

Iaquis Conference Proceedings

*Fostering organizational transformation for a
sustainable future:
Enhancing synergies between quality, innovation and
sustainability*



Iaquis International Conference
11th – 13th September 2024
Viterbo, Italy

Iaquis Conference Proceedings

Iaquis Conference 2024

**Fostering organizational transformation for a
sustainable future:**

**Enhancing synergies between quality, innovation and
sustainability**

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International Conference

IAQUIS 2024

Viterbo, Italy

2024/09/11 – 2024/09/14

www.iaquisacademy.com

ISBN: 979-12-210-9378-0

Foreward

The current economic, social, and environmental landscape is marked by a profound crisis, underscoring the urgent need for a paradigm shift in production and consumption patterns. The interconnectedness of these domains has become increasingly evident, with the effects of unsustainable practices rippling through economies, societies, and ecosystems.

Recent environmental and geopolitical events have further highlighted the fragility of the existing production system. Climate change, resource depletion, and geopolitical tensions have exposed the vulnerabilities of traditional economic models and the imperative for transformative action. Organizations must adapt to these challenges by embracing sustainable practices and innovating to create more resilient and equitable systems.

A synergistic contribution from academics, practitioners, and policymakers is essential to navigate this complex landscape. Academics can bring their research expertise to identify emerging trends, develop innovative solutions, and inform policy decisions. Practitioners can offer insights into the practical challenges and opportunities faced by organizations in their respective sectors. Policymakers can create enabling environments that support sustainable practices and incentivize innovation.

Academia, in particular, can play a pivotal role in driving the development of new ideas through research activities. The International Association of Quality, Innovation, and Sustainability (IAQUIS) can serve as a valuable platform for aggregating, coordinating, and mediating these efforts. By fostering collaboration among professors, researchers, doctoral students, and practitioners from around the world, IAQUIS can facilitate constructive discussions and knowledge sharing.

The choice of the main themes, "Quality, Innovation, and Sustainability," reflects the interconnected nature of these concepts and their critical importance for a sustainable future. Quality, as a cornerstone of excellence and customer satisfaction, is essential for long-term organizational success. Innovation, as the driving force behind progress and adaptation, is crucial for addressing emerging challenges and creating new opportunities. Sustainability, encompassing environmental, social, and economic dimensions, is a fundamental imperative for ensuring the well-being of future generations.

By adopting a cross-cutting and synergistic perspective, organizations can unlock the full potential of quality, innovation, and sustainability. This involves integrating these elements into all aspects of business operations, from product design and production to supply chain management and customer relationships.

The First IAQUIS Conference provides a unique opportunity to initiate a network of relationships and connections among key stakeholders from academia, industry, and policymaking. Through collaborative discussions and knowledge sharing, participants can explore innovative approaches, identify best practices, and develop strategies for fostering organizational transformation.

By focusing on quality, innovation, and sustainability, IAQUIS aims to contribute to a more equitable, resilient, and sustainable future for all.

Viterbo, Italy

Alessandro Ruggieri

Preface

The first Iaquis Conference was held in Viterbo (Italy) from 11th to 13th September 2024. It was promoted by the International Association for Quality, Innovation and Sustainability and hosted by the Department of Department of Economics, Engineering, Society and Business Organisation of University of Tuscia in Viterbo, Italy.

The objective of the Conference was to stimulate and foster collaboration and knowledge exchange in the areas of Quality, Innovation and Sustainability among researchers, educators, practitioners, and doctoral students hailing from diverse countries and backgrounds.

Over the course of the three-day Conference, the participants had the opportunity to present their research in both plenary and parallel sessions.

The central theme that permeated all discussions revolved around the synergies between Quality, Innovation, and Sustainability, embracing an interdisciplinary perspective and a cross-cutting approach.

A pre-conference Doctoral Consortium was held. During the Doctoral Consortium the PhD Students presented their research program and findings, and received suggestions by the mentors. Moreover a seminar on how to develop an impactful paper was held to provide young scholars with in-depth feedback from experienced lecturers on their ongoing research.

The Conference collected a total of 83 Papers from 15 countries. Some of the authors asked not to be publish their paper in these proceedings, thus some contributions will not appear, besides being counted.

