



Finanziato nell'ambito del Piano Nazionale di Ripresa e Resilienza PNRR. Missione 4, Componente 2, Investimento 1.3 Creazione di "Partenariati estesi alle università, ai centri di ricerca, alle aziende per il finanziamento di progetti di ricerca di base"



1.3.3 Environmental Footprint national and regional datasets for the main Italian production systems – section a: agri-food supply chain

Document data	
Title	Spoke 1 Work Package 3 D 1.3.3 Environmental Footprint national and regional datasets for the main Italian production systems - section a: agri-food supply chain
Owner	Università degli Studi di Bari Aldo Moro
Contributor/s	Università degli Studi di Bari Aldo Moro,
Document version	D1.3.3 – v1
Last version date	12/02/2026

List of Abbreviations

CE - Circular Economy

CF - Carbon Footprint

EF - Environmental Footprint

EPD – Environmental product declaration

FU - Functional Unit

GHG – Greenhouse gases

GRINS – Growing Resilient, Inclusive and Sustainable

ISMEA - Institute of Services for the Agricultural and Food Market

ISPRA - Istituto Superiore per la Protezione e la Ricerca Ambientale

ISTAT - Istituto Nazionale di Statistica Italiano

LCA - Life Cycle Assessment

NRRP – National Recovery Resilience Plan

PCR – Product Categories Rules

WP – Work Package

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1 Executive summary

The present report focuses on the table grape agri-food supply chain, providing an overview of its distinctive characteristics and the main impact categories that define it.

The activities of the Working Group also involved the main trade associations, which provided primary data related to table grapes cultivation in the Apulian context. Among these, the research team selected some representative production areas of Apulian table grapes.

The document also presents the results of a specific Life Cycle Assessment (LCA) study applied to the table grapes supply chain, which considered the production of 1 kg of product.

The LCA study was focused on the agricultural production stage and the related upstream processes required for table grape cultivation, while downstream stages and the consumer use phase were not included in the assessment. The data used are predominantly primary data, collected from the companies directly involved in the study as aforementioned, complemented by literature and/or sector data representative of supply chains analogous to the one under analysis and of the technologies employed therein.

The results of the LCA study, assessed using the EF 3.1 (Environmental Footprint) methodology adopted within the European Commission's Environmental Footprint framework, show that the environmental profile of table grape production is primarily driven by water use, followed by climate change, land use, acidification, particulate matter, and resource use. The analysis also highlights the significant contribution of direct field emissions, irrigation-related processes, and, depending on the cultivation system, fertiliser, pesticide, and energy-related inputs. With specific reference to the climate change impact category, the lowest burden was observed for organic covered table grape production.

2 Purpose of the document

This report was produced within the framework of the GRINS (Growing Resilient, Inclusive and Sustainable) NRRP (National Recovery and Resilience Plan) project with the aim of "Set-up of Environmental Footprint national and regional datasets for the main Italian production systems". The report falls within Spoke 1 "Firms sustainability" (Business strategies and technical actions to face sustainability challenges, environmental aspects and Circular Economy (CE) paths, resilience of companies and supply chains to climate change and other risks), sub-section WP3 "To increase firms' efficiency in circular resource management along the whole value chain", Milestone 1.2.3 "Set-up of Environmental Footprint national and regional datasets for the main Italian production systems (M36)".

This report represents the study of the supply chain of table grapes for direct consumption grown in Apulia Region, and the development of the related LCA datasets in ILCD format in the context of Milestone 1.3.1. “Set-up of LCI national and regional datasets for the main Italian production systems (M24)”, for the same WP3.

3 Table grapes cultivation

Globally, from 2018 to 2024, table grape production and consumption grew: particularly, production grew by 20.35% and consumption by 16% (Tab.1), suggesting greater availability of product relative to domestic consumption, which may support increased exports, higher stock levels, greater potential for value-added uses.

Tab. 1 – Global production and consumption table grapes

Year	Production (tonnes)	Consumption (tonnes)
2018	27,697,361	28,053,057
2019	28,843,504	29,541,709
2020	29,436,523	28,608,695
2021	30,218,895	29,176,872
2022	31,498,076	30,564,919
2023	32,239,049	31,893,153
2024	33,333,561	32,539,279

Source: Authors' elaboration on OIV data (2026).

Conversely, at European level, from 2018 to 2024, production and consumption decreased by 10.45% and 52.18%, respectively (Tab. 2). From 2022 onward, consumption declined more sharply than production, resulting in positive balances in 2022–2024. Italy is Europe's largest producer and one of the top producers globally.

Tab. 2 – European production and consumption table grapes

Year	Production (tonnes)	Consumption (tonnes)
2018	2,018,921	2,483,579
2019	1,983,347	2,309,419
2020	2,181,699	2,277,994
2021	1,883,570	2,160,990
2022	1,867,118	1,838,421
2023	1,632,565	1,289,848
2024	1,807,972	1,187,638

Source: Authors' elaboration on OIV data (2026).

The 2024 commercial season for table grapes was characterized by an increase in farm-gate prices compared to both 2023 and the three-year average for 2021–2023. However, exceptions were observed for certain varieties (e.g., Vittoria) and in specific markets, where negative price variations were recorded (ISMEA, 2024).

Tab. 3 - Table grapes – national production

Indicator	2018	2019	2020	2021	2022	2023	2024	2025
Total surface - ha	47,030	47,416	47,585	47,549	47,583	47,559	47,514	44,595
Surface area in production - ha	46,613	46,725	46,950	47,019	47,248	47,334	47,086	44,360
Total production - tons	1,065,339.3	1,030,762.2	1,063,593.3	1,041,031.9	1,010,397.7	812,898	1,041,794.4	909,683

Harvested production - tons	1,028,107.1	1,009,108.9	1,039,841.7	1,014,656.7	966,259.3	798,595.3	1,002,693.4	849,363
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Source: Authors' elaboration on data ISTAT (2026) (last accessed date 30.01.2026).

At the national level, from 2018 to 2025, a decrease was observed for all the indicators included in Tab. 3; particularly, the most reduction of 19.46% occurred for harvested production.

Tab. 4 - Table grapes – regional production (Apulia)

Indicator	2018	2019	2020	2021	2022	2023	2024	2025
Total surface - ha	26,640	24,985	25,085	25,065	25,135	25,205	25,455	24,935
Surface area in production - ha	24,385	24,455	24,655	24,685	24,905	25,075	25,135	24,765
Total production - tons	634,150	616,155	634,955	608,255	572,055	386,250	529,600	614,000
Harvested production - tons	602,042	599,512.5	614,394.5	583,725	529,580	374,100	567,000	559,455

Source: Authors' elaboration on data ISTAT (2026) (last accessed date 30.01.2026).

Apulia region is the leading table grape producing area in Italy, accounting for approximately 66% of the country's total table grape output, followed by Sicily at about 28%. Some decreases were recorded in Apulia: particularly, table 4 shows -6.40% in terms of total area, -3.17% in terms of total production and -5.46% in terms of production harvested in 2025.

Tab. 5 - Table grapes – local production (Foggia)

Indicator	2018	2019	2020	2021	2022	2023	2024	2025
Total surface - ha	700	700	700	700	700	700	700	700
Surface area in production - ha	700	700	700	700	700	700	700	700
Total production - tons	17,500	17,500	17,500	17,500	17,500	11,500	11,500	13,100
Harvested production - tons	16,625	16,625	16,625	16,625	16,625	11,200	11,200	12,588

Source: Authors' elaboration on data ISTAT (2026) (last accessed date 30.01.2026).

