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Abstract

INRA and CIRAD have launched the MEANS-InOut software, an operational and user-friendly tool to generate Life Cycle Inventories of the main crops and livestock systems. MEANS-InOut ensures that users do not forget any input, resource, waste, or pollutant flows and follow a consistent method to implement their inventories. MEANS-InOut remains under continual development to follow the evolution of sustainability assessment methods.

Keywords: *LCI tool, agri-food systems, multi-criteria assessment, methodology, AGRIBALYSE.*

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1. Introduction

Agriculture is one of the main global drivers of environmental impacts. Improving the environmental performance of this sector requires multi-criteria assessment, in order to define ways of sustainable evolutions and to inform both producers and consumers. Performing multi-criteria assessment of a system implies dealing with complexity; it requires a methodological framework, managing a large amount of information, and many calculations. For those not specialized in assessment, using software that embeds a methodology and associated datasets, guides data collection and calculates indicators can be of great help. This is why INRA (French National Institute for Agricultural Research) has developed the MEANS platform since 2012 (http://www.inra.fr/means_eng/), dedicated to multi-criteria sustainability assessment of agri-food systems, with the support of ADEME (the French environmental agency) since 2014. CIRAD (French agricultural research and international cooperation organization working for the sustainable development of tropical and Mediterranean regions) has co-developed the MEANS platform since 2018. The main objectives of the platform are to facilitate multi-criteria assessments of agri-food systems for non-specialists, to share research results and tools to support multi-criteria sustainability assessment, and to share data describing agri-food systems.

2. Material and methods

To define the needs of users of the MEANS platform, semi-structured interviews were conducted with 15 French multi-criteria assessment practitioners. These interviews helped define which functions the platform needed to have. Then, potential functions were validated and prioritized by another panel of ten potential users.

The MEANS platform is intended to be used by (1) researchers or value-chain stakeholders, who

are specialists of the systems they want to assess, but not specialists of multi-criteria assessment methods and (2) consultants, who are experts in assessment methods but may be less familiar with the modeling of farming systems. These users need (1) a robust tool following a standard methodology to ensure transparency, reliability (independence from economic interests), and reproducibility of the study, and (2) a flexible tool that can be extended to integrate new criteria. The protection and confidentiality of data during data entry and storage was a main concern for the users.

The MEANS platform was first designed for environmental assessment within the methodological framework of Life Cycle Assessment (LCA), with a focus on French condition to begin with. Since 2012, the MEANS team has developed the MEANS-InOut software, a user-friendly tool to generate Life Cycle Inventories (LCIs) of the main crops and livestock at the farm gate. MEANS-InOut follows the AGRIBALYSE methodology (Koch and Salou, 2016), which is an adaptation of ecoinvent methodology for French context and results from a consensus among the main stakeholders of the French agricultural sector. It follows international recommendations (ISO, ILCD).

In the future, INRA and CIRAD aim to expand the platform with data and tools for other environmental indicators and methods, for economic and social assessment, and for others systems. A user network will be created to identify future functions of MEANS-InOut, especially which sustainability assessment methods to include. Currently, the MEANS team is working with a group of process scientists to define specifications for studying food processing using MEANS-InOut.

3. Results

3.1. Functions of MEANS-InOut

MEANS-InOut, which is a turnkey web application accessible without installing anything by the user, was launched in 2016. It provides forms to guide detailed data collection on production systems at the level of individual fields and animal production units. It contains a reference dataset for the characteristics of the main inputs of agri-food systems (AGRIBALYSE and ecoinvent LCIs, so far), and mathematical models to estimate direct pollutant emissions and resource use for annual crops (including intercrops), grassland, vineyards, tree crops, greenhouse crops, cattle, sheep, goats, pigs, poultry and rabbit. Crop production can be studied in a product-oriented approach or as part of a cropping system, including the crop rotation. The cropping system as a whole can also be studied in MEANS-InOut.

Using MEANS-InOut to create agricultural LCIs ensures that users do not forget any important input, resource, waste, or pollutant flows by following a consistent method for crop and livestock production based on the AGRIBALYSE methodology. Since MEANS-InOut embeds background data and models to estimate pollutant flows, users need only provide the information describing the foreground system to create an LCI (Fig. 1). An export feature generates a file in EcoSpold format from the data collected and calculated in MEANS-InOut. This file can be imported into LCA software to create a LCI of the system described in MEANS-InOut. LCA software (such as SimaPro or openLCA) is required to calculate impact indicators from MEANS-InOut output.

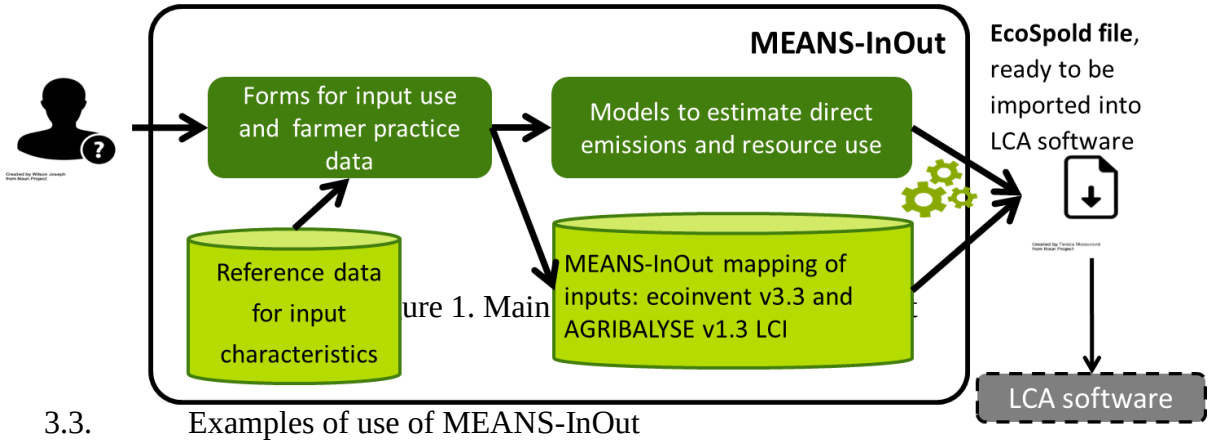
Since MEANS-InOut standardizes data collection and emission calculations, it should greatly ease critical review of agricultural LCIs. MEANS-InOut is also the main tool for the updating of the AGRIBALYSE database (ADEME, 2017).