The great number of papers and the variety of the topics allowed us to organize numerous parallel sessions, by dividing the papers into 18 tracks, plus the Doctoral Consortium:

- 1) Circularity
- 2) Healthcare
- 3) Sustainability in Tourism
- 4) Sustainability in Agri-Food
- 5) Sustainability
- 6) Life Cycle Assessment
- 7) Quality and Innovation in Food Sector
- 8) Innovation Industry 4.0
- 9) Quality Management
- 10) TQM and Sustainability
- 11) TQM and Employees
- 12) Quality Management and Improvement
- 13) Management Systems
- 14) Life Cycle Assessment
- 15) Sustainability and Service Innovation
- 16) Sustainability
- 17) Sustainability in Energy Sector
- 18) Innovation.

Due to the conspicuous number of the papers which fell under the topics of “Sustainability” and “Life Cycle Assessment”, each of these parallel sessions were split in two sessions, allowing all the authors to present their contribution.

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The role of uncertainty in representative Italian LCA database: the case of olive datasets

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Abstract

Data uncertainty plays a crucial role in influencing the quality of results obtained from a Life Cycle Assessment (LCA) study. Alongside, the use of representative data for the agrifood sector is fundamental, on the one hand, to account for the various technological, biological, and environmental factors affecting its related productions and, on the other, to reduce their related uncertainty. In this regard, as part of a research project (PRIN 2017, ID code 2017EC9WF2) funded by the Ministry of University and Research (MUR), the Italian Life Cycle Inventory Database of Agrifoods (ILCIDAF) database has been developed in order to provide LCA practitioners with regionalised data for four main Italian agrifood products, i.e., olive oil, wine, citrus and bread/pasta. This paper aims to analyse two different approaches to calculate the uncertainty related to the regionalised data for Italian olive production included in the ILCIDAF database. In addition, these two approaches are compared in order to understand how these data and their related uncertainty may affect the final results. In the ILCIDAF database, the datasets for olive production have been developed by normalising the input and output to the olive yield of 19 Italian regions and considering its temporal variation between 2015 and 2020. In this context, the first approach consists of calculating the uncertainty connected to the temporal fluctuation of each region, assuming that the uncertainty is related to the annual variation of olive yield among regions. Instead, the second approach involves the use of the basic uncertainty reported in Ecoinvent for some categories of products and emissions. Results underscore that the uncertainty calculated according to the annual olive yield fluctuation is overestimated for the input and underestimated for the direct emissions when compared to the one based on Ecoinvent. Consequently, this contributes to differences in the uncertainty of the LCA outcomes, highlighting that the use of inappropriate uncertainty values may significantly affect the results.

Keywords: Life Cycle Assessment, ILCIDAF database, Olive, Regionalised data, Uncertainty

Relevant Topic: Fostering sustainable transition

Introduction

The agri-food sector plays a fundamental role in the achievement of sustainable development and the related Sustainable Development Goals (SDGs). According to OECD/FAO (2024), the World population is expected to grow by 700 million people by 2033, resulting in an increasing demand for agri-food products and consequently causing environmental, economic and social issues. For example, focusing on global greenhouse gas emissions (GHGs), the growing food consumption may contribute to about 288 million tonnes of carbon dioxide equivalent (CO₂eq) per year by 2100 (Yin et al., 2024). In this regard, among scholars, institutions and businesses there is common consensus on the need to identify and assess sustainable strategies for reducing environmental charges related to agri-food systems. Among the various methods available for assessing the environmental performance of agri-food systems, the Life Cycle Assessment (LCA) is considered one of the most suitable and adopted due to its specific focus on a life cycle perspective (Notarnicola et al., 2017). Indeed, LCA is a standardised method which allows the assessment of the potential environmental impacts of a product, process or service throughout its entire life cycle, thus including raw material extraction, transformation and manufacturing, distribution, use and end-of-life (Guinée, 2002). Among the four phases characterising the LCA framework (ISO, 2006a; ISO, 2006b), the inventory analysis includes the collection and quantification of the inputs and outputs needed to carry out the LCA study. With specific regard to agri-food products, the inventory should be built using, as much as possible, representative and regionalised data (Notarnicola et al., 2022). This is particularly important to improve data quality and reduce the uncertainty of the LCA results. Indeed, agricultural practices implemented in the agri-food sector depend on biological, technological and environmental factors which may strongly vary among countries and regions and their related geographical characteristics (Liliane and Charles, 2020). In this context, the national research project PRIN 2017 (ID code 2017EC9WF2) funded by the Italian Ministry of University and Research (MUR), aimed at developing the Italian Life Cycle Inventory Database of Agrifoods (ILCIDAF), with the scope to provide regionalised data to be used in LCA studies, for four main Italian agri-food products, i.e., olive oil, wine, citrus and bread/pasta. Starting from the datasets provided by the ILCIDAF database, this study aims to analyse and compare two different approaches to calculate the uncertainty related to the regionalised inputs and outputs for olive production in 19 Italian regions. In particular, the first approach consists in calculating the uncertainty of data considering the annual variation of olive yields among regions, in the period 2015-2020, which represents the timeframe selected for developing the ILCIDAF database (ILCIDAF, 2024). While the second approach is based on using the basic uncertainty related to some categories of products and emissions and reported in the Ecoinvent database (Ecoinvent, 2024). The latter represents the most common method adopted to calculate uncertainty in commercial databases.