Table grapes harvested in the province of Foggia in 2025 represented 2.21% of the entire production harvested in Apulia, as shown in Table 5.

Tab. 6- Table grapes – local production (Bari)

Indicator	2018	2019	2020	2021	2022	2023	2024	2025
Total surface - ha	10,750	11,000	11,100	11,100	11,100	11,100	11,350	11,000
Surface area in production - ha	10,600	10,700	10,900	10,950	11,100	11,100	11,150	11,000
Total production - tons	233,200	235,400	241,000	215,000	215,000	215,100	230,000	260,000
Harvested production - tons	225,000	230,000	240,000	210,000	211,000	215,100	230,000	260,000

Source: Authors' elaboration on data ISTAT (2026) (last accessed date 30.01.2026).

Conversely, table grapes harvested in the province of Bari in 2025 represented 45.68% of the entire production harvested in Apulia, as shown in Table 6.

Tab. 7 - Table grapes – local production (Taranto)

Indicator	2018	2019	2020	2021	2022	2023	2024	2025
Total surface - ha	8,100	8,100	8,100	8,100	8,200	8,300	8,400	8,400
Surface area in production - ha	8,100	8,000	8,000	8,000	8,200	8,200	8,300	8,400
Total production - tons	243,000	224,000	224,000	240,000	205,000	20,750	215,000	215,000
Harvested production - tons	230,000	224,000	224,000	224,000	170,000	9,500	190,000	175,000

Source: Authors' elaboration on data ISTAT (2026) (last accessed date 03.02.2026).

Instead, table grapes harvested in the province of Taranto in 2025 represented 30.75% of the entire production harvested in Apulia, as shown in Table 7.

Tab. 8 - Table grapes – local production (Brindisi)

Indicator	2018	2019	2020	2021	2022	2023	2024	2025
Total surface - ha	800	900	850	830	800	770	670	650
Surface area in production - ha	800	870	820	800	770	740	650	630
Total production - tons	28,800	27,300	24,500	23,800	22,600	21,900	19,300	19,100
Harvested production - tons	28,800	27,000	23,900	23,200	22,000	21,300	19,000	18,800

Source: Authors' elaboration on data ISTAT (2026) (last accessed date 03.02.2026).

Instead, table grapes harvested in the province of Brindisi in 2025 represented 3,30% of the entire production harvested in Apulia (Table 8).

Tab. 9 - Table grapes – local production (Lecce)

Indicator	2018	2019	2020	2021	2022	2023	2024	2025
Total surface - ha	90	85	85	85	85	85	85	85
Surface area in production - ha	85	85	85	85	85	85	85	85
Total production - tons	1,650	1,955	1,955	1,955	1,955	2,000	1,800	1,800
Harvested production - tons	1,617	1,896.5	1,869.5	1,900	1,955	2,000	1,800	1,800

Source: Authors' elaboration on data ISTAT (2026) (last accessed date 03.02.2026).

Table grapes harvested in the province of Lecce in 2025 represented 0.32% of the entire production harvested in Apulia (Table 9).

Tab. 10 - Table grapes – local production (Barletta-Andria-Trani)

Indicator	2018	2019	2020	2021	2022	2023	2024	2025
Total surface - ha	4,200	4,200	4,250	4,250	4,250	4,250	4,250	4,100
Surface area in production - ha	4,100	4,100	4,150	4,150	4,150	4,250	4,250	4,050
Total production - tons	110,000	110,000	110,000	110,000	110,000	115,000	115,000	105,000
Harvested production - tons	110,000	100,000	108,000	108,000	108,000	115,000	115,000	101,000

Source: Authors' elaboration on data ISTAT (2026) (last accessed date 03.02.2026).

Finally, table grapes harvested in the province of Barletta-Andria-Trani in 2025 represented 17.74% of the entire production harvested in Apulia (Table 10).

3.1 Table grape supply chain

Italian table grape supply chain is a well-established and export-oriented agricultural system that integrates production, post-harvest handling, and international commercialization. Italy is the leading producer of table grapes in Europe and ranks among the top global exporters, accounting for roughly 10 % of global trade in the sector and generating export revenues exceeding €820 million in 2023. High international demand, particularly from key European markets like Germany, France and Poland, underscores the supply chain's strategic role in Italy's fresh fruit export performance (Unione Coltivatori Italiani, 2024).

Particularly, Italian table grape supply chain is characterized by domestic production (98%), while imports account for the remaining 2% and are mainly intended for off-season consumption.

Regarding product destination, approximately 38% of total availability is absorbed by domestic consumption, while around 45% is allocated to export markets, confirming the high export orientation of the sector. About 15% of production is directed toward industrial processing, mainly for juice production, whereas the residual share consists of losses along the supply chain and product withdrawals from the market aimed at stabilizing supply. Concerning domestic consumption, it is estimated that approximately 75% is channeled through retail outlets, while the remaining 25% is destined for the collective catering sector (ISMEA, 2024).

From the demand perspective, both domestic and international markets showed strong interest. Notably, the domestic market exhibited a growing preference for seedless grapes, with strengthened demand supported by retail sales data for packaged table grapes (ISMEA, 2024).

On the price side, limited supply has generated positive market momentum, with farm-gate prices stabilizing at levels similar to those recorded in 2023. Field-level negotiations have been swift and based on satisfactory price conditions. Seeded varieties are also experiencing favorable market dynamics, comparable to those of seedless grapes, largely due to the reduction in supply following vineyard removals (ISMEA, 2024).

This production campaign highlights how a balanced relationship between supply and demand can lead to satisfactory economic outcomes for producers. At the same time, it confirms that managing this balance remains challenging and that policy instruments aimed at market coordination require further development within this supply chain. A key limitation continues to be the complexity of coordination, exacerbated by structural resistance to collective action and the sharing of strategic information (ISMEA, 2024).

Climatic conditions affect not only yields but also production costs (ISMEA, 2024).

In the context of retail sales, it has been noted that table grape purchases for home consumption occur primarily in the second half of the year, between July and December. This is the period when national production peaks. In the first nine months of 2024, sales increased by 24% year-on-year, also recording a 2.5% increase in retail prices. In terms of volume, 38% of grape sales are packaged and 62% are loose. Furthermore, a 2% reduction in the average weight of packages was observed, with the 500-gram package rapidly gaining popularity at the expense of the 1-kg package. At the same time, packaged products are becoming more popular than loose ones, and seedless grapes are becoming more popular at the expense of seeded varieties (ISMEA, 2024).

3.1.1 Agricultural cultivation

Currently, Italian table grape sector is facing a series of challenges through constant varietal renewal (especially in seedless grape production) and careful production planning. To achieve these goals and ensure

the competitiveness of the supply chain, agronomic innovation, adaptability, and supply diversification are key elements today (Uva da tavola, 2025). Among the 10 most widely grown table grape varieties in Italy (Tab. 12), the cultivars Italia, Vittoria, and Autumncrisp® stand out among the top three nationwide.

