets for food products consumed in Germany, Spain and The Netherlands, will be built by extrapolating from Agribalyse datasets, applying this guideline. Agribalyse was chosen for this task as it is one of the most complete national databases. This data will then be used and analysed in the rest of the project, providing feedback which will enable us to refine this guideline in 2025.

This method was developed based on hotspots highlighted regarding environmental assessment of food products and therefore of elements already included in life cycle inventories. However, it is important to note that other parameters currently not included in life cycle inventories (because they are not used in impact methods—but could be in the future) would be important to take into account, such as cultural and landscape diversity (crop rotation, structural elements like hedges, groups of trees…, etc.) as well as antibiotics used, or land use change. Depending on the progress of the other tasks in WP2 of the Eco Food Choice project, it may be necessary to complete data collection on certain points.

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Appendix 1 – Matrix of hotspots per product categories

This document contains the matrices produced for the hotspot analysis of food product categories. It can be consulted here: Appendix 1 – Matrix of hotspots per product categories. Context on how it was developed, and key information on how it can be used, is contained in detail in Appendix 2.

Tabs include:

- Literature Review : this tab contains the hotspot matrix for the different food categories across different papers. Specific annotations on the irrigation and greenhouse life cycles are located at the right end of the matrix.
- Literature Review References : this tab contains the list of references utilized in the literature review.
- Primary Foods : this tab contains a similar matrix as the one used for the literature review, but with the addition of the specific hotspot scores.
- Processed products : this tab shows the impacts of the processed products that can be found along thirty separated tabs named after the general processed food category analyzed. In each tab, there is a list of food products belonging to that food category, with the hotspot scores.
- Recipes : this section includes the tables built for the comparison of similar meals that follow different recipes. The Life Cycle stage with the highest impact is shown for four impact categories, with the impact contribution associated with the ingredients that contribute the most in that Life Cycle stage.

A hotspot is defined as a combination that contributes 10% or more to an environmental impact category, which contributes 10% or more to the single score. A "hotspot score" for each life cycle stage was defined as the share of the selected impact categories for which the life cycle stage contributes more than 10%.

Appendix 2 – Hotspot analysis methodology

Conducting a hotspot analysis provided a starting point for identifying which parameters had to be prioritized in the efforts to build the transposition methodology. We wanted to reach a balance between representativeness, reliability, and efficiency without mobilising significant resources and time (because this would defeat the advantages of transposing a database compared to building one from scratch).

For the hotspot identification, a literature review and a quantitative analysis of the different food categories were conducted. It was concluded that using both methods would increase the availability of robust data and, therefore, the consistency of the study. The food categories of the analysis followed the categorization used in the Individual and National Studies on Food Consumption (INCA[1]), carried out in France. INCA groups food products into 44 categories based on the European Food Safety Authority nomenclature (FoodEx2 system) and linked with the nutritional composition data of the Ciqual table (a database on the nutritional composition of the most consumed foods in France), considering the specific characteristics of the foods consumed. We acknowledge that Agribalyse uses Ciqual categorization (which groups food based on their nutritional composition), however, for the purpose of this study, we have decided to group these categories according to the INCA categorization for the sake of simplicity.

The system boundaries of our analysis were cradle-to-grave, including all potential impacts across the life cycles (LC). Within this framework, we identified and defined one main subdivision: the agricultural stage and all the subsequent stages. For the agricultural phase, we defined 15 additional sub-parameters to cover all food products, both plant and animal based. These parameters were identified through a comprehensive literature review, which also led to the inclusion of additional parameters related to agricultural practices.

Agricultural stage parameters:

- Feed production
- Animal raising
- Manure management
- Building/Farm
- Animal emissions (enteric fermentation)
- Lifetime animal productivity
- Fertilizers
- Field emissions
- Pesticides
- Irrigation
- Breeding mechanization
- Field mechanization and fuel use
- Yields
- Greenhouse heating
- Greenhouse building

Other stages:

- Consumption mix
- Recipe
- Transport
- Energy mix
- Industrial process/Food processing
- Packaging
- Water use
- Waste management
- Cooking/Consumption
- Food loss and waste

[1] INCA surveys are carried out by the French Agency for Food, Environmental and Occupational Health & Safety (ANSES), to assess food-related health and nutritional risks and benefits in France. The last INCA survey (INCA3) was launched in 2014–2015.

Literature review

A critical review of papers focusing on LCAs of food categories and food systems was conducted. The keywords for the search criteria were "review LCA food system," "LCA food review," and "LCA systemic review food." This literature review helped highlight gaps or inconsistencies, becoming a preliminary step to guide the quantitative analysis.

