

A cura di

MARIA CLAUDIA LUCCHETTI, MARIA FRANCESCA RENZI

QUALITÀ, INNOVAZIONE E SOSTENIBILITÀ NELLA FILIERA AGRO-ALIMENTARE

Il contributo delle Scienze Merceologiche



Roma TrE-Press
2025



Dipartimento di Economia Aziendale



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COLLANA DEL DIPARTIMENTO
DI ECONOMIA AZIENDALE

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Development of regionalised inventory data for Life Cycle Assessment in agri-food sector: the case of italian olive production

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ABSTRACT

The lack of representative data is one of the most important issues arising for Life Cycle Assessment (LCA) studies focused on the agri-food sector. Indeed, agricultural processes are strongly influenced by technological, biological, and environmental factors depending on the geographical context in which the practices are implemented. Furthermore, when primary data are not available, the LCA practitioner shall use secondary data through the international scientific literature and databases that should be representative of the investigated system as far as possible. Despite this, the use of secondary data from not regionalised sources may result in missing such representativeness as well as the “true” inventory that reports site-specific data. In this context, the aim of this study is to propose regionalised inventory data, based on secondary sources, related to olives production in Italy. Datasets are referred to 19 Italian Regions and are built starting from the olive yield per ha per each region, as well as using national statistical data, scientific literature, and integrated production regulations. The importance of using such data for implementing LCA studies to evaluate olive production and related derivatives has been confirmed through descriptive statistical analysis, by which high variability in terms of input and output among the different Regions has emerged.

This study is part 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, sector ERC SH2, Linea C – funded by the Ministry of University and Research).

KEYWORDS: Life Cycle Assessment, inventory data, ILCIDAF, agri-food, olive, regionalised data

1 Introduction

During the last decades, the Life Cycle Assessment (LCA) method has been widely adopted by academics for assessing the environmental impacts caused by the agrifood sector (Bessou et al., 2013). The increasing use of the LCA method is mainly due to the need to identify environmentally friendly solutions aimed at reducing resource use while increasing production performances, as well as at achieving carbon neutrality, which is currently challenging, in the sector (Notarnicola et al., 2017; Acampora et al., 2023). Indeed, the agrifood sector is responsible for about 16 billion tons of carbon dioxide equivalent (CO₂eq) per year, contributing about 31% to the global anthropogenic greenhouse gasses (GHG) emission. These impacts mainly occur during the agricultural and transformation phases (FAO, 2022). Among the various agrifood productions, olives and olive oil are considered one of the most important supply chains in the Mediterranean countries, in terms of economic value, production volumes, and cultivation practices (Fernández-Lobato et al., 2021; Dahdouh et al., 2023). The European Union contributes 67% to the world's production of olive oil, being the leading producer worldwide. In particular, Spain and Italy represent the main EU countries in terms of olive oil production, respectively contributing for 66% and 15%, followed by Greece (13%) and Portugal (5%) (European Commission, 2020). But, despite their importance, olives and olive oil are also responsible for high environmental impacts (Baniyas et al., 2017). In this regard, the LCA method has been widely adopted for assessing the environmental performance of olive oil, considering all the phases among its life cycle. According to Rapa et al. (2022), most of these studies adopted secondary data, coming from commercial databases for building the Life Cycle Inventory (LCI). In particular, among the various available commercial LCA databases, the Ecoinvent is the most adopted in LCA studies concerning olive oil productions, specifically referring to analysis in which the geographical area is related to the Italian boundaries (Mondello et al., 2022). In this context, despite the LCA being considered “not-site specific” (Udo de Haes, 2006), there is a common consensus among practitioners about the need for data that should be site-specific and thus as much as possible representative of the investigated system (Frischknecht et al., 2018). This is particularly true for the agrifood sector and, in particular, for olive oil, since its production activities, specifically the agricultural ones, are characterized by high variability in terms of tech-

nological, biological, and environmental factors, that are strongly connected to the geographical boundaries (Liliane and Charles, 2020).

Regarding the use of secondary data from databases, the ILCD Handbook (JRC-IES, 2010) points out that datasets from databases should be accurate, precise, and complete for the investigated system. In addition, the handbook states that, when the LCI phase is carried out, the datasets related to a specific geographical area may be adapted for another one only if these data are appropriate and representative of the analysed technology. In the specific context of olives and olive oil, Notarnicola et al. (2022) highlighted that the Ecoinvent database includes four datasets directly related to olive production, and only one is referred to the Italian context, including data related to 70 inputs and outputs. Despite this, the study also pointed out that, among these inputs and outputs, only four data are really representative of the Italian boundaries. The use of such secondary data may result in biases in the LCI as well as in increasing the uncertainty of the LCA outcomes. Thus, there is a need for appropriate, representative, and regionalized datasets that are able to capture the intrinsic and extrinsic characteristics of the investigated agrifood system. In this context, the 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] has the scope of developing and providing LCIs for four Italian agri-food products, i.e., olive oil, citrus, wine, and grain products.