Tab. 11 - Top 10 varieties

Position	Cultivar	% of production	kind	Ripening period	With seeds/ Seedless
1	Italia	25	white	mid-late	with
2	Vittoria	11.5	white	early	with
3	Autumn Crisp	9.3	white	mid-late	Seedless
4	Superior seedless - Sugraone	4.7	white	early	Seedless
5	Crimson Seedless	4.2	red	mid-late	Seedless
6	Red Globe	3.9	red	mid-late	with
7	Regal Seedless	3.6	white	mid-late	Seedless
8	Allison	3.0	red	mid-late	Seedless
9	Scarlotta Seedless	2.8	red	mid-late	Seedless
10	Arra 30 Sugar Drop	2.7	white	early	Seedless
	Other cultivars	29.3	-----	-----	-----
TOTAL		100%			

Source: Authors' elaboration on data CUT - Uva da Tavola (2025).

In 2023 Italian table grapes were predominantly white (71%), followed by red (22%) and black varieties (7%). Furthermore, the trend in the cultivation of seedless varieties is growing, reaching over 57% of the total in 2023, with peaks of 78%, compared to 42.5% of the areas cultivated with seeded varieties (Uva da tavola, 2025).

It has also been observed that seedless varieties, particularly those developed by professional breeders and protected by intellectual property rights (IPR), tend to fetch significantly higher prices on the market compared with traditional seeded varieties. This premium reflects both consumer preferences and the perceived added value of these modern cultivars. Moreover, the introduction of club varieties—exclusive, often IPR-protected seedless cultivars marketed through structured licensing programs—has played an important role in meeting the rising global demand for high-quality seedless table grapes. These club varieties help growers differentiate their product offerings and align with evolving consumer tastes for premium seedless grapes (Seccia et al., 2024).

3.1.2 Import and export

Globally, table grape imports total approximately 5 million tonnes of product, with an estimated value of around €9 billion in 2023. In that year, Peru emerged as the world's leading exporter, capturing about 19 % of global export value, followed by the Netherlands and Italy, each with roughly 10 %, and then China, Chile (9 %), and the United States (8 %). Although Italy is the largest producer of table grapes in Europe, it ranks third among global exporters, with export shipments valued at approximately €820 million in 2023/24 (ISMEA, 2024).

In terms of supply quality, the Italian table grape sector is responding better to international demand than in the past, offering "historical" varieties such as Vittoria, Palieri, Italia, and Red Globe, alongside a growing number of seedless varieties, highly sought after by foreign markets (ISMEA, 2024).

3.1.3 Environmental impacts

Generally, cultivation of table grapes is widespread throughout the planet and the fruit is consumed both fresh (table grapes) and processed (mainly wine) (Roselli et al., 2020). From an environmental perspective, table grapes cultivation shows a value of global warming equal to 122.17 kg CO₂eq and the nitrogen fertilizer has the largest weight among the energy inputs in the production of grapes (Rahmani et al., 2022). Amongst the production phases that have the greatest impact on the environment, the agricultural production phase, compared to the subsequent transformation, transportation, packaging, and distribution phases, is responsible for many of the environmental impacts of food products (Roselli et al., 2020). Moreover, fertilizer use - especially nitrogen fertilizer as also aforementioned - represents a key driver of GHG (Greenhouse Gases) emissions in vineyards, often contributing to the largest share of the CF (Carbon Footprint) of table grapes production, with agricultural inputs dominating global warming potential from a cradle-to-farm-gate perspective (Hefler & Kissinger, 2023).

Particularly, the main environmental aspects of table grape production, based on LCAs and sustainability studies retrieved in literature, are cultivation inputs and farming practices, water use and irrigation, agrochemicals and soil impacts, infrastructure and materials, packaging and waste (Roselli et al., 2020).

Firstly, the cultivation stage - particularly irrigation, fertilizer application and agrochemical inputs - contributes most to the environmental burden of table grape production, outweighing impacts from later stages such as packaging, transport, and distribution. This is mainly due to the intensive use of on-farm inputs and energy (Roselli et al., 2020).

Secondly, irrigation can have notable environmental consequences, as it often involves high water use and energy consumption for pumping and distribution, particularly in areas with limited rainfall where additional irrigation is needed to maintain crop yields and quality (Matos et al., 2024).

Thirdly, the use of plant protection products and other agrochemicals can lead to soil and water contamination, and both their manufacture and application are significant contributors to environmental impacts in agricultural life-cycle assessments (ISPRA, 2025).

Moreover, infrastructure elements such as polytunnels, plastic covers and metal supports add to the environmental burden of grape production through the energy used in manufacturing and the emissions associated with their materials (Gardenersbayswater, 2024).

Finally, although on-farm production typically accounts for the largest share of environmental impacts, packaging materials - especially single-use plastics with low recycling rates - and the generation of food waste also contribute significantly to life-cycle environmental burdens when all stages from material production to disposal are considered. This reflects the role of packaging in resource use, emissions, and waste management across the food supply chain (Kan & Miller, 2022).

4 Methodological framework

4.1 Goal and scope of the study

The aim of this study is to assess the environmental footprint of table grape production systems in Apulia by applying the Environmental Footprint 3.1 (EF 3.1) methodology. The assessment was developed to support the environmental characterization of the sector and to provide a consistent analytical basis for the development and interpretation of product-level environmental datasets.

The study focuses on table grapes intended for direct consumption and considers the main cultivation systems identified within the regional production context, namely conventional and organic management under covered and uncovered conditions. The purpose of the assessment is to identify the most relevant impact categories, determine the main environmental hotspots, and compare the environmental profile of the different cultivation systems considered in the study.

The results are intended to support technical interpretation within the project framework and to provide an evidence-based basis for environmental analysis of the table grape supply chain. Any comparison among the production systems is therefore intended as an internal analytical exercise aimed at understanding the relative contribution of the main processes, emissions, and inputs under the modelling assumptions adopted in this study.

The environmental impacts were assessed using the EF 3.1 methodology, which enables the calculation of a comprehensive product-level environmental profile through midpoint indicators and the subsequent interpretation of normalized, weighted, and single-score results.

4.2 Functional unit and reference flow

The functional unit of the study is 1 kg of table grapes.

All input and output data were quantified and modelled with reference to this unit. Accordingly, the results represent the environmental impacts associated with the production of 1 kg of product under each cultivation system considered.

The reference flow corresponds to all the material and energy inputs, agricultural operations, direct emissions, and ancillary processes required to produce 1 kg of table grapes. This includes, where relevant to the model, the use of fertilisers, plant protection products, irrigation water, fuel, electricity, and other technical inputs, together with the emissions generated during cultivation activities. The use of a common functional unit allows a consistent comparison of the environmental profile of the different production systems analysed in the study.

4.3 System boundaries

The system boundaries include the processes required for the production of table grapes and the associated upstream and on-site activities considered relevant to the functional unit. The model includes the production and supply of agricultural inputs, cultivation operations, irrigation, fertilisation, plant protection treatments, fuel and electricity use, and direct emissions generated at field level. The system also includes the background processes associated with the production of the main inputs and utilities used within the agricultural stage, as represented through the selected datasets. Direct emissions to air, water, and soil resulting from cultivation practices are included in the analysis where relevant. The assessment is focused on the agricultural production system and the related upstream supply chain processes needed to obtain 1 kg of table grapes. The system boundaries were defined consistently across all four cultivation systems in order to ensure methodological comparability of the results.

4.4 Data sources

The study was developed by combining foreground data describing the cultivation systems with secondary datasets used to model background processes. Foreground data refer to the technical and agronomic information required to represent the production systems under analysis, including crop management practices, input use, irrigation, field operations, and direct emissions associated with cultivation.