Out of the 55 papers analysed, 10 were excluded because they lacked data on the impact assessment of food categories. The reviewed papers were published between 2004 and 2024, with 60% of them being released in the past five years, and most of the LCAs focused on European countries to ensure better representation. Among the final 45 papers included in the literature review, 70% employed cradle-to-grave system boundaries, while the remaining 30% used a cradle-to-gate approach. The impact assessment method and database used in the reviewed papers were recorded, together with a quick evaluation of the data availability and reliability for each paper. The most mentioned database among the literature reviewed was Ecoinvent, and the most used impact assessment methods were ReCiPe and CML.

A matrix was constructed to identify hotspots for the same food category across different papers. The food products analysed in each paper were on the left, and the LC stages were described at the beginning and at the top. The identified hotspots in papers were marked with an "x" on the matrix, and the LC stages not mentioned in the paper or not part of the LC of that product were coloured in grey (Figures 11 and 12). In total, 51 different food products were analysed, covering both agricultural and processed food products.

The initial literature review had ambiguous conclusions regarding the irrigation and greenhouse life cycle stages. To clarify why these stages were identified as hotspots in some cases, a more specific review was conducted. The additional articles analysed for this purpose are already included in the 45 final studies mentioned.

		Agricultural processes														
Paper ID	Food items	Feed production	Animal raising	Manure management	Building/ Farm	Animal emissions (enteric fermentation)	Lifetime animal productivity	Fertilizers	Field emissions	Pesticides	Irrigation	Breeding mechanization	Field mechanization (fuel use)	Yields	Greenhouse heating	Greenhouse
10	Rice (non-organic)							x					x			
10	Rice (organic)			x										x		
11	Citrus fruit (orange, lemon, mandarin)							x		x			x			
12	Milk	x		x	x											
13	Dairy (milk, yoghurt, cheese, but	x		x	x	x										
14	Mozzarella	x				x										
15	Poultry (chicken)	x														
15	Poultry (egg production)	x														
16	Fish and seafood															
17	Wine							x		x			x			
18	Apple							x		x	x		x			
18	Peach							x		x	x					

Figure 11: Part of the matrix constructed for the literature review analysis of the agricultural life cycle stages.

Paper ID	Food items	Consumption mix	Recipe	Transport	Energy mix	Industrial process / Food processing	Packaging	Water use	Waste management	Cooking	Food loss and waste
10	Rice (non-organic)					x					
10	Rice (organic)					x					
11	Citrus fruit (orange, lemon, mandarin)										
12	Milk										
13	Dairy (milk, yoghurt, cheese, butter)					x					
14	Mozzarella	x		x		x	x				
15	Poultry (chicken)	x									
15	Poultry (egg production)										
16	Fish and seafood						x		x		x
17	Wine						x				
18	Apple										
18	Peach										

Figure 12: Part of the matrix constructed for the literature review analysis of the processing life cycle stages.

Quantitative analysis

Plant-based and animal products (fruits, vegetables, meat, raw milk…)

The relative contribution of the abovementioned LC stages to the single score and to individual environmental impact categories was determined for 70 products from Agribalyse (version 3.1). SimaPro software was used to extract the LCIA results using the impact assessment method "EF v3.1 method". These products consisted of 32 fruit species, 15 animal product species and 23 crops from arable cropping and vegetable cultivation. From these results, a score reflecting the importance of a hotspot was determined.

First, the relative contributions of the environmental impact categories to the single score of the EF method were determined for all 70 products, and the categories contributing more than 10% to the single score were selected for further study. Next, each background process from Agribalyse was allocated to the predetermined LC stages, so that the relative contribution of each LC stage to the selected categories could be determined. If this contribution was larger than 10%, this combination of LC stage and impact category was marked as a hotspot. A hotspot is thus defined as a combination that contributes 10% or more to an environmental impact category which contributes 10% or more to the single score. A "hotspot score" of each LC stage reflects for how many of the selected impact categories the LC stage contributes more than 10%.

The same matrix as the one for the literature review was used for the hotspot identification (Figure 13). Green cells include a hotspot score for the importance of the hotspot and orange indicates it cannot be determined if this LC stage is a hotspot; grey means the LC stage does not occur in the products supply chain.

Several classification issues arise which did not limit the high-level learnings taken from this analysis: it was challenging to identify all relevant processes for feed production, building and infrastructure and animal raising. On the other hand, it was also challenging to separate manure management and enteric fermentation from other animal farm emissions and to separate irrigation from other crop cultivation activities, occurring in the same background processes. While yield, cultivation type/import mix and energy mix are influential factors, these could not be seen as an LC stage and hence not as a hotspot.