The goal of this study is to propose regionalized datasets related to olives production in Italy, also highlighting the methodological approach applied starting from secondary sources. In addition, a descriptive statistical analysis is carried out in order to point out the importance of using regionalized data, by highlighting the degree of variability in terms of input and output among the different Italian Regions.

2 Methodology

In this section, the methodology used for developing the regional inventories related to olive production in Italy, as well as the descriptive statistical analysis are described. In particular, the datasets are related to 19 Regions, excluding Valle d’Aosta for which the data needed for building the related LCI are not available. Furthermore, data are normalized to 1 ha of olive yield.

2.1 Development of regional inventories

Figure 1 describes the methodological steps adopted for developing the Italian regional LCIs related to olive production. Specifically, three main

steps have been considered: 1) calculation of olive yields; 2) estimation of main inputs; and 3) quantification of direct emissions.

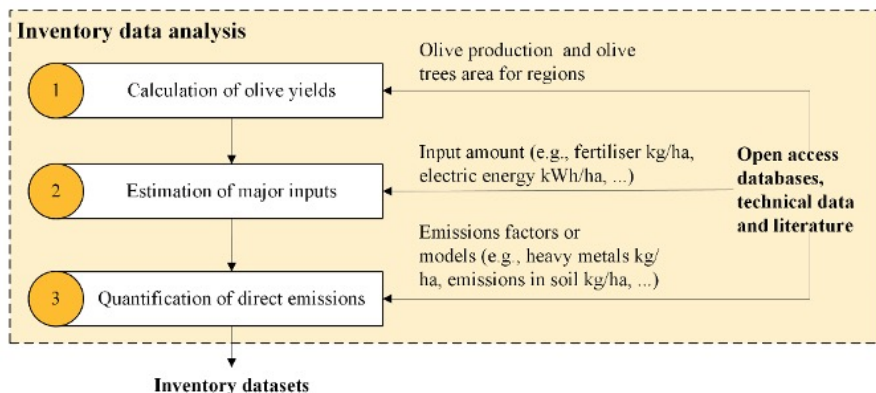


Figure 1 – Illustration depicting the process of creating inventory datasets

The first step involves calculating olive yields for different Italian regions. This requires utilizing the statistical database provided by the National Institute of Statistics (ISTAT, 2021). In relation to the olive oil supply chain, this database provides information about olives produced by each region and their related cultivated area for olive growing, and olive oil produced. By dividing the olives produced (in kilograms or tons) by the cultivated area (in hectares), the olive yields are calculated. This data is crucial for quantifying all inputs (e.g., fertilizer, pesticides, etc.) and then related outputs (e.g., emissions). To accommodate for fluctuations in olive production over the years, the datasets are developed using multi-year data spanning from 2015 to 2020.

The second step involves estimating the main inputs. Unlike the olive yield calculations, specific statistical data representing resource flows for processes such as fertilization, pesticide control, irrigation, and ancillary materials used for soil management, pruning, and harvesting were not identified. For these phases, data are estimated using scientific literature (Ribaud, 2017) and integrated production regulations (IPRs) (MASAF, 2021). The first document is an agricultural handbook that offers information on the average usage of general resources (such as materials, energy, and water) in specific Italian regions for established production procedures of distinct varieties of olive trees. From it, data related to ancillary materials (i.e., diesel and lubricant) and, if available, water and energy used for irrigation were selected. While the document also provides data on the types and amounts

of fertilizers and pesticides used, most of them and their quantities are no longer permitted by national legislation. For this reason, the data for these two types of inputs were estimated based on the IPRs specific to each region for standard integrated cultivation. Three types of synthetic fertilizers were selected for the datasets: nitrogen (N), phosphorus pentoxide (P_2O_5), and potassium oxide (K_2O). As for pesticides, copper oxide, and mancozeb were selected. An exception to the input data was made for the transportation of both pesticides and fertilizers. In this case, it was estimated that the distance traveled for transportation is equivalent to the national average distance estimated for the transport of chemical substances, as reported in the EUROSTAT statistical database (EUROSTAT, 2021). All these input data were normalized to regional olive yield values.