Secondary data were used to model upstream processes related to the production of agricultural inputs, energy carriers, and other background activities relevant to the functional unit. These data were drawn from available datasets selected according to their technological, geographical, and temporal relevance for the study. The use of secondary datasets made it possible to ensure completeness of the inventory and consistency in the representation of background processes.

4.5 Life cycle inventory

The Life Cycle Inventory for table grapes was developed through the creation of four specific agricultural datasets, representing the main cultivation systems identified in the Apulian production context: conventional covered, conventional uncovered, organic covered, and organic uncovered. These datasets were developed to describe the main differences in agronomic management and cultivation conditions and to provide the inventory basis for the subsequent environmental assessment.

The datasets used in this study are defined with reference to 1 hectare of cultivated area. This reference allows a consistent representation of agricultural management practices and input use at field level. Within each dataset, the corresponding yield is also reported, in order to link the inventory data to the amount of harvested product obtained under each cultivation system. Although the inventory datasets were structured on a hectare basis, the environmental results were calculated and expressed per 1 kg of table grapes by applying the corresponding yield of each cultivation system.

The datasets were developed in ILCD format within the GRINS project framework and focus on the cultivation stage, including the main input and output flows associated with table grape production. In particular, they account for land occupation, irrigation water use, fuel and electricity consumption, fertiliser and pesticide application, and direct emissions to air, water, and soil associated with field operations and crop management.

The inventory construction was based on the integration of primary and secondary data sources. Primary data were collected from producers and sector stakeholders through structured surveys and technical records, while secondary data were used to model background processes and complete missing information where necessary. This approach ensured both representativeness of the local production systems and methodological consistency in dataset development.

The four datasets reflect the two main variables used to classify table grape production systems in the study area, namely production management (conventional or organic) and cultivation condition (covered or uncovered). This distinction made it possible to represent the main technical differences among systems, particularly in relation to irrigation practices, synthetic input use, and crop management.

These hectare-based datasets constitute the inventory framework used to analyse the environmental profile of the four cultivation systems on a consistent and comparable basis.

Conventional covered



PROCESS INFORMATION	
Key data set information	
Name (Base name; Treatment; Mix and location types); Synonym; Class name; Class name	Cultivation of table grapes. Conventional production, uncovered, high load crop production between 6-18 years. On Field, Apulia (IT). Average Annual YIELD, not weighted, 1 ha. Coltivazione di uva da tavola. Produzione con entonnoia sotto coperta. Produzione di coltura ad alto carico tra 6-18 anni. On Field, Puglia (IT). Resa media annua, non ponderata, 1 ha.
Quantitative reference	Reference flow(s)
Reference flow(s)	25.339 kg of table grapes for ha
Time representativeness	Reference year
Reference year	2023
Data set valid until	2022
Time representativeness description	The On Field data are collected over the 2022/2023 year
Geographical representativeness	Location
Location	Apulia (IT)
Geographical representativeness description	The process describes the average production of table grapes cultivated in 1 hectare of land in Apulia. Fetters (based on Nitrogen, Phosphorous and Phossam) and Pesticides data refer to On Field Treatments Report regarding 570 ha crop in Apulia (IT)

TECHNOLOGICAL REPRESENTATIVENESS	
Technology description including background system	
Farming; Fertilization and Pest control; Use of agricultural machines, metering, harvesting.	
Technical purpose of product or process	
The product (Grapes fruit) can be used for fresh consumption	
MODELING AND VALIDATION	
LCI method and allocation	
Type of dataset	Unit process, single operation
LCI method principle	Attributional
LCI method approaches	Not applicable
Deviations from LCI method approaches/explanations	
none	

Data sources, treatment and representativeness	
Date cut-off and completeness principles	Production of machineries, equipment and infrastructures is not included.
Data selection and combination principles	Data were collected using primary sources. Secondary data were derived from statistical and literature sources.
Data treatment and extrapolations principles	The analysis of production and cultivated area, and the relative production yield are the result of surveys done directly to farmers in the provinces of Taranto, Lecce, Brindisi and Bari for the annual yield of the crop. Fertilizer application rates (in term of N, P, K) are derived from Trattamenti Report of the 2022-2023 year, same for
Data collection period	2022-2023
Data sources(s) used for this data set	ELROSTAT, 2016. Soil European Emission Rhaudo F. (2017) Protonomi di Agricoltura, Hoopik Zampori L., & Pan. R. (2019). IBC Technical Reports: Suggestions for updating the Organisation Environmental Footprint (OEF) method. Publications Office of the European Union, Luxembourg WFLDB - World Food LCA Database, 2015 ISTAT, 2024 https://www.istat.it/it/dati/banche-dati/ Pianeta PSR https://www.pianetapsr.it/levcmpages/Service/BO.php/LIT_ID/Pagina/1

Completeness	
Completeness product model	All relevant flows quantified
Validation	
Type of review	Independent external review
Review details	Inventory data quality validation at the conclusion of the Project "PNRR GRINS" was reviewed according to GRINS methodology. The following criteria were evaluated for each dataset: 1. Reliability; 2. Completeness; 3. Temporal correlation; 4. Geographical correlation; 5. Further technological correlation.
Subsequent review comments	Based on the evidences collected during the review activities, considering the goal and scope of the study and of the critical review activities, it can be stated that the report and the datasets produced are in line with the reference standards: ISO 14049:2021 and ISO 14044:2021.
Data Quality Indicator	Reliability: Very Good - Sufficient "between 2 and 3" - Completeness: Excellent - Sufficient "between 1 and 4" - Temporal correlation: Excellent - Good "between 1 and 3" - Geographical correlation: Excellent - Sufficient "between 1 and 4" - Further technological correlation: Very Good - Good "between 2 and 3"
Reviewer name and institution	Spin Life srl (Spin Off dell'Università degli Studi di Padova)
Compliance declaration	
Compliance system name	ISO 14040
Approval of overall compliance	Fully compliant
Non-compliances compliance	Fully compliant
Methodological compliance	Fully compliant
Review compliance	Fully compliant
Documentation compliance	Fully compliant
Quality compliance	Fully compliant
Compliance system name	ISO 14044
Approval of overall compliance	Fully compliant
Non-compliances compliance	Fully compliant
Methodological compliance	Fully compliant
Review compliance	Fully compliant
Documentation compliance	Fully compliant
Quality compliance	Fully compliant

ADMINISTRATIVE INFORMATION	
Commissioner and goal	
Reference to commissioner	Unione Europea Next Generation EU, Piano Nazionale di Ripresa e Resilienza (PNRR), Missione 4, Componente 2, Investimento 1.3 "Creazione di Partenariati estesi alle Università, ai Centri di Ricerca, alle Aziende per il finanziamento di progetti di ricerca di base"
Project	GRINS PFD00018 - Growing Resilient, Inclusive and Sustainable, CUP: H99C2200060001
Data set generator, modeler	
Data set generator/modeler	Università degli Studi di Bari Aldo Moro - Dipartimento di Economia Management e Diritto dell'Impresa
Publication and ownership	
Copyright	None
License type	Free of charge for all users and uses
Owner of data set	Università degli Studi di Bari Aldo Moro - Dipartimento di Economia Management e Diritto dell'Impresa
Access and use restriction	Type of license: Open Database License (ODBL)