		Agricultural processes											
Food items	PROPOSED FOOD CATEGO	Feed production	Animal raising / Fishery	Manure management (AB-An: LU)	Building/ Farm (AB: Capital Goods)	Animal emissions (enteric fermentation)	Lifetime animal productivity	Fertilizers	Field emissions (AB-An: E for Feed)	Pesticides	Irrigation	Breeding mechanization	Field mechanization (fuel use) (AB-An: E for animal raising)
Mussel	Crustaceans and mollusks				40%				60%				
Egg	Eggs and egg-based dishes	80%	60%	20%									
Salmon	Fish	100%		20%				20%					
Tuna	Fish								80%				
Pear	Fresh and dried fruit								50%				
Pineapple	Fresh and dried fruit							100%	75%				
Plum	Fresh and dried fruit								50%				25%
Raspberry	Fresh and dried fruit							25%	100%				
Red berries (raspberries)	Fresh and dried fruit							25%	100%				
Pork Chop	Meat (excluding poultry)	80%	80%	20%									
Veal Mince	Meat (excluding poultry)	100%	80%						20%				
Cassava	Potatoes and other tubers								75%				
Chicken Breast	Poultry	80%	60%	20%									

Figure 13: Part of the matrix constructed for the quantitative analysis of three product groups. Non-agricultural LC stages were assessed but are not shown.

Processed foods (cheese, bread, meals...)

The relative contribution of the mentioned LC stages to the single score and to individual environmental impact categories was also determined for 1574 processed products from Agribalyse 3.1. SimaPro software was used to extract the LCIA results using the impact assessment method EF v3.1 method. These products consisted of 30 different categories of food in total.

In this analysis, the LC stages included were the agricultural phase, transport, industrial process, packaging, cooking/consumption, and supermarket/distribution. A matrix for each INCA product category was developed (Figure 14); in the process, the Ciqual categories used in Agribalyse were associated with the INCA categories. According to the abovementioned hotspot criteria, contributions of less than 10% were not included in the matrices.

Refined bread and dry bakery products							
CIQUAL code	Food items (LCI name grouping)	Agricultural phase	Transport	Industrial process / Food processing	Packaging	Consumption / Cooking	Supermarket & distribution
7258	Bagel	65%		27%			
7300, 7330, 7310	Rusk	50%		33%			
38500, 7430, 7432	Croutons	85%					
7352	Puffed rice textured bread, wholemeal	81%					
7525	Grissini or bread stick	63%		23%			
7115	Bran grain bread	50%		37%			
7260	Bread, home-made, with flour for home-mad	54%		35%			
7225	Brioche or Vienna bread	67%		17%	11%		
7012	Bread, French bread, ball, 400g	54%		35%			
7261	Country-style bread, home-made (with flour	54%		35%			
7112, 7200	Sandwich loaf	59%		24%	12%		
7125	Rye bread, and wheat	52%	12%	33%			

Figure 14: Part of the matrix constructed for the quantitative analysis of processed food

Lastly, an impact assessment of processed foods with different recipes was carried out to know how their variability can influence impact results. Four different meals selected from Agribalyse 3.1 were run in open LCA, obtaining the LCIA results with the EF v3.1 impact assessment method.

Similar meals with different recipes were selected for the analysis, such as ravioli with different fillings or pizzas with different toppings. We focused on the environmental impact categories with higher impact after normalization and then examined the processes and sub-processes within the meals that contributed the most to these impacts. The results of similar meals were compared to see the effect that different ingredients had on total environmental impacts, as shown in Table 1.

Additionally, because previous analyses had revealed that animal-based food had higher impacts, meals with recipes with and without meat were compared to increase the results' robustness and confirm the hypothesis that most of the impact in meals that contained animal-based ingredients was due to these ingredients.

CLIMATE CHANGE					
	Process	% of total impact	Sub process	% of total impact	kgco2eq
Fresh pasta, stuffed with meat (e.g. bolognese-style ravioli)	Fresh pasta, stuffed with meat, raw, at plant	96,45	**Ground beef, fresh, for processing - FR**	**85,08**	**11,7425**
			Chicken egg, raw, without shell, at plant - FR	4,74	0,6548
			Parmesan cheese, from cow's milk, at plant {FR} U - FR	4,16	0,573
			Wheat flour, at industrial mill - FR	1,43	0,197
			Cooking, industrial, 1kg of cooked product - FR	1,02	0,140
Fresh pasta, stuffed with cheese and vegetables (e.g. ravioli)	Fresh pasta, stuffed with cheese (e.g. ravioli), raw, at plant - FR	83,68	**Hard cheese, emmental-type cheese, reduced fat, at plant - FR**	**46,29**	**1,389**
			Chicken egg, raw, without shell, at plant - FR	**12,42**	**0,372**
			Butter, 82% fat, unsalted, at dairy - FR	**11,62**	**0,348**
			Wheat flour, at industrial mill - FR	7,42	0,222
			Cooking, industrial, 1kg of cooked product - FR	4,69	0,140
			Parsley, peeled, at processing - FR	1,25	0,037

Table 1. Impact assessment results for the climate change category. Own sources.