Afterward, the third final step involves estimating direct emissions associated with various agricultural inputs, including fertilizers, pesticides, and fuel combustion, as well as the output harvested (such as from the amounts of harvested olives) or losses due to natural phenomena (e.g., erosion, leaching, etc.). For this purpose, various models sourced from the literature were applied, covering the following categories:

- *Emissions from fertilization*: this category encompasses emissions released into the air and water resulting from the use of NPK fertilizers. The emissions were calculated using the simplified method described by Zampori and Pant (2019) for estimating the emissions of dinitrogen monoxide (N_2O), nitrogen oxides (NO_x), ammonia (NH_3), and nitrate (NO_3^-) due to the use of nitrogen fertilizers. Additionally, the SALCA-P emission models (Prasuhn, 2006) were employed to estimate phosphorus (P) emissions to water resulting from the use of phosphorus fertilizers.
- *Emissions from pesticide control*: this category encompasses emissions into the air, water, and soil resulting from the application of the two pesticides. The emissions were calculated using the model proposed by Zampori and Pant (2019), which assumes that 90% of the active ingredient is absorbed into the ground, 9% into the air, and 1% into the water.
- *Emissions from fuel combustion*: this category encompasses emissions released into the air because of burning fuel used as ancillary materials in machinery or tools (e.g., pneumatic scissors, etc.) for soil management, pruning, and harvesting processes. The emissions were calculated using the model proposed by Nemecek and Kägi (2007) related to diesel consumption.
- *Emissions of heavy metals*: this category encompasses emissions of seven heavy metals – Chromium (Cr), Cadmium (Cd), Lead (Pb), Nickel (Ni), Copper (Cu), Zinc (Zn), and Mercury (Hg) -

released into surface water, groundwater, and the soil. These emissions result from both natural processes (erosion and leaching phenomena) and human activities (e.g., soil tillage, application of fertilizers and pesticides, harvesting of olives, etc.). The extent of these emissions is significantly influenced by the topography and climatic conditions of the studied regions. Therefore, the model proposed by Notarnicola et al. (2023) is utilized to estimate the regionalized effects.

2.2 Data analysis

In line with the study's aim, statistical calculations are employed to highlight the extent of variation in input and output across the different regional datasets. These calculations are then graphically represented, whenever possible, through plot boxes or reported in tables. Specifically, the 19 datasets and 59 parameters are analyzed using the data analysis toolkit in MS Excel, with a focus on applying descriptive statistics. This toolkit comprises various tools for quantitatively summarizing data, computing measures of central tendency (such as Mean, Median, and Mode) and dispersion (including minimum and maximum values, range, standard deviation/variance, etc.) for a given dataset (Gudivada, 2017).

3 Results and Discussion

Table 1 and Table 2 report an example of inventories related to the cultivation of 1 ha of olives in Italian Regions, in terms of main inputs and direct emissions. In particular, data refer to the main Italian olive producers in 2022, i.e., Apulia, Calabria, and Sicily (ISTAT, 2022). The inventories related to the inputs are grouped by categories (e.g., fertilisers, pesticides, etc.) while data related to the direct emissions are reported considering the compartment to which the emissions are released. It is important to highlight that the data related to the heavy metals' emissions to soil shows a negative value (Table 2). This is due to the fact that the emissions to surface water and groundwater, in terms of leaching and erosion, are higher than the amount of heavy metals contained in the pesticides and fertilisers as input, causing a negative balance to soil. A first analysis of the regional inventories obtained using secondary data permits highlighting a high variability in terms of data among the different Regions. In this regard, the differences between regions, in terms of inputs and outputs related to the production of olives, are further investigated through the descriptive statistical analysis.

Category	Name	Unit	Apulia	Calabria	Sicily
Fertilizer	Nitrogen	kg	29.11	28.71	26.27
	Phosphorus pentoxide	kg	12.13	34.18	10.95
	Potassium oxide	kg	29.11	61.52	26.27
Pesticides	Copper	kg	0.97	1.37	0.88
	Mancozeb	kg	0.61	0.85	0.55
Machinery and equipment	Diesel	kg	32.19	45.45	32.57
	Lubricant	kg	0.61	0.86	0.62
Irrigation	Water	m ³	406.42	573.78	411.12
	Electricity	kWh	215.03	303.58	217.52
Transport	Pest. and fert. transport	tkm	20.21	35.58	18.24

Table 1 – Main inputs related to the cultivation of 1 ha olives field (regional data for the main Italian olive producers)

Compartment	Category	Name	Unit	Apulia	Calabria	Sicily
Emissions to air	Fertilisers	Dinitrogen monox.	kg	6.40E-01	6.32E-01	5.78E-01
	Fertilisers	Nitrogen oxides	kg	1.34E-01	1.33E-01	1.21E-01
	Fertilisers	Ammonia	kg	3.49E+00	3.45E+00	3.15E+00
	Pesticides	Copper	kg	8.73E-02	1.23E-01	7.88E-02
	Pesticides	Mancozeb	kg	5.46E-02	7.69E-02	4.93E-02
	Fuel	Ammonia	kg	6.44E-04	9.09E-04	6.51E-04
	Fuel	Benzene	kg	2.35E-04	3.32E-04	2.38E-04
	Fuel	Benzo (a)pyrene)	kg	9.66E-10	1.36E-09	9.77E-10
	Fuel	Cadmium	kg	3.22E-10	4.55E-10	3.26E-10
	Fuel	Carbon diox., fossil	kg	1.00E+02	1.42E+02	1.02E+02
	Fuel	Carbon mon., fossil	kg	1.75E-01	2.47E-01	1.77E-01
	Fuel	Chromium	kg	1.61E-06	2.27E-06	1.63E-06
	Fuel	Copper	kg	5.47E-05	7.73E-05	5.54E-05
	Fuel	NMVOC,	kg	8.53E-02	1.20E-01	8.63E-02
	Fuel	Methane	kg	4.15E-03	5.86E-03	4.20E-03
	Fuel	Nickel	kg	2.25E-06	3.18E-06	2.28E-06
	Fuel	Nitrogen oxides	kg	1.35E+00	1.90E+00	1.36E+00
	Fuel	Dinitrogen monox.	kg	3.86E-03	5.45E-03	3.91E-03
	Fuel	Part. < 2.5 um	kg	1.39E-01	1.96E-01	1.41E-01
	Fuel	Sulfur dioxide	kg	3.25E-02	4.59E-02	3.29E-02
Fuel	Zinc	kg	3.22E-05	4.55E-05	3.26E-05	
Fuel	Heat, waste	MJ	1.46E+00	2.06E+00	1.48E+00	