Input and output		
PRODUCT/FUNCTIONAL UNIT		
Functional unit	Amount Unit Description (including Reference Flow)	
1	1.00E+00 ha	The dataset refers to the average production of table grapes in apulia. (Average yield: 25.339 kg/ha)
Input flows		
Type of flow	Flow Amount Unit SD ² or SD Description	
Resources from environment (elementary flows)	Land occupation	1.00E+00 ha 1.11 (1.1.1.1.2) Data based on average production (ISTAT, 2024)
Material input	Irrigation	1.36E+02 mm m2 1.07 (1.1.1.1.2) Data based on field
Resources from environment	Rainwater	6.45E+02 mm m2 1.07 (1.1.1.1.2) Data based on Average 2022-2023, PianetaPSR
Intermediate material input	N	2.41E+02 kg 1.07 (1.1.1.1.2) Data based on field
Intermediate material input	P205	1.16E+02 kg 1.07 (1.1.1.1.2) Data based on field
Intermediate material input	K2O	1.13E+02 kg 1.07 (1.1.1.1.2) Data based on field
Intermediate material input	Calcium	6.05E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Copper	1.96E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Zinc	1.25E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Lead	7.94E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Nickel	1.67E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Chromium	2.98E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Intermediate material input	Dinethomoph	6.06E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Intermediate material input	Mancozeb	1.80E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Intermediate material input	Copper oxychloride	2.98E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Intermediate material input	Wettable sulfur	3.26E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Intermediate material input	Colloidal sulfur	1.80E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Intermediate material input	Bacillus thuringiensis	4.08E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Intermediate material input	Chlorpyrifos-methyl	2.40E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Intermediate material input	Fenazapron	6.06E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Intermediate material input	Diazinil	1.27E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Intermediate material input	Electricity	6.80E+02 kWh 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Accessory material input	Lubricant oil	2.40E+02 kg 1.14 (3.3.2.3.2) Data based on Rhaudo et al. (2017) tab. 142.17.4
Output flows		
Type of flow	Flow Amount Unit SD ² or SD Description	
Product	Grapes	2.53E+04 kg 1.07 (1.1.1.1.2) Data based on field
Emission in air	Ammonia	8.80E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in air	Nitrogen oxides	2.79E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in air	Dinitrogen monoxide	4.00E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in air	Dinethomoph	5.85E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Mancozeb	1.62E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Copper oxychloride	2.52E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Wettable sulfur	2.88E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Colloidal sulfur	1.62E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Bacillus thuringiensis	3.66E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Chlorpyrifos-methyl	2.40E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Fenazapron	5.84E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water (specie/acid)	Nitrate	2.78E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in water (ground water)	Phosphate leaching	7.08E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in water (surface water)	Phosphorus non-O	2.26E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in water (specie/acid)	Phosphorus	7.07E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Calcium	4.48E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Copper	3.21E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Zinc	1.91E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Lead	1.79E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Chromium	2.03E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Dinethomoph	6.06E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Mancozeb	1.80E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Copper oxychloride	2.88E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Wettable sulfur	3.26E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Colloidal sulfur	1.80E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Bacillus thuringiensis	4.08E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Chlorpyrifos-methyl	6.06E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Fenazapron	6.06E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Calcium	5.84E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Copper	1.84E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Zinc	6.12E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Lead	2.11E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Nickel	1.26E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Chromium	5.20E+02 kg 1.15 (2.3.3.3.2) Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Dinethomoph	5.84E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Mancozeb	1.62E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Copper oxychloride	2.52E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Wettable sulfur	2.88E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Colloidal sulfur	1.62E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Bacillus thuringiensis	3.66E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Chlorpyrifos-methyl	2.16E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Fenazapron	5.84E+02 kg 1.15 (2.2.2.2.2) Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)

Conventional uncovered

PROCESS INFORMATION	
Key data set information	
Name (Base name; Treatment; Mix and location types);	Cultivation of table grapes. Conventional production, open field, high load crop production between 6-18 years, On Field, Apulia (IT), Average Annual Yield, not weighted, 1 ha
Stoniness;	Coltivazione di uva da tavola. Produzione con convenzionale a pieno campo. Produzione di coltura ad alto carico tra 6-18 anni, On Field, Puglia (IT), Resa media annua, non ponderata, 1 ha
Class name;	Material Production
Class name;	Food and renewable raw materials
Quantitative reference	
Type of quantitative reference;	Reference flow(s)
Reference flow(s);	26,513 kg of table grapes for ha
Time representativeness	
Reference year;	2023
Data set valid until;	2022
Time representativeness description;	The On Field data are collected over the 2022/2023 year
Geographical representativeness	
Location;	Apulia (IT)
Geographical representativeness description;	The process describes the average production of table grapes cultivated in 1 hectare of land in Apulia. Fertilisers (based on Nitrogen, Phosphorous and Potassium) and Pesticides data refer to On Field Treatments Report regarding 173 ha crop in Apulia (IT)

TECHNOLOGICAL REPRESENTATIVENESS	
Technology description including background system;	Farming: Fertilization and Pest control; Use of agricultural machines, metering, harvesting.
Technical purpose of product or process;	The product (Grapes fruit) can be used for fresh consumption
METHODOLOGICAL VALIDATION	
LCI method and allocation;	N
Type of dataset;	Unit process, single operation
LCI method principle;	Attributional
LCI method approaches;	No applicable
Deviations from LCI method approaches/ explanations;	none

DATA SOURCES, TREATMENT AND REPRESENTATIVENESS	
Date cut-off and completeness principles;	Production of machinery, equipment and infrastructures is not included.
Data selection and combination principles;	Data were collected using primary sources. Secondary data were derived from statistical and literature sources.
Data treatment and extrapolations principles;	The analysis of production and cultivated area, and the relative production yield are the result of surveys done directly to farmers in the provinces of Taranto, Brindisi and Barietta-Andria-Trani for the annual yield of the crop. Fertiliser application rates (in term of N, P, K) are derived from Treatments Report of the 2022-2023 year.
Data collection period;	2022
Data sources(s) used for this data set;	ELROSTAT, 2016, Soil European Emission Ribaudo F. (2017) Promoting of Agriculture, Hoopik Zampori L., & Pan, R. (2019). JRC Technical Reports: Suggestions for updating the Organisation Environmental Footprint (OEF) method. Publications Office of the European Union, Luxembourg WFLDB, World Food LCA Database, 2015 ISTAT, 2024 https://www.istat.it/it/dati/banche-dati/ Pianeta PSR https://www.pianetapsr.it/levicompages/Service/BO.php/LIT_ID/Pagina/1

COMPLETENESS	
Completeness product model;	All relevant flows quantified
VALIDATION	
Type of review;	Independent external review
Review details;	Inventory data quality validation at the conclusion of the Project "PNRR-GRINS" was reviewed according to GRINS methodology. The following criteria were evaluated for each dataset: 1. Reliability; 2. Completeness; 3. Temporal correlation; 4. Geographical correlation; 5. Further technological correlation.
Subsequent review comments;	Based on the evidences collected during the review activities, considering the goal and scope of the study and of the critical review activities, it can be stated that the report and the datasets produced are in line with the reference standards, ISO 14040:2021 and ISO 14044:2021.
Data Quality Indication;	Reliability: Very Good - Sufficient "between 2 and 3", - Completeness: Excellent - Sufficient "between 1 and 4", - Temporal correlation: Excellent - Good "between 1 and 3", - Geographical correlation: Excellent - Sufficient "between 1 and 4", - Further technological correlation: Very Good - Good "between 2 and 3"
Reviewer name and institution;	Spin Life srl (Spin Off dell'Università degli Studi di Padova)
COMPLIANCE DECLARATION	
Compliance system name;	ISO 14040
Approval of overall compliance;	Fully compliant
Non-exclusion compliance;	Fully compliant
Methodological compliance;	Fully compliant
Review compliance;	Fully compliant
Quality compliance;	Fully compliant
Compliance system name;	ISO 14044
Approval of overall compliance;	Fully compliant
Non-exclusion compliance;	Fully compliant
Methodological compliance;	Fully compliant
Review compliance;	Fully compliant
Documentation compliance;	Fully compliant
Quality compliance;	Fully compliant