Appendix 3 – Review of existing extrapolation methods

As stated in the introduction, we naturally began our extrapolation work by reviewing what had already been done. We quickly concluded that no study had previously aimed to extrapolate an entire database from one country to another. Nevertheless, we found five studies that could be of interest to us.

Three studies particularly focus on the extrapolation of the agricultural upstream of the food value chain. The other two focus on downstream issues. We will detail in this appendix what can be learned from each study and the lessons they have taught us in developing our method.

The table below provides a comparative summary of the main methodological choice made in each study.

Method	Agricultural part	Following steps
French organic LCI (ADEME)	Yield, fertilizers, pesticides, irrigation, and mechanization. *NO extrapolation for animal products*	/
MEXALCA (Agroscope)	9 farming operations estimated **only with crop yields**: tillage, machinery use, variable machinery, NPK, fertiliser use, pesticide use, irrigation, and drying.	/
HESTIA (Oxford University)	Provide models to Gap-fill missing data using geospatial datasets and lookup tables.	/
French West Indies (ADEME)	/	Electric mix, water production, transport phase, waste management.
Australian database (TimGra/Eco2)	/ *Specific Australian datasets for a selected range of products.*	Transports phase, energy production. ***No extrapolation of transformation process.***

French organic LCI (Ademe)

Construction of LCIs for organic agricultural products: Extrapolation from conventional inventories in Agribalyse. Gingko21, 2023 [8].

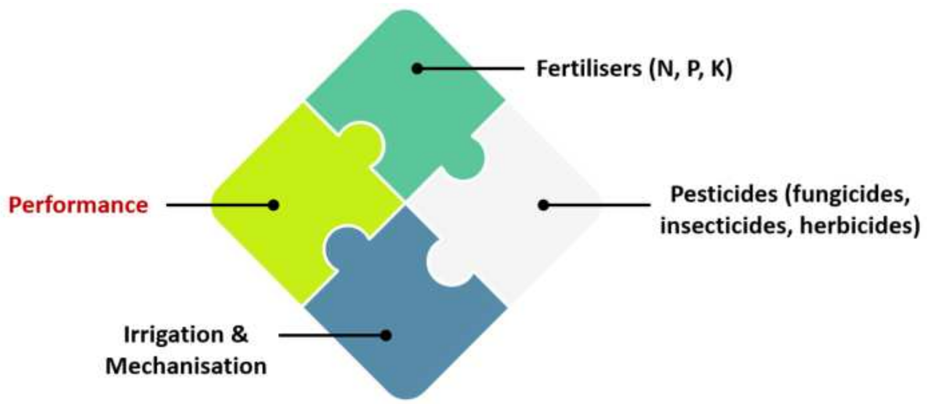
The French Ministry for Ecological Transition has asked ADEME to study the environmental labelling of food products. To do this, we need life cycle inventories (LCIs) for organic products in France. The aim of this study is to write a method for extrapolating organic LCIs from conventional LCIs from Agribalyse.

Given the complexity of the work and the time available, the work was carried out on crop production, but not on animal production (which would have required additional parameters to be considered: animal feed, buildings....). Some LCIs have also been excluded from the extrapolation because they are not relevant to organic farming (crops grown in heated greenhouses, fishery products....).

The study extrapolated 369 'raw' LCIs and 279 'parent' LCIs. The 'parent' LCIs include the national average and the consumption mix, extrapolated in the same way for organic farming (AB), assuming that the consumption mix is the same as for conventional farming. The proxies also remain the same: for example, the LCI for artichokes is approximated by that for cauliflower in conventional farming, and the same for organic farming.

This approach, based on consumption mixes and proxies, was a great inspiration for our extrapolation method.

The large-scale extrapolation approach consists in selecting the key parameters to be modified (the other flows remaining unchanged), these parameters being chosen based on a review of the literature and discussions with experts and members of the monitoring committee. The method has chosen to focus on four main categories of agricultural upstream parameters, as shown in the diagram below:



We can go into more detail on each of these categories and retain what interested us for our extrapolation method:

<u>Performance = yields</u>: For each product, determination of a yield ratio, corresponding to the difference between AB (organic farming) and AC (conventional farming) yields.