After this introduction, the paper is structured as follows:

- Methods section, in which a description of the ILCIDAF database is reported as well as the two approaches used to calculate the uncertainty are described;
- Results and discussion section, in which the results related to the uncertainty analysis calculated using the two approaches are compared and discussed;
- Conclusions section, in which the main remarks of the study are reported.

Methods

The ILCIDAF database consists of 924 datasets, among which 384 are related to the agricultural phase for olive production (ILCIDAF, 2024). The datasets are related to 19 of 20 Italian regions (excluding Valle D'Aosta for which data were not available) and are built using both literature and statistical sources (secondary data), and data obtained through direct interviews and questionnaires (primary data). To pursue the aim of this study, the uncertainty is calculated for 19 datasets based on secondary data and related to the average olive production in 19 Italian regions, thus including all the processes involved in the agricultural phase (e.g., fertilisers and pesticide use, irrigation, transport, etc.). The functional unit selected per each of the datasets is represented by 1 kg of harvested olives, while system boundaries follow a cradle-to-distribution approach. It is important to highlight that the datasets are developed starting from the yield of harvested olives per each region. In this regard, to address the annual variation in olive production, a six-year period is considered focusing on the timeframe from 2015 to 2020. Then, the average production per each region is calculated as the mass (expressed in kg) of harvested olives per year, by the olive tree cultivated area (expressed in ha) per year. A detailed description of the technical and scientific profile as well as of the procedures applied for developing the datasets for olive production in the ILCIDAF database are reported in Saija et al. (2024).

According to ISO (2006a; 2006b), uncertainty analysis is a sensitivity check to be performed at the level of Life Cycle Inventory (LCI) and Life Cycle Impact Assessment (LCIA) phases in an LCA study. Regarding the LCI phase, the uncertainty of inputs and outputs shall be evaluated in order to understand how data variability may affect the outcomes of the LCIA. Thus, uncertainty is strongly related to the quality of the data used to carry out the LCA study as well as to their spatial and temporal variation (ISO, 2006b). Different methods are available in the literature to measure uncertainty. Among these, the most commonly adopted is the one based on the use of the so-called pedigree matrix (Weidema and Wesnæs, 1996) and on the calculation of a geometric standard deviation (GSD) (Ciroth et al., 2012). The pedigree matrix allows the assignment of quality levels, based on expert judgment, through data quality indicators (DQIs), which consist of five quality scores to be referred to specific quality parameters, i.e., reliability, completeness, temporal correlation, geographical correlation, and further technological correlation. Then, each quality score is associated with an additional uncertainty as reported by Giroth et al. (2012). Thus, the overall uncertainty (U_c) of the inventory data is represented by the GSD of a basic uncertainty (U_b) to which various additional uncertainty factors related to

the five quality parameters (U_1, U_2, U_3, U_4, U_5) are added (Ciroth et al., 2012). The resulting value is dimensionless and can be equal to 1, representing a low uncertainty, or higher than 1 (the higher the value the higher the uncertainty).