Emissions to water (surface water)	Heavy metal	Cadmium	kg	3.20E-05	6.85E-04	2.76E-04
	Heavy metal	Chromium	kg	1.89E-02	4.97E-01	1.83E-01
	Heavy metal	Copper	kg	4.05E-03	3.49E-01	4.06E-02
	Heavy metal	Mercury	kg	1.54E-07	4.45E-05	3.61E-06
	Heavy metal	Nickel	kg	1.00E-02	3.28E-01	7.64E-02
	Heavy metal	Lead	kg	7.97E-04	1.82E-01	1.82E-02
	Heavy metal	Zinc	kg	6.88E-03	6.46E-01	1.57E-01
Emissions to water (groundwater)	Heavy metal	Cadmium	kg	2.59E-04	1.56E-03	7.32E-05
	Heavy metal	Chromium	kg	1.74E-02	2.08E-02	2.00E-02
	Heavy metal	Copper	kg	1.18E-03	1.74E-02	7.83E-04
	Heavy metal	Mercury	kg	2.15E-08	1.79E-07	6.51E-08
	Heavy metal	Lead	kg	1.53E-04	7.59E-03	1.51E-04
	Heavy metal	Zinc	kg	1.08E-03	4.39E-02	1.37E-03
Emissions to water (river, lake, etc)	Fertilisers	Nitrate	kg	3.87E+01	3.82E+01	3.49E+01
	Fertilisers	Phosphorus	kg	2.67E-01	7.52E-01	2.41E-01
	Pesticides	Copper	kg	9.70E-03	1.37E-02	8.76E-03
	Pesticides	Mancozeb	kg	6.06E-03	8.54E-03	5.47E-03
Emissions to soil	Heavy metal	Cadmium	kg	3.41E-04	-4.82E-04	2.21E-04
	Heavy metal	Chromium	kg	-2.63E-02	-4.92E-01	-1.94E-01
	Heavy metal	Copper	kg	-2.98E-03	-3.61E-01	-3.93E-02
	Heavy metal	Mercury	kg	3.96E-06	-3.93E-05	5.18E-08
	Heavy metal	Nickel	kg	-8.06E-03	-3.23E-01	-7.46E-02
	Heavy metal	Lead	kg	3.53E-05	-1.87E-01	-1.74E-02
	Heavy metal	Zinc	kg	6.73E-03	-6.56E-01	-1.46E-01
	Pesticides	Copper	kg	8.73E-01	1.23E+00	7.88E-01
	Pesticides	Mancozeb	kg	5.46E-01	7.69E-01	4.93E-01

Table 2 – Direct emissions related to the cultivation of 1 ha olives field (regional data for the main Italian olive producers)

The results obtained through the descriptive statistical analysis permit to point out whether there is variability among the data related to olive production for each Italian Region, and its magnitude.

Table 3 and Figure 2 report the statistical analysis related to the main inputs accounted for the regional datasets. The results show that a high variability exists, among the different Regions, for all the data used for developing the LCIs. In particular, the widest variability emerges for the electricity and water used for irrigation processes (table 3), for which the coefficient of variation is equal to 156.1%. This high variability is because the irrigation activities have been only considered for regions that are geographically located in areas with a low rainfall distribution, while, for the other ones, no inputs in terms of electricity and water have been calculated. Considering the regions for which the irrigation process has been accounted, the maximum values are related to the Molise Region, for which the water and electricity inputs are respectively equal to 869.76 m³ per hectare (ha) and 460.18 kWh per ha. On the contrary, the Sardinia Region shows the minimum values for irrigation, respectively 187,81 m³ per ha of water, and 99.37 kWh per ha of electricity. Regarding the other inputs (figure 2), the statistical analysis points out that the coefficient of variation ranges from 0.50 for lubricant oil to 0.61 for K₂O as fertiliser. As previously stated, it is important to underscore that the inputs are normalised to the regional olive yield values, thus lower amount of inputs is expected for those regions with a lower productive yield (e.g., Molise).