- ➔ If ratio available in SSP (Shared Socio-Economic Pathway) report or "Cour des Comptes" report: exact values were considered.
- ➔ Otherwise, a tiered approach is applied:
- Difference between -80% and -35% => ratio of -45% applied
- Difference between -35% and -20% => ratio of -25% applied
- Difference between -20% and 0% => difference of -10% applied

Fertilizers: Replacing all mineral fertilisers with a unique mix of organic fertilisers*:
- calculation of the amount of mineral nitrogen in conventional LCIs
- calculating the quantity of organic mix to be applied
- replace all fertilisers with the organic fertiliser mix
- modulation according to yield (AB/AC ration)

Fungicides: removal of all conventional fungicides and addition of copper and sulphur (quantities taken from organic LCIs in Agribalyse, or data from ANSES, failing which dose calculated based on the IFT, by comparison with quantities taken from organic LCIs in Agribalyse).

Insecticides:
- Classification of crop production into two categories according to insecticide requirements (based on IFT (in French "Indicateur de Fréquence de Traitements phytosanitaires", meaning Indicator of Frequency of Phytosanitary Treatments) and conventional production)
- If sensitive production (IFT > 1.2): conventional insecticides replaced by insecticides authorised in AB -> only the case for arboricultural production (taking a % of the maximum authorised dose depending on the IFT: 30% - 60% or 100%).
- Otherwise: no insecticides

Irrigation: an AB/AC ratio built by category, based on existing LCIs in Agribalyse.

Mechanisation: same process (comparison kg of diesel ha/year) > only processes linked to a key parameter (fertiliser and pesticide spreading, tillage, etc.) have been adjusted. The others (transport, drying, sowing, etc.) have been left unchanged.

Mexalca (Agroscope)

Modular extrapolation of crop LCA (MEXALCA): Sensitivity to varying crop yields. K. Weiler et al. 2010. [7].

LCA's are often limited by the lack of data specific to different production systems around the world, making them costly and time-consuming to carry out. To overcome this limitation, several simplified methods have been developed, including MEXALCA (Modular EXtrapolation of Agricultural Life Cycle Assessment).

This study relies on FAO statistical data for its extrapolations, and is limited to agricultural life cycle inventories, without taking subsequent stages into account.

The study focuses on 9 key agricultural operations: tillage, machinery use, variable machinery, NPK fertiliser, fertiliser use, pesticide use, irrigation, and drying.

The method used to estimate these key agricultural parameters from yields has been detailed earlier in the report to compensate for the lack of specific data. Below is a summary diagram of this principle.

The results of the study underline the importance of yield in estimating environmental impacts, and demonstrate that increasing yields, although associated with an intensification of inputs, can lead to reductions in impacts per unit of product.

MEXALCA proves to be an effective method for generalizing the environmental impacts of agricultural crops, while considering geographical and temporal variations in yields and can thus be a valuable tool for strategic decision-making and understanding large-scale production variability.

Hestia (Oxford University)

HESTIA, which stands for "Harmonized Environmental Storage and Tracking of the Impacts of Agriculture", is distinguished by its ability to store agricultural datasets in a consistent format, facilitating their analysis and use. This method also makes it possible to fill gaps in missing data.

French west indies (Ademe)

Adapting the Agribalyse Life Cycle Inventory database to French overseas territories: Réunion, French Guiana, Martinique, Guadeloupe. EVEA-ADEME, 2024 [9].

The context of this study is the need to adapt the AGRIBALYSE database, specifically version 3.1.1, to the French overseas territories. The main objective was to produce a version of AGRIBALYSE adapted to four territories: Guadeloupe, French Guiana, Martinique and Réunion.

The main difficulties encountered concerned data collection, particularly the origin of products, which often differs from that of mainland France. To overcome these difficulties, various hypotheses and models were developed to contextualize the data to the local specificities of these territories.

The adaptations made focus on six downstream stages in the food value chain. This parameter selection was a first step in the analysis of hotspots for our extrapolation method:

- Adaptation of electricity mixes: Electricity mixes have been adjusted to reflect the specific sources and distribution of electricity production in each territory.
- Adaptation of tap water: Water purification technologies have been adapted to take account of local water extraction compartments and electricity mixes.
- Adaptation of transport stages: Transport distances and modalities (sea, air and road freight) have been modelled according to the geographical and logistical realities of each territory.
- Organic waste management: Organic waste treatment processes were adapted according to the local channels available in each region.
- Packaging waste management: Packaging waste treatment processes were also modified to match local infrastructures and practices.
- Modelling value chain configurations: Three value chain configurations were defined for each territory, taking into account the provenance of raw products and their processing either in mainland France or locally.

The main conclusions of the study underline the importance of focusing on these six stages to obtain representative results on the environmental impacts of food products in overseas territories. In particular, the agricultural production stages have not been adapted, considering that production methods and impacts remain constant whatever the territory.