Focusing on the aim of the study, two different approaches are adopted to calculate the uncertainty related to the investigated ILCIDAF datasets (figure 1). In particular, the first approach (Approach 1) adopted for measuring the uncertainty is based on the use of the GSD of elementary flows (e.g., fertilisers, pesticides, water, electricity, etc.) as the basic uncertainty calculated focusing on the temporal variation of olive yield (throughout the timeframe 2015-2020) in each region. Thus, it is assumed that the uncertainty may be related to the annual fluctuation of olive yields among the 19 Italian regions. On the other hand, the second approach (Approach 2) involves the use of the basic uncertainty reported in Ecoinvent and related to some categories of products and emissions according to Ciroth et al. (2012). For both approaches, the quality levels according to the DQIs approach are also assigned to include additional uncertainty. In this regard, considering that the 19 datasets evaluated in this study are developed using secondary sources, various data present the same quality scores. Overall, the 19 ILCIDAF datasets taken into consideration have an average DQI equal to 2.05, resulting in a good level of data quality.

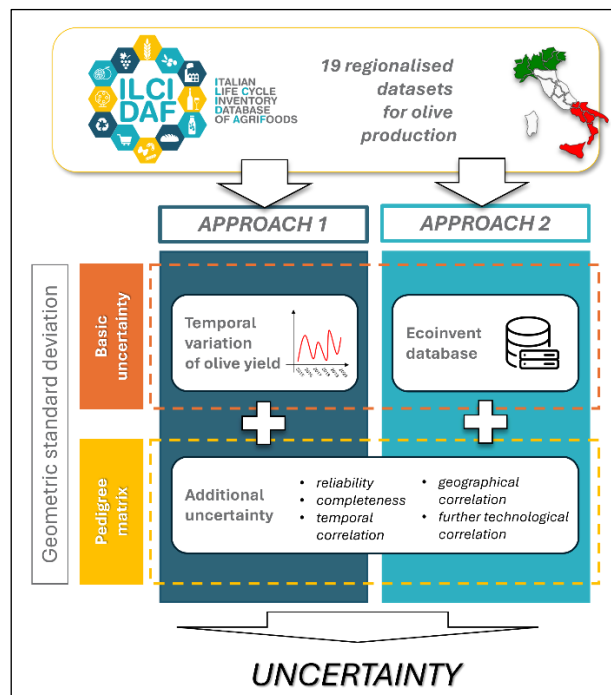


Figure 1. Graphical representation of the two approaches applied to calculate the uncertainty of the ILCIDAF datasets.

Results and Discussion

Figure 2 reports the results related to the comparison of the two approaches applied for calculating the uncertainty. Overall, the main findings show that, when Approach 1 is applied considering the annual variation in olive yields among the Italian regions, the uncertainty compared to the Approach 2 is overestimated for

most of the inputs and underestimated for the outputs, with specific regard to the air, water and soil emissions. The uncertainty calculated using the Approach 1 shows differences among the elementary flows accounted for the regionalised datasets but remains within acceptable values for most of them. For example, focusing on Molise, the uncertainty ranges from 1.08 for water and soil emissions to 1.64 for packaging materials. This low uncertainty is mainly due to the lower annual variation of olive yield while maintaining a high olive harvesting over the years (about 2,000 kg/ha). Despite this, remarkable differences and higher uncertainty values emerge for the ILCIDAF datasets related to Lombardy, Veneto and Campania. Indeed, these regions are characterised by a significant variability in annual olive yield within the timeframe of six years considered for the Approach 1. Focusing on Lombardy, which has the highest values among the 19 Italian regions, the uncertainty shows a percentage variation ranging from 98% for the emissions to water and soil to 51% for the packaging materials, when compared to Molise region. An in-depth analysis of the elementary flows underscores that all the inputs and outputs show uncertainty values lower than 1.5 in 16 of the 19 ILCIDAF datasets, except for the data related to transport activities and packaging materials.