Utilities (irrigation)	<i>Mean</i>	<i>Standard deviation</i>	<i>Minimum value</i>	<i>Maximum value</i>	<i>Coefficient of variation</i>
Water	164.76	257.13	0	869.76	1.56
Electricity	87.18	136.04	0	460.18	1.56

Table 3 – Statistical analysis related to electricity and water inputs (data for 19 Italian Regions; reference unit: 1 ha olives)

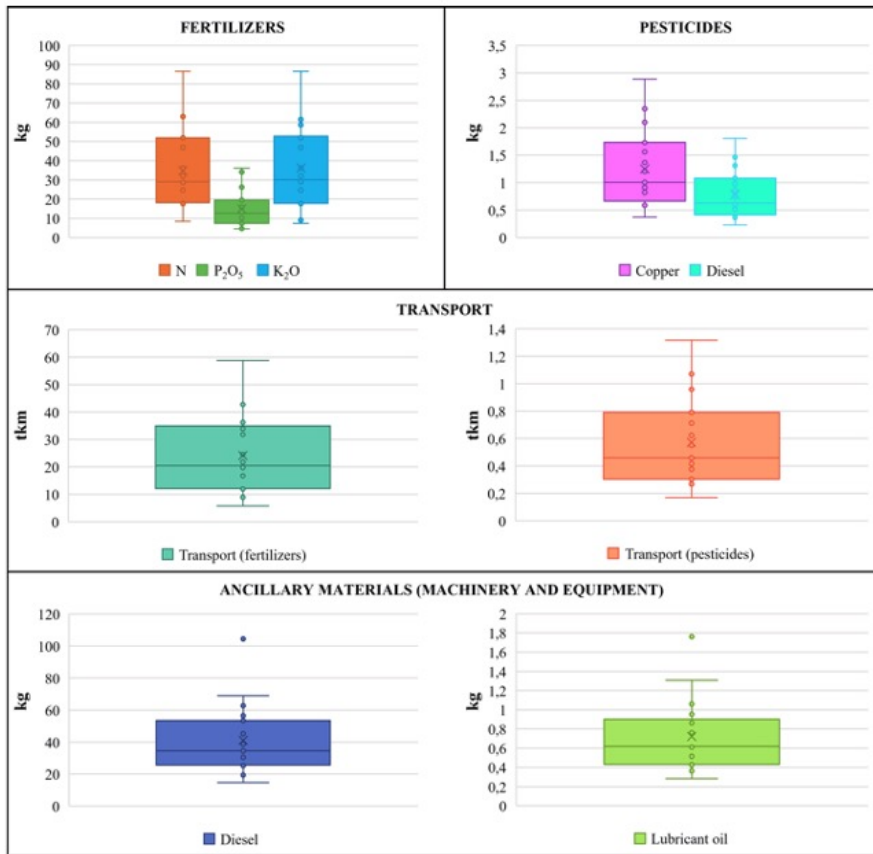


Figure 2 – Descriptive statistical analysis of the main input for the cultivation of 1 ha olives field (data for 19 Italian Regions)

The analysis of the direct emissions caused by fertilisers and pesticides use also underscores a high variability among regions (Figure 3 and Table 4). Regarding fertilisers, the highest direct emissions to air are related to NH_3 , for which the minimum and maximum values among the Italian regions vary from 1 kg per ha to 10.85 kg per ha (the mean is equal to 4.17 kg per ha). While, for the water compartment, the emissions are mainly connected to nitrate, for which the mean value related to the 19 regions accounts for 46.22 kg per ha. The coefficient of variation for the fertilisers ranges from 0.56 for N_2O , NO_x , NH_3 , and NO_3^- to 0.61 for P.

Instead, the main findings related to the direct emissions from pesticides (table 4), specifically copper and mancozeb, highlights that, as expected, the main releases are to soil compartment, for which the copper

emissions range from 0.33 kg per ha to 2.60 kg per ha, while the mancozeb emissions vary from 0.21 kg per ha to 1.62 kg per ha. In particular, the regions accounting for the lowest and highest direct emissions to soil are respectively represented by Sardinia and Trentino Alto Adige. As for fertilisers, pesticides emissions also widely vary among the Italian regions, resulting in a coefficient of variation equal to 0.56.

The results from the statistical analysis also highlight a remarkable diversity in terms of direct emissions due to fuel, for which the related coefficient of variation is equal to 0.52.

The variability in terms of direct emissions to air, water and soil from fertilisers, pesticides and diesel is mainly related, on the one hand, to the specific olive yield accounted from statistical data per each Region, on the other, to the models used for their quantification, which were gathered from the international scientific literature.