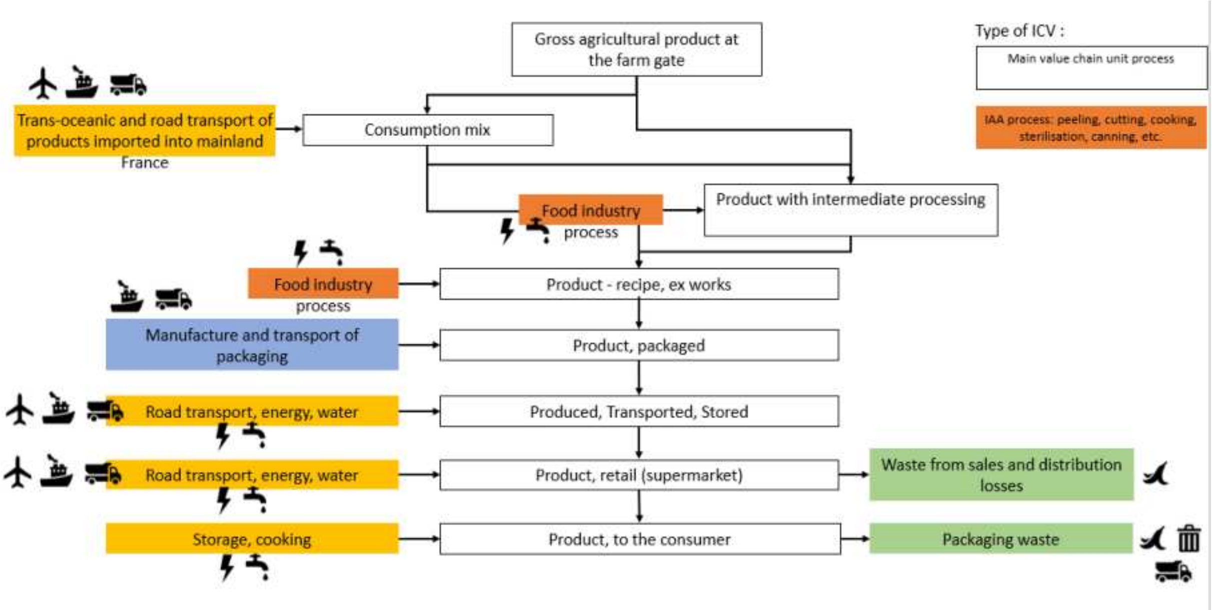


Figure 15. Stages in the value chains of the food products in Agribalyse and changes in the processes where LCIs are adapted

Australian database (TimGra/Eco2)

Adapting the Agribalyse Life Cycle Inventory database to Australia – a first step towards a comprehensive Australian food and agriculture model. Paul-Antoine Bontinck, 2022 [4].

The Agribalyse adaptation study for Australia aims to produce a local version of the Agribalyse v3.1.1 database, using Australian-specific data while maintaining the general structure of the database.

The environmental assessment is carried out using PEF method (Fazio et al., 2018 [10]), weighted into a single score (Sala et al., 2017 [19]). A key assumption is that, although electricity and water needs are similar between France and Australia, the impacts of their production differ, thus requiring a model specific to the Australian network. Water production and road transport are modelled using an Australian specific database (ALCAS, 2021 [20]).

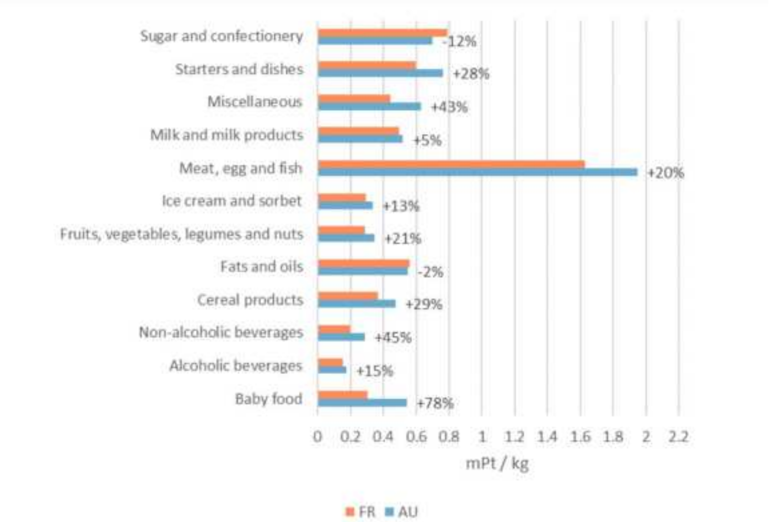


Figure 16: Comparing Australian single score results against the original Agribalyse models.

The study on adapting Agribalyse for Australia showed that electricity and water requirements differ between France and Australia. Primary production models, such as for tomatoes and strawberries, revealed significant variations. The food processing stages also need to be adapted to the Australian context. Figure 16 shows that **electricity production mixes can vary the single score of a product considerably.**

This approach allows Agribalyse to be better adapted to the Australian context and improves the accuracy of environmental assessments to support sustainable consumption practices in Australia.