MEANS-InOut also contains a database of production system description, which allows the sharing of these data among users.

3.2. Data quality

Once their results will have been validated, users will be invited to add their production system data (farmer practices, types and quantities of inputs) to the MEANS-InOut database, so that they can be shared with other MEANS users. Systems of quality management and data review procedures are

under development, and will ensure and qualify the reliability of data so that data can be used or adapted by other users. Forms to collect a large amount of metadata (data sources, quality scores, etc.) are already available in MEANS-InOut, as an initial step in the system of quality management.



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3.3. Examples of use of MEANS-InOut

Two examples of collaborations are presented here, illustrating the potential of the tool.

3.3.1. LCA of fruits and vegetables using MEANS-InOut

The French Technical Center for Fruits and Vegetables (CTIFL) used MEANS-InOut to study production scenarios for twelve fruits and vegetables – strawberry, apple, pear, walnut, tomato, zucchini, melon, lettuce, chicory witloof, leek, cauliflower and onion – for the AGRIBALYSE database. The main production methods of these products were studied: conventional or organic, field grown, in plastic greenhouses (heated or not), and in small tunnels. MEANS-InOut allowed rapid data entry and creation of 112 LCIs, and its "scenario copy-paste" function facilitated testing and comparing of production methods. The analysis of LCA results permitted to better describe the issues of vegetable production.

If one focuses on Climate Change impact, five types of production can be distinguished by the origin of greenhouse gas (GHG) emissions:

- Field-grown vegetables (cauliflower, onion, leek, lettuce): more than 50% of GHG emissions are caused by nitrogen fertilization
- Products from heated greenhouses (tomato, strawberry): more than 80% of GHG emissions are caused by heating
- Products from non-heated greenhouses (lettuce, melon, strawberry): most GHG emissions are caused by construction and maintenance of the greenhouse
- Perennial crops on trellises (apple and pear): 55% of GHG emissions are due to mechanization
- Products that need post-harvest processes (walnut) or stages for forcing or root storage and forcing (chicory witloof): most GHG emissions are caused by refrigerant leaks

From these initial results, it is possible to identify practices that contribute most to climate change. Farmers may adapt these practices to significantly decrease the climate change impact of their products. Alternative production methods should be analysed to avoid the risk of burden shift.

3.3.2. Integration of water use in LCIs

The MEANS platform is a partner of the AGRIBALYSE water scarcity assessment project, which aims to develop an operational method to estimate use and loss of water in French agricultural productions, and to update the AGRIBALYSE database with the results of the project. The FAO's

CROPWAT water balance model (Allen et al., 1998) was chosen, by the project partners on scientific validity and data availability criteria, to estimate water flows. CROPWAT has been incorporated into MEANS-InOut with some adaptations, to ease both data entry and the interpretation of water flows calculated by the model. For example, the original CROPWAT needs the duration (in days) of four stages of plant growth. For French agronomists, these durations are not easily available, since they depend on climate and cultivar, but the agronomists do know the cumulative temperatures (in degree-days) needed for each stage. In MEANS-InOut, we adapted data-collection forms and the model so that users can enter the duration of each growth stage in either days or degree-days. Also, the original CROPWAT calculates water flows (irrigation, evapotranspiration, water loss by runoff and percolation) but does not specify whether these flows are blue or green water. In MEANS-InOut, each water flow calculated is identified as blue or green water and is attributed to an environmental compartment (e.g. resource use, emission to air, emission to groundwater or to river), which greatly facilitates the use of CROPWAT for LCA and allows the impact assessment: green water use and water going back to water in the watershed where is was taken have no impact on water scarcity. Users can now create LCIs with MEANS-InOut that include water flows in addition to pollutant and resource use flows. As the original CROPWAT, the model can be used in MEANS-InOut to calculate water flows for any crop and climate and soil conditions, if users can describe them accurately.

4. Conclusion and perspectives

MEANS-InOut aims to become an international reference tool for environmental assessment and innovation support in the agri-food sector. It is operational for agricultural LCI calculation and database management in France, and its scope could be expended to other conditions thought partnerships. The platform also intends to deliver tools that help researchers and stakeholders apply methodological developments such as territorial LCA. User feedback and requests are important for the team to identify which methods and functions are a priority. INRA and CIRAD are looking for partnerships and scientific collaborations to develop the MEANS platform according to these objectives. Further developments will be pursued in 2019 to model food processing, to assess whole farms as a system, to include methods for economic assessment and other methods for environmental assessment. Access to and use of MEANS-InOut (available in English and French) is open to anyone and is subject to the terms of a service contract.

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