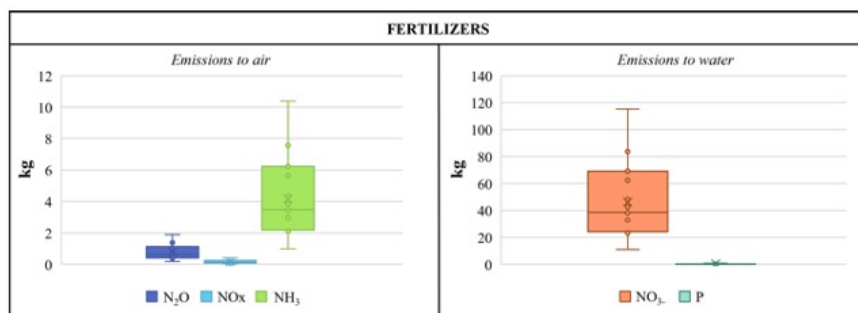


Figure 3 – Descriptive statistical analysis of the data related to fertiliser emissions (data for 19 Italian Regions; reference unit: 1 ha olives field)

Pesticide		Mean	Standard deviation	Minimum value	Maximum value	Coefficient of variation
Emission to air	<i>Copper</i>	0.11	0.06	0.03	0.26	0.56
	<i>Mancozeb</i>	0.07	0.04	0.02	0.16	0.56
Emission to water	<i>Copper</i>	1.25E-02	6.96E-03	3.71E-03	2.89E-02	0.56
	<i>Mancozeb</i>	7.82E-03	4.35E-03	2.32E-03	1.80E-02	0.56
Emission to soil	<i>Copper</i>	1.13	0.63	0.33	2.60	0.56
	<i>Mancozeb</i>	0.70	0.39	0.21	1.62	0.56

Table 4 – Statistical analysis related to the direct emissions from pesticides (data for 19 Italian Regions; reference unit: 1 ha olives field)

The main outcomes connected to the direct emissions, in terms of heavy metals, caused by natural phenomena and human activities are reported in Figure 4, in which the results are summarised considering leaching and erosion phenomena as well as the mass balance of the soil.

The analysis shows that the data associated with heavy metals emissions are characterised by the highest variability among all the inputs and outputs accounted for the proposed regional inventories. In particular, Lead and Mercury show the highest coefficient of variation for the data related to the emissions to surface water (leaching), accounting for 1.38 and 1.34. Considering, for instance, the Lead, the minimum and maximum emission values range from 0.0002 kg per ha for Calabria to 0.18 kg per ha for the Liguria Region. Regarding the other emissions due to leaching, the results show that the variability is higher than 0.7 for all the heavy metals (values vary from 0.78 for Chromium to 1.01 for Zinc).

Regarding the data related to the emissions to groundwater connected to erosion phenomena, the main findings underscore that, in addition to Lead and Mercury, a high variability is connected to Zinc (coefficient of variation equal to 1.10), which also shows the highest maximum value in terms of emission to groundwater among the different heavy metals included in the inventories (0.04 kg per ha for the Calabria Region).