ADMINISTRATIVE INFORMATION	
Commissioner and goal;	Unione Europea Next Generation EU, Piano Nazionale di Ripresa e Resilienza (PNRR), Missione 4, Componente 2, Investimento 1.3 "Creazione di Partenariati estesi alle Università, ai Centri di Ricerca, alle Aziende per il finanziamento di progetti di ricerca di base"
Reference to commissioner;	GRINS PE000018 - Growing Resilient, Inclusive and Sustainable, CUP: I19C2200065000
Project;	
Data set generator/modifier;	Unità esecutiva degli Studi di Bari Aldo Moro - Dipartimento di Economia Management e Diritto dell'Impresa
Data set generation/modifier;	
PUBLICATION AND OPENING	
Publication and opening;	Yes
Copyright;	Free of charge for all users and users
License type;	Open Access
Owner of data set;	Università degli Studi di Bari Aldo Moro - Dipartimento di Economia Management e Diritto dell'Impresa
Access and use restriction;	Type of license: Open Database Licence (ODL)

INPUT-FUNCTIONAL UNIT		Name	Amount	Unit	Description (including Reference Flow)
Functional unit		Area	1,00E+00	ha	The dataset refers to the average production of table grapes in apulia. (Average yield: 26,513 kg/ha)
Input flows					
Type of flow	Flow	Amount	Unit	SD-2 or SD	Description
Resources from environment (elementary flows)	Land occupation	1,00E+00	ha	1,11	(1,2,1,1,2)Data based on average production (ISTAT, 2024)
Material input	Irrigation	2,20E+02	mm/m2	1,07	(1,1,1,1,2)Data based on field
Resources from environment	Rainwater	6,45E+02	mm/m2	1,07	(1,2,1,1,2)Data based on Average 2022 - 2023, PianetaPSR
Intermediate material input	N	1,75E+02	kg	1,07	(1,1,1,1,2)Data based on field
Intermediate material input	P205	1,03E+02	kg	1,07	(1,1,1,1,2)Data based on field
Intermediate material input	K2O	6,02E+01	kg	1,07	(1,1,1,1,2)Data based on field
Intermediate material input	Cadmium	5,34E-03	kg	1,15	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Copper	1,46E-02	kg	1,15	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Zinc	1,05E-01	kg	1,15	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Lead	6,52E-03	kg	1,15	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Nickel	1,38E-02	kg	1,15	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Chromium	2,98E-03	kg	1,15	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Dibenzothoph	6,06E-01	kg	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Mancozeb	1,80E+00	kg	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Copper oxychloride	2,98E+00	kg	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Wettable sulfur	3,20E+00	kg	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Colloidal sulfur	1,80E+00	kg	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Bacillus thuringiensis	4,00E-03	kg	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Chlorpyrifos-methyl	2,40E+00	kg	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Fenaziquin	6,06E-01	kg	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Diurel	1,27E+00	kg	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Electricity	6,80E+02	Kwh	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Acquility material input	Infrastruc oil	2,40E+00	kg	1,14	(3,2,3,2,2)Data based on Ribaudo et al. (2017) tab.142.17.4
Output flows					
Type of flow	Flow	Amount	Unit	SD-2 or SD	Description
Product	Grapes	2,65E+04	kg	1,07	(1,1,1,1,2)Data based on field
Emission in air	Ammonia	6,38E-03	kg	1,25	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in air	Nitrogen oxides	2,02E+00	kg	1,43	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in air	Dibenzophenone	2,91E+00	kg	1,43	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in air	Diethyleneglycol	5,48E+02	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Mancozeb	1,62E+01	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Copper oxychloride	2,52E+01	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Wettable sulfur	2,80E+01	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Colloidal sulfur	1,62E+01	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Bacillus thuringiensis	3,66E-02	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Chlorpyrifos-methyl	2,40E+00	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Fenaziquin	5,48E+02	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water (atmospheric)	Nitrate	2,65E+01	kg	1,43	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in water (ground water)	Phosphate leaching	7,08E+02	kg	1,51	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in water (surface water)	Phosphorus run-off	2,30E+01	kg	1,51	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in water (atmospheric)	Phosphorus	7,07E+01	kg	1,51	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Cadmium	4,42E-05	kg	1,83	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Copper	3,14E-03	kg	1,83	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Zinc	1,76E-02	kg	1,83	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Lead	1,52E-04	kg	1,83	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Chromium	2,01E-02	kg	1,83	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Diethyleneglycol	6,06E+03	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Mancozeb	1,80E+00	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Copper oxychloride	2,80E+02	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Wettable sulfur	3,20E+02	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Colloidal sulfur	1,80E+02	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Bacillus thuringiensis	4,00E-03	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Chlorpyrifos-methyl	6,06E-01	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Fenaziquin	6,06E-01	kg	1,51	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Cadmium	4,68E-03	kg	1,51	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Copper	1,16E-02	kg	1,51	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Zinc	4,52E-02	kg	1,51	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Lead	1,64E-03	kg	1,51	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Nickel	9,91E-03	kg	1,51	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Chromium	4,80E-03	kg	1,51	(2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Diethyleneglycol	5,48E+01	kg	1,22	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Mancozeb	1,62E+00	kg	1,22	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Copper oxychloride	2,52E+00	kg	1,22	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Wettable sulfur	2,80E+00	kg	1,22	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Colloidal sulfur	1,62E+00	kg	1,22	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Bacillus thuringiensis	3,66E-01	kg	1,22	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Chlorpyrifos-methyl	2,16E+00	kg	1,22	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Fenaziquin	5,48E-01	kg	1,22	(2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)

Organic covered



PROCESS INFORMATION	
Key data set information	
Name (Base name; Treatment; Mixed and location types); Synonym	Cultivation of table grapes, Organic production, open field, undercover, high crop production between 6-18 years, On Field, Apulia (IT), Average Annual Yield, not weighted, 1 ha Coltivazione di uva da tavola, Produzione biologica sotto copertura, Produzione di coltura ad alto carico tra 6-18 anni, On Field, Puglia (IT), Resa media annua, non ponderata, 1 ha
Class name	Material Production
Class name	Food and renewable raw materials
Quantitative reference	
Type of quantitative reference	Reference flow(s)
Reference flow(s)	34,306 kg of table grapes for ha
Time representativeness	
Reference year	2023
Data set valid until	2022
Time representativeness description	The On Field data are collected over the 2022/2023 year
Geographical representativeness	
Location	Apulia (IT)
Geographical representativeness description	The process describes the average production of table grapes cultivated in 1 hectare of land in Apulia. Fertilizers (based on Nitrogen, Phosphorous and Phossam) and Pesticides data refer to On Field Treatments Report regarding 108 ha crop in Apulia (IT)