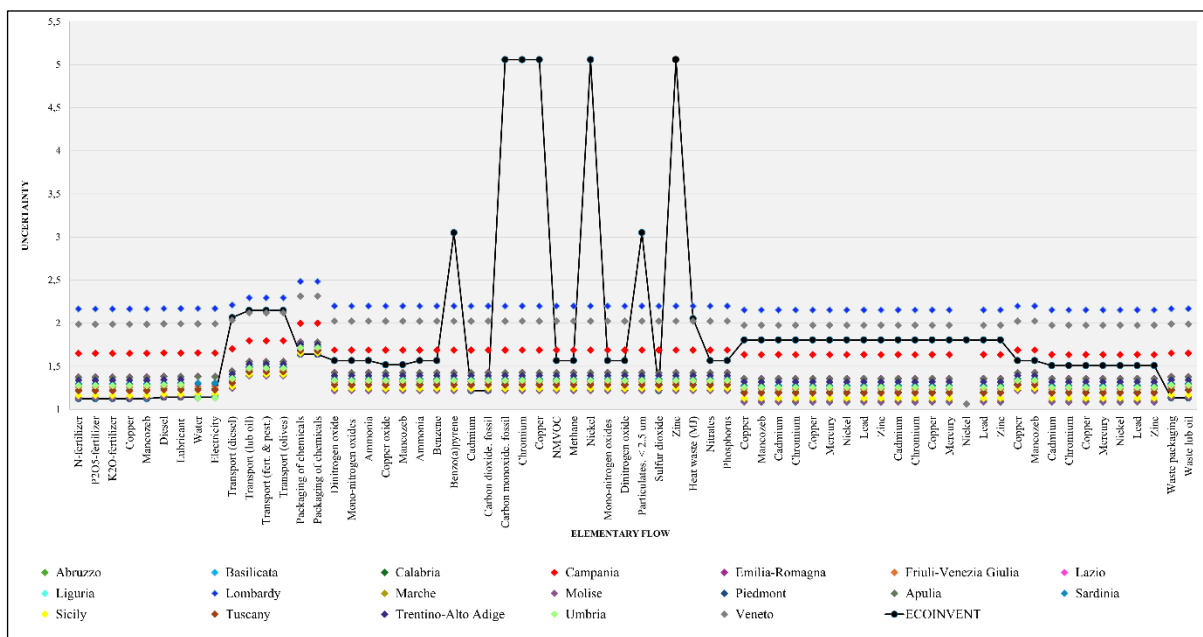


Figure 2. Comparison between the uncertainty of ILCIDAF datasets calculated considering the annual olive yield variation for the 19 Italian regions and the basic uncertainty reported in Ecoinvent.

It is important to highlight that a significant overestimation of uncertainty values for air emissions may occur when the basic uncertainty reported in Ecoinvent (Approach 2) is applied. This is because in the Ecoinvent database a high uncertainty and, consequently, low data quality is reported for air emissions, specifically for those related to heavy metals, such as Chromium, Copper and Zinc. In this context, the investigated ILCIDAF datasets are characterised by a lower uncertainty related to heavy metals. This is mainly due to the good quality

scores allocated to heavy metals estimation in the datasets, for which regional and crop-specific data are adopted according to Notarnicola et al. (2023).

The results here reported permit to highlight the importance of adopting the most suitable method for calculating data uncertainty in LCA study, specifically when regionalised data are used to assess agri-food systems. In this regard, the use of GSM values based on temporal variability of olive yields may strongly affect the uncertainty of representative inventory data and consequently of the LCIA outcomes.

Conclusions

The aim of this study was to analyse and compare two different approaches to calculate the uncertainty related to the regionalised datasets included in the ILCIDAF database, reporting data related to the production of olives in 19 Italian regions. In particular, the Approach 1 involved the calculation of uncertainty considering the olive yield variability, among each region, in the period from 2015 to 2020. On the contrary, the Approach 2 was based on using the basic uncertainty values report in Ecoinvent for some products and emissions. The main findings pointed out that using Approach 1 instead of Approach 2 resulted in an underestimation of the uncertainty for most of the inputs as well as an overestimation of the outputs, with specific regard to the direct emissions to air water and soil. The results from this analysis are in line with the outcomes from previous studies available in the literature (e.g., Yang et al. 2018), confirming that geographical variability plays a fundamental in agri-food systems. In addition, this study highlighted the need to calculate data quality and uncertainty using sector-specific GSD values in LCI datasets, associated with DQIs, also including temporal variability in yields, when agri-food products are investigated.

Acknowledgment

This article is part of the results of the research project “Promoting Agri-Food Sustainability: Development of an Italian LCI Database of Agri-Food Products (ILCIDAF)” (PRIN – Progetti di Ricerca di Interesse Nazionale 2017- Prot. 2017EC9WF2, settore ERC SH2, Linea C – funded by the Ministry of University and Research).

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