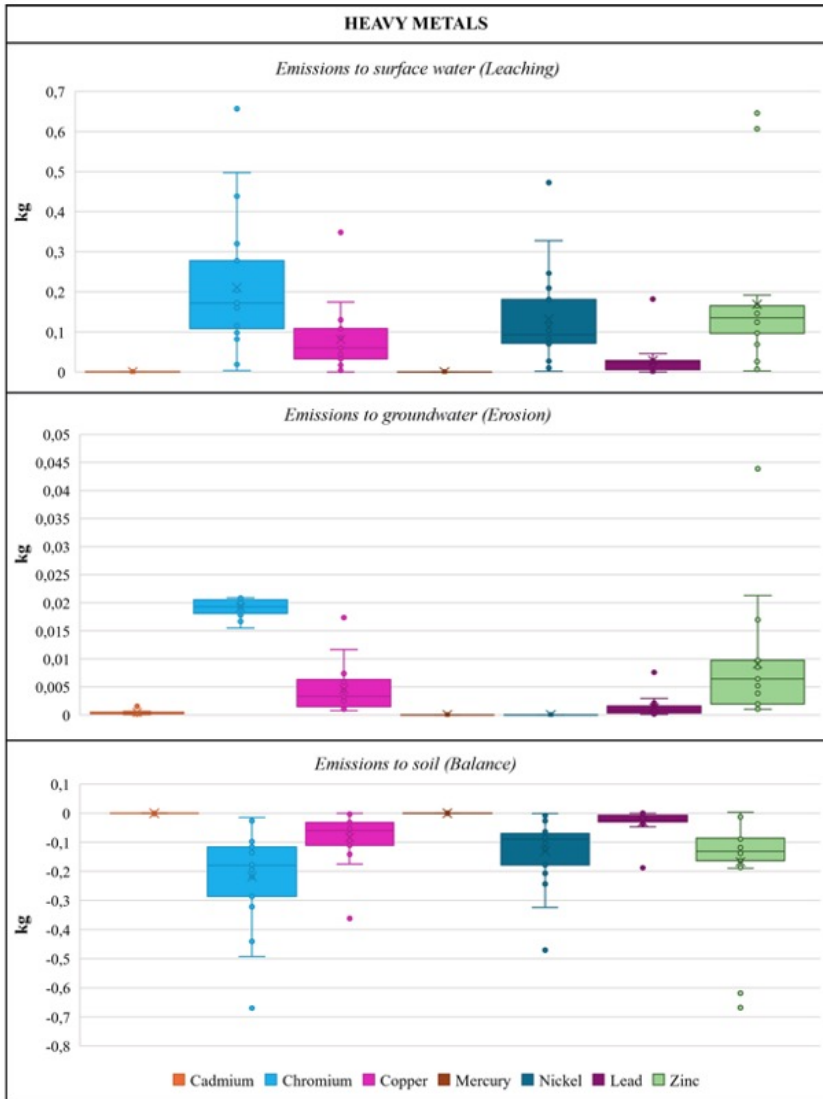


Figure 4 – Descriptive statistical analysis of the data related to heavy metals emissions (data for 19 Italian Regions; reference unit: 1 ha olives field)

Lastly, most of the data related to the emissions to soil, show negative values in terms of mass balance of heavy metals to soil. As previously pointed out, this is because the emissions connected to leaching and erosion

(as outputs) are higher than the amount of heavy metals, as inputs, related to natural phenomena and human activities, thus resulting in negative values when the mass balance to soil is calculated. This is particularly true for Cadmium and Mercury, for which the coefficient of variation is respectively of - 9.99 and -1.97.

The remarkable variability of heavy metals emissions is mainly due to the fact that the related amounts have been calculated starting from geospatial data on cropland, and site-specific data on concentration and soil characteristics as reported in Notarnicola et al. (2023).

4 Conclusions

The aim of this study was to propose regionalized LCIs related to olives production in Italy. In this regard, the methodological approach adopted for building the inventories related to 19 regions, starting from secondary sources, has been also proposed. Furthermore, the importance of using regionalized data has been pointed out through a descriptive statistical analysis, by which variabilities among the LCIs for the Italian regions were investigated. Due to space limits, only data for 3 inventories related to the main Italian regions in terms of olive oil production (i.e., Apulia, Calabria, and Sicily) are here provided. In particular, the data refer to main inputs, in terms of fertilisers, pesticides, fuel, lubricant oil, electricity, water, and transport, as well as to outputs, in terms of direct emission from fertilisers and pesticides use, diesel combustion, and heavy metals. Furthermore, the results obtained from the statistical analysis highlighted a high variability among the investigated inventories related to the different Italian regions. Indeed, the main findings underlined that the coefficient of variation among the regions is higher than 50% for all the LCIs proposed. With specific regard to heavy metals, results showed that negative values in terms of direct emission occur when the mass balance to soil is calculated. This also permits to underscore that building a representative inventory is fundamental also to capture specific peculiarities (i.e., negative emissions) that may allow to account potential environmental benefits related to the investigated agrifood system.

The outcomes of this study highlight and confirm the importance of using representative and regionalised data in LCA studies related to olives and related derivatives. This may also be widened to the whole agrifood sector, considering the intrinsic and extrinsic factors characterising the products and the production activities.

Considering that this study is focused on the LCI phase, further future analysis should be oriented in investigating how the use of represen-

tative inventories for olive and olive oil production may influence the results obtained through the Life Cycle Impact Assessment (LCIA) phase.

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References

- ACAMPORA, A., RUINI, L., MATTIA, G., PRATESI, C.A., LUCCHETTI, M.C. (2023). Towards carbon neutrality in the agri-food sector: Drivers and barriers. *Resources, Conservation and Recycling*, 189, 106755.
- BANIAS, G., ACHILLAS, C., VLACHOKOSTAS, C., MOUSSIOPOULOS, N., STEFANOPOULOU, M. (2017). Environmental impacts in the life cycle of olive oil: A literature review. *Journal of the Science of Food and Agriculture*, 97(6), 1686-1697.
- BESSOU, C., BASSET-MENS, C., TRAN, T., BENOIST, A. (2013). LCA applied to perennial cropping systems: a review focused on the farm stage. *The International Journal of Life Cycle Assessment*, 18(2), 340-361.
- DAHDOUH, A., KHAY, I., LE BRECH, Y., EL MAAKOUL, A., BAKHOUYA, M. (2023). Olive oil industry: a review of waste stream composition, environmental impacts, and energy valorization paths. *Environmental Science and Pollution Research*, 30(16), 45473-45497.
- EUROPEAN COMMISSION. (2020). Olive oil: An overview of the production and marketing of olive oil in the EU. European Commission. https://ec.europa.eu/info/food-farming-fisheries/plants-and-plant-products/plant-products/olive-oil_en (accessed 09.09.2023).
- EUROSTAT. (2021). National annual road transport by group of goods and type of transport (1 000 t, Mio Tkm), from 2008 onwards [ROAD_GO_NA_TGTT__custom_1947811] https://ec.europa.eu/eurostat/databrowser/view/road_go_ta_tg/default/table?lang=en (accessed 26.07.2023).
- FAO (2022). Greenhouse gas emissions from agrifood systems. Global, regional and country trends, 2000-2020. FAOSTAT Analytical Brief Series No. 50. Rome, FAO.
- FERNÁNDEZ-LOBATO, L., GARCÍA-RUIZ, R., JURADO, F., VERA, D. (2021) 'Life cycle assessment, C footprint and carbon balance of virgin olive oils production from traditional and intensive olive groves in southern Spain', *Journal of Environmental Management*, 293, 112951.
- FRISCHKNECHT, R., PFISTER, S., BUNSEN, J., HAAS, A., KÄNZIG, J., KILGA, M., WERNET, G. (2019). Regionalization in LCA: current status in concepts, software and databases—69th LCA forum, Swiss Federal Institute of Technology, Zurich, 13 September, 2018. *The International Journal of Life Cycle Assessment*, 24(2), 364-369.
- GUDIVADA, V.N. (2017). Data analytics: fundamentals. In *Data analytics for intelligent transportation systems* (pp. 31-67). Elsevier.
- ISTAT. (2021). Istat.it [WWW Document]. URL <https://www.istat.it/> (accessed 20.07.2023).