Conclusion

In conclusion, the aim of this review work was to create an innovative method, avoiding duplication of what had already been achieved in previous studies. Although these studies provide solid foundations and varied approaches for extrapolating agricultural and food data, our ambition was to develop a more comprehensive and adapted method, capable of handling a dataset at any scale. On the lessons learned from these five studies, we have designed a unique approach that specifically addresses the needs of our project and overcomes the limitations identified in previous work.

Appendix 4 - Main methodological assumptions regarding Agribalyse data

Below a summary of the main methodological assumptions regarding Agribalyse database. For a complete overview, refer to Agribalyse documentation: https://doc.agribalyse.fr/documentation-en/agribalyse-data/documentation

- **Agribalyse's structuring methodological choices to be taken into account**

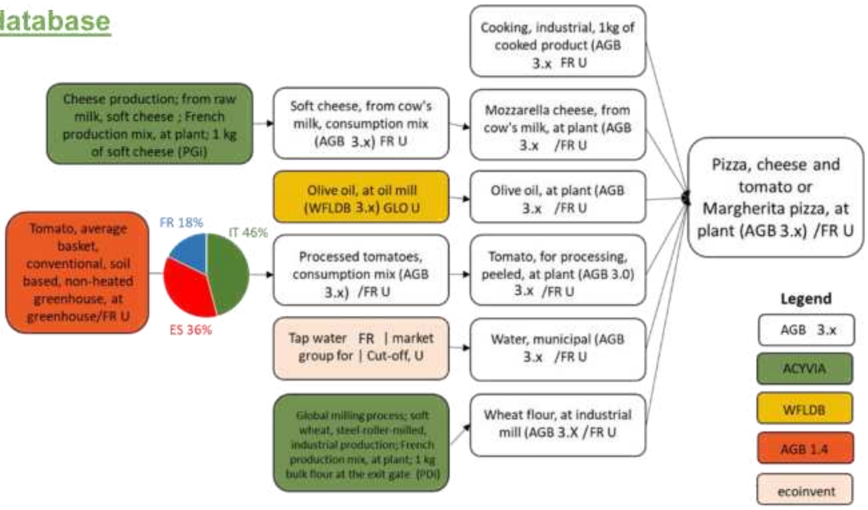
Structuration of the database

- Variable data sources (for imported products) may lead to methodological discrepancies
- Priority in data selection :

In general :
AGRIBALYSE > Ecoinvent > WFLDB

For Agribalyse datasets :
National average > Conventional

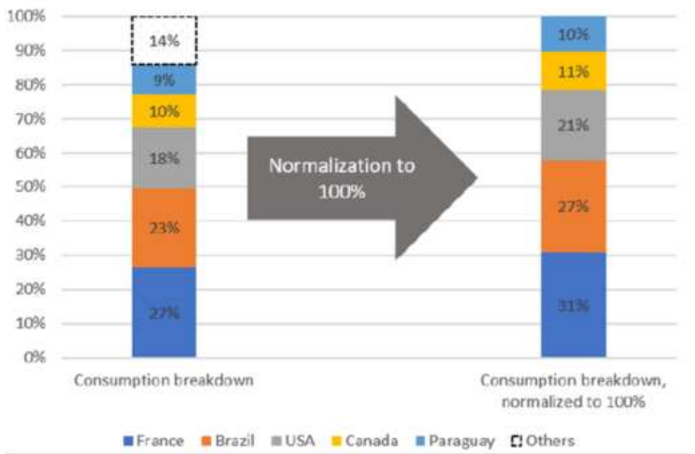
For ecoinvent datasets :
Production datasets > "Market for"



- **Agribalyse's structuring methodological choices to be taken into account**

Consumption mixes

- Consumption mixes defined for each agricultural product, to take account of imported products, with a 70% cut-off threshold
- Distinction between "direct consumption" and "products intended for processing" for 4 products (tomatoes, strawberries, chicken and beef)
- Distinction between "in season" and "out of season" for 2 products (tomatoes, strawberries)



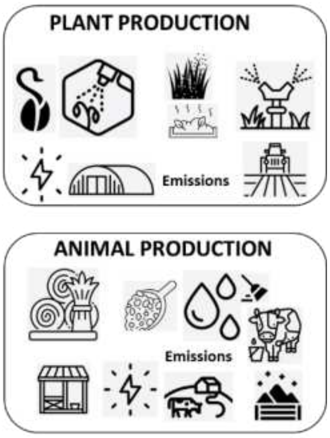
igure 6 : Répartition de la consommation de soja, application du seuil et normalisation à 100%.