Technical purpose of product or process	
The product (Grapes fruit) can be used for fresh consumption	
Method and allocation	
Type of dataset	Unit process, single operation
LCI method principle	Attributional
LCI method approaches	Not applicable
Deviations from LCI method approaches/explanations	
none	

Data sources, treatment and representativeness	
Date cut-off and completeness principles	Production of machinery, equipment and infrastructures is not included.
Data selection and combination principles	Data were collected using primary sources. Secondary data were derived from statistical and literature sources.
Data treatment and extrapolations principles	The analysis of production and cultivated area, and the relative production yield are the result of surveys done directly to farmers in the provinces of Bari and Taranto for the annual yield of the crop. Fertilizer application rates (in term of N, P, K) are derived from Treatments Report of the 2022-2023 year, same for Pesticides
Data collection period	2022-2023
Data sources(s) used for this data set	ELROSTAT, 2016, Soil European Envision Ribaudo F. (2017) Protonomi di Agricoltura, Hoopik Zampori L., & Pan. R. (2019). IBC Technical Reports: Suggestions for updating the Organisation Environmental Footprint (OEF) method. Publications Office of the European Union, Luxembourg WILDEF - World Food LCA Database 2015 ISTAT, 2024 https://www.istat.it/it/dati/banche-dati/ Pianeta PSR https://www.pianetapsr.it/levicpage/Service/BLOR.php/LIT_ID/Pagina/1

Completeness	
Completeness product model	All relevant flows quantified
Validation	
Type of review	Independent external review
Review details	Inventory data quality validation at the conclusion of the Project "PNRR/GRINS" was reviewed according to GRINS methodology. The following criteria were evaluated for each dataset: 1. Reliability; 2. Completeness; 3. Temporal correlation; 4. Geographical correlation; 5. Further technological correlation.
Subsequent review comments	Based on the evidences collected during the review activities, considering the goal and scope of the study and of the critical review activities, it can be stated that the report and the datasets produced are in line with the reference standards: ISO 14049:2021 and ISO 14044:2021.
Data Quality Indicator	Reliability: Very Good - Sufficient; Between 2 and 3 - Completeness: Excellent - Sufficient; Between 1 and 4 - Temporal correlation: Excellent - Good; Between 1 and 4 - Geographical correlation: Excellent - Sufficient; Between 1 and 4 - Further technological correlation: Very Good - Good; Between 2 and 3
Reviewer name and institution	Spin Life srl (Spin Off dell'Università degli Studi di Padova)
Compliance declaration	
Compliance system name	ISO 14040
Approval of overall compliance	Fully compliant
Non-compliances compliance	Fully compliant
Methodological compliance	Fully compliant
Review compliance	Fully compliant
Documentation compliance	Fully compliant
Quality compliance	Fully compliant
Compliance system name	ISO 14044
Approval of overall compliance	Fully compliant
Non-compliances compliance	Fully compliant
Methodological compliance	Fully compliant
Review compliance	Fully compliant
Documentation compliance	Fully compliant
Quality compliance	Fully compliant

ADMINISTRATIVE INFORMATION	
Commissioner and goal	
Reference to commissioner	Unione Europea Next Generation EU, Piano Nazionale di Ripresa e Resilienza (PNRR), Missione 4, Componente 2, Investimento 1.3 "Creazione di Partenariati estesi alle Università, ai Centri di Ricerca, alle Aziende per il finanziamento di progetti di ricerca di base"
Project	GRINS P0000018 - Growing Resilient, Inclusive and Sustainable, CUP: H95C2200060000
Data set generator/modifier	
Data set generator/modifier	Università degli Studi di Bari Aldo Moro - Dipartimento di Economia Management e Diritto dell'Impresa
Publication and ownership	
Copyright	None
License type	Free of charge for all uses and uses
Owner of data set	Università degli Studi di Bari Aldo Moro - Dipartimento di Economia Management e Diritto dell'Impresa
Access and use restriction	Type of license: Open Database License (ODBL)

Input flows			
Functional unit	Amount	Unit	Description (including Reference Flow)
Functional unit	1,00E+00 ha		The dataset refers to the average production of table grapes in apulia. (Average yield: 34,306 kg/ha)
Input flows			
Type of flow	Flow	Amount	Unit SD*2 or SD Description
Resources from environment (elementary flows)	Land occupation	1,00E+00 ha	1,11 (1,11,1,2)Data based on average production (ISTAT, 2024)
Material input	Irrigation	1,79E+02 mm/m2	1,07 (1,11,1,2)Data based on field
Resources from environment	Rainwater	6,45E+02 mm/m2	1,07 (1,11,1,2)Data based on Average 2022-2023, PianetaPSR
Intermediate material input	N	6,54E+01 kg	1,07 (1,11,1,2)Data based on field
Intermediate material input	P205	5,21E+01 kg	1,07 (1,11,1,2)Data based on field
Intermediate material input	K2O	5,38E+01 kg	1,07 (1,11,1,2)Data based on field
Intermediate material input	Cadmium	2,76E-03 kg	1,15 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Copper	7,95E-03 kg	1,15 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Zinc	5,06E-02 kg	1,15 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Lead	3,35E-03 kg	1,15 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Nickel	6,76E-03 kg	1,15 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Chromium	2,48E-03 kg	1,15 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Dinethomorph	6,00E-01 kg	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4
Intermediate material input	Mancozeb	1,80E+00 kg	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4
Intermediate material input	Copper oxychloride	2,80E+00 kg	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4
Intermediate material input	Wettable sulfur	3,20E+00 kg	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4
Intermediate material input	Colloidal sulfur	1,80E+00 kg	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4
Intermediate material input	Bacillus thuringiensis	4,00E-03 kg	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4
Intermediate material input	Chlorpyrifos-methyl	2,40E+00 kg	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4
Intermediate material input	Fenazquin	6,00E-01 l	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4
Intermediate material input	Calcium	1,27E+02 kg	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4
Intermediate material input	Electricity	6,80E+02 kWh	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4
Accessory material input	Lubricant oil	2,40E+00 kg	1,14 (3,3,3,3,2)Data based on Ribaudo et al. (2017) tab. 142, 17, 4