- ISTAT. (2022). Istat.it [WWW Document]. URL <http://dati.istat.it/Index.aspx?QueryId=33706> (accessed 29.09.2023).
- JRC-IES (2010). European Commission – Joint Research Centre – Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook – General guide for Life Cycle Assessment – Detailed guidance. First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union; 2010.
- LILIANE, T.N., CHARLES, M.S. (2020). Factors Affecting Yield of Crops. In (Ed.), *Agronomy – Climate Change & Food Security*. IntechOpen.
- MASAF. (2021). *Disciplinari regionali: Produzione integrata* [WWW Document]. Ministero dell'agricoltura della sovranità alimentare e delle foreste. URL <https://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/22398> (accessed 23.07.2023).
- MONDELLO, G., GULOTTA T.G., SAIJA, G., SALOMONE, R., PRIMERANO, P. (2022) 'Regionalizing LCI data for olive oil production: food for thought et al.' in XVI Convegno Associazione Rete Italiana LCA, La sostenibilità nel contesto del PNRR: il contributo della Life Cycle Assessment, 22-24 June 2022, Palermo, Italy.
- NEMECEK, THOMAS, BENGUA, X., LANSCH, J., ROESCH, A., FAIST-EMMENEGGER, M., ROSSI, V., HUMBERT, S. (2019). *Methodological Guidelines for the Life Cycle Inventory of Agricultural Products*. World Food LCA Database Report.
- NOTARNICOLA, B., ASTUTO, F., DI CAPUA, R., GULOTTA, T.M., MONDELLO, G., SAIJA, G., ARZOUANIDIS, I., D'EUSANIO, M., PETTI, L., FALCONE, G., FAZARI, A., STRANO, A. (2023). Estimation of heavy metals emissions in agricultural productions: the case of Italian products. *Cleaner Environmental Systems* 9, 100122.
- NOTARNICOLA, B., SALA, S., ANTON, A., MCLAREN, S.J., SAOUTER, E., SONESSON, U. (2017). The role of life cycle assessment in supporting sustainable agri-food systems: A review of the challenges, *Journal of Cleaner Production*, 140, 399-409.
- NOTARNICOLA, B., TASSIELLI, G., RENZULLI, P.A., DI CAPUA, R., SAIJA, G., SALOMONE, R., MISTRETTA, M. (2022). Life cycle inventory data for the Italian agri-food sector: background, sources and methodological aspects. *The International Journal of Life Cycle Assessment*, 1-16.
- PRASUHN, V. (2006). Erfassung der PO₄- Austräge für die Ökobilanzierung. In *SALCA-Phosphor*. Agroscope FAL Reckenholz, Zürich.
- RAPA, M., CIANO, S. (2022). A review on life cycle assessment of the olive oil production. *Sustainability*, 14(2), 654.

- RIBAUDO, F. (2017). *Prontuario di agricoltura: ordinamenti colturali, aziende agricole, fabbricati rurali, cure colturali e tempi di lavoro, coltivazioni e allevamenti, selvicoltura e cantieri forestali, prezziario*, Seconda Edizione. Hoepli Editore, Milano.
- UDO DE HAES, H. (2006). How to approach land use in LCIA or, how to avoid the Cinderella effect?. *The International Journal of Life Cycle Assessment*, 11(4), 219-221.
- ZAMPORI, L., PANT, R. (2019). Suggestions for updating the Organisation Environmental Footprint (OEF) method. EUR 29682 EN, Publications Office of the European Union, Luxembourg.