Agricultural inventories

- Modelling of **French agricultural production inventories** using Means InOut (INRAE-CIRAD tool), which enables to identify all inputs and outputs from agricultural systems, and estimate pollutant emissions using emission models for France

  See the Agribalyse methodology report for background emission models (see the datasheets from page 123) : [access here]

- Capital goods (infrastructure): not considered in the PEF, but considered in Agribalyse (agricultural machinery infrastructure)
- No consideration of land transformation in agricultural agribusiness processes - scheduled for 2026 - version 3.3
- Economic allocation for meat/bone/leather and biophysical allocation for milk/meat

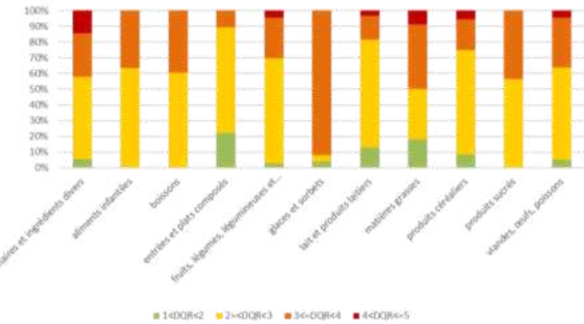


Use of proxies and dummies

Proxies used :

- **For certain raw agricultural products** for which we have no data (orange data for grapefruit, chicken data for rabbit)
- **For some recipes** same recipes for different « CIQUAL products »
- **For transformation processes** (e.g. "wheat flour production" proxy for "barley flour production" but applied with the raw material "barley")

Industrial processes have been simplified :
Some Dummies ("empty processes") : For some processes, known for their low environmental impact. *Examples: operations to remove the inedible part of raw materials, such as shucking, peeling, etc.*



Transformation stage

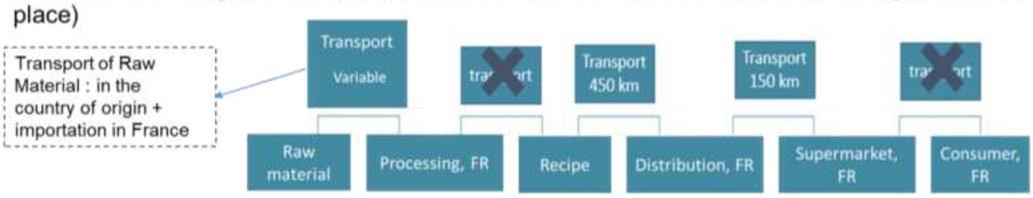
- **Transformation stage :** With the exception of drying, we assume that all processing operations are carried out in France, for ingredients, processed products and recipes.
- **Recipes** most often correspond to "home-made" rather than "industrial" recipes
- **Edible losses unconsidered** – only unedible losses considered
- **Water :** The use of water for washing fruit and vegetables has not been taken into account.

Distribution

- **Edible losses at retail considered**
- **Energy consumption** as a function of storage time, product density and 3 archetypes (ambient, refrigerated, frozen)

Transport along the chain

- **Transport** from supermarket to consumer not considered (existing default values in PEF), as well as between Processing and "Recipe" (as if the 1st and 2nd transformations were taking place in the same place)



At consumer

- **Food waste at the consumer level not considered** (existing default values in PEF),
- **Energy consumption** depending on storage time, and 3 archetypes (ambient, refrigerated, frozen)
- Manufacture of household appliances not taken into account (fridges, microwaves, dishwashers, etc.)

Packaging

Change in version 3.2 – release summer 2024 – 2 precision levels :

1. **Specific data from the Pack-AGB project (45% of products covered) :** A specific packaging solution for each CIQUAL product (deemed representative) including all packaging components + variations of secondary solutions

2. **Specific data from the Proxy-Pack AGB project (55% of products) :** A single specific packaging solution for each CIQUAL product concerned (no variations) + simplified solution (only 1 material taken into account)

***Product categories covered by level 2** (specific modelling) PACK-AGB project*	***Product categories covered by level 1** (simplified modelling) PPSE*
• Vegetable oils • Margarine • Sauces • Wine (sparkling and still) • Cheeses • Dairy products and desserts • Milk • Creams • Meat (all types: pork, chicken, beef, lamb, etc.) • Cereal products • Fruit, vegetables, processed pulses • Fish Starters Prepared dishes • Jams	• Baby food • Non-alcoholic drinks • Beers, ciders and cocktails • Breakfast biscuits and cereals • Bread and pastries Cakes • Flours and pastries • Nuts and seeds • Miscellaneous • Sugar and confectionery (except jams)
TOTAL 486 SOLUTIONS IN THE CATALOGUE3 15 SOLUTIONS MODELLED 1136 products processed	