Output flows					
Type of flow	Flow	Amount	Unit	SD*2 or SD	Description
Product	Grapes	3,43E+04 kg		1,07 (1,11,1,2)Data based on field	
Emission in air	Ammonia	2,28E-03 kg		1,25 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in air	Nitrogen oxides	7,56E-01 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in air	Dinitrogen monoxide	1,12E+00 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in air	Dinethomorph	5,40E-02 kg		1,51 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in air	Mancozeb	1,62E-01 kg		1,51 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in air	Copper oxychloride	2,52E-01 kg		1,51 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in air	Wettable sulfur	2,80E-01 kg		1,51 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in air	Colloidal sulfur	1,62E-01 kg		1,51 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in air	Bacillus thuringiensis	3,60E-02 kg		1,51 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in air	Chlorpyrifos-methyl	2,16E-01 kg		1,51 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in air	Fenazquin	5,40E-02 l		1,51 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in water (unspecific)	Nitrate	2,28E-01 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in water (ground water)	Phosphate leaching	7,00E-02 kg		1,51 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in water (surface water)	Phosphate run-off	1,98E-01 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in water (unspecific)	Phosphorus	7,95E-03 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in water	Cadmium	3,97E-05 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in water	Copper	2,77E-03 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in water	Zinc	1,19E-02 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in water	Lead	9,12E-05 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in water	Chromium	1,92E-02 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in water	Dinethomorph	6,00E-03 kg		1,43 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in water	Mancozeb	1,80E-02 kg		1,43 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in water	Copper oxychloride	2,80E-02 kg		1,43 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in water	Wettable sulfur	3,20E-02 kg		1,43 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in water	Colloidal sulfur	1,80E-02 kg		1,43 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in water	Bacillus thuringiensis	4,00E-03 kg		1,43 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in water	Chlorpyrifos-methyl	2,40E-02 kg		1,43 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in water	Fenazquin	6,00E-01 l		1,43 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in soil	Cadmium	2,11E-03 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in soil	Copper	5,90E-03 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in soil	Zinc	1,40E-02 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in soil	Lead	4,95E-04 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in soil	Nickel	9,76E-04 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in soil	Chromium	1,52E-03 kg		1,43 (2,3,3,3,2)Data based on World Food LCA Database (WFLDB) (2015)	
Emission in soil	Dinethomorph	5,40E-01 kg		1,22 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in soil	Mancozeb	1,62E+00 kg		1,22 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in soil	Copper oxychloride	2,52E+00 kg		1,22 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in soil	Wettable sulfur	2,80E+00 kg		1,22 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in soil	Colloidal sulfur	1,62E+00 kg		1,22 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in soil	Bacillus thuringiensis	3,60E+00 kg		1,22 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in soil	Chlorpyrifos-methyl	2,16E+00 kg		1,22 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	
Emission in soil	Fenazquin	5,40E-01 l		1,22 (2,2,2,2,2)Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)	



PROCESS INFORMATION					
Key data set information					
Name (Base name; Treatment; Mix and location types);	Cultivation of table grapes, Organic production, open field, high load crop production between 6-18 years, On Field, Apulia (IT), Average Annual Yield, not weighted, 1 ha				
Stoniness;	Coltivazione di uva da tavola, Produzione biologica a pieno campo, Produzione di coltura ad alto carico 6-18 anni, On Field, Puglia (IT), Resa media annua, non ponderata, 1 ha				
Class name	Materials Production				
Class name	Food and renewable mv materials				
Quantitative reference					
Type of quantitative reference	References flow(s)				
Reference flow(s)	30,553 kg of table grapes for ha				
Time representativeness					
Reference year	2023				
Data set valid until	2022				
Time representativeness description	The On Field data are collected over the 2022/2023 year				
Geographical representativeness					
Location	Apulia (IT)				
Geographical representativeness description	The process describes the average production of table grapes cultivated in 1 hectare of land in Apulia. Fertilizers (based on Nitrogen, Phosphorous and Phossam) and Pesticides data refer to On Field Treatments Report regarding Z88 ha crop in Apulia (IT)				
Technological representativeness					
Technology description including background system	Farming; Fertilization and Pest control; Use of agricultural machines, metering, harvesting.				
Technical purpose of product or process	The product (Grapes fruit) can be used for fresh consumption				
METHODOLOGY AND VALIDATION					
LCI method and allocation					
Type of dataset	Unit process, single operation				
LCI method principle	Attributional				
LCI method approaches	Not applicable				
Deviations from LCI method approaches/explanations	none				
Data sources, treatment and representativeness					
Date cut-off and completeness principles	Production of machineries, equipment and infrastructures is not included.				
Data selection and combination principles	Data were collected using primary sources. Secondary data were derived from statistical and literature sources.				
Data treatment and extrapolations principles	The analysis of production and cultivated area, and the relative production yield are the result of surveys done directly to farmers in the provinces of Bari, Brindisi and Barletta-Andria-Trani for the annual yield of the crop. Fertiliser application rates (in term of N, P, K) are derived from Treatments Report of the 2022-2023 year.				
Data collection period	2022-2023				
Data sources(s) used for this data set	ELICOSTAT, 2016, Soil European Envision Ribaudo F. (2017) Protonomi di Agricoltura, Hoopik Zampori L., & Pan. R. (2019). IBC Technical Reports: Suggestions for updating the Organisation Environmental Footprint (OEF) method. Publications Office of the European Union, Luxembourg WILDEF - World Food LCA Database 2015 ISTAT, 2024 https://www.istat.it/it/dati/banche-dati/ Pianeta PSR https://www.pianetapsr.it/levicompages/Service/BO.php/LIT_ID/Pagina/1				
Completeness					
Completeness product model	All relevant flows quantified				
Validation					
Type of review	Independent external review				
Review details	Inventory data quality validation at the conclusion of the Project "PNRR/GRINS" was reviewed according to GRINS methodology. The following criteria were evaluated for each dataset: 1. Reliability; 2. Completeness; 3. Temporal correlation; 4. Geographical correlation; 5. Further technological correlation.				
Subsequent review comments	Based on the evidences collected during the review activities, considering the goal and scope of the study and the critical review activities, it can be stated that the report and the datasets produced are in line with the reference standards: ISO 14040:2021 and ISO 14044:2021.				
Data Quality Indicator	Reliability: Very Good - Sufficient "between 2 and 3" - Completeness: Excellent - Sufficient "between 1 and 4" - Temporal correlation: Excellent - Good "between 1 and 3" - Geographical correlation: Excellent - Sufficient "between 1 and 4" - Further technological correlation: Very Good - Good "between 2 and 3"				
Reviewer name and institution	Spin Life srl (Spin Off dell'Università degli Studi di Padova)				
Compliance declaration					
Compliance system name	ISO 14040				
Approval of overall compliance	Fully compliant				
Non-compliances compliance	Fully compliant				
Methodological compliance	Fully compliant				
Review compliance	Fully compliant				
Documentation compliance	Fully compliant				
Quality compliance	Fully compliant				
ADMINISTRATIVE INFORMATION					
Commissioner and goal					
Reference to commissioner	Unione Europea Next Generation EU, Piano Nazionale di Ripresa e Resilienza (PNRR), Missione 4, Componente 2, Investimento 1.3 "Creazione di Partenariati estesi alle Università, ai Centri di Ricerca, alle Aziende per il finanziamento di progetti di ricerca di base"				
Project	GRINS P0000018 - Growing Resilient, Inclusive and Sustainable, CLP: IPBC2200060000				
Data set generator/ modifier					
Data set generator/ modifier	Università degli Studi di Bari Aldo Moro - Dipartimento di Economia Management e Diritto dell'Impresa				
Publication and ownership					
Copyright	None				
Licence type	Free of charge for all uses and uses				
Owner of data set	Università degli Studi di Bari Aldo Moro - Dipartimento di Economia Management e Diritto dell'Impresa				
Access and use restriction	Type of license: Open Database Licence (ODBL)				
Input and output					
PRODUCT/FUNCTIONAL UNIT					
Functional unit	Name	Amount	Unit	Description (including Reference Flow)	
	Area	1,00E+00	ha	The dataset refers to the average production of table grapes in apulia. (Average yield: 30,553 kg/ha)	
Input flows					
Type of flow	Flow	Amount	Unit	SD*2 or SD	Description
Resources from environment (elementary flows)	Land occupation	1,00E+00	ha	1,11 (1,11;1,2)	Data based on average production (ISTAT, 2024)
Material input	Irrigation	2,54E+02	mm ³ m ²	1,07 (1,11;1,2)	Data based on field
Resources from environment	Rainwater	6,45E+02	mm ³ m ²	1,07 (1,11;1,2)	Data based on average 2022-2023, PianetaPSR
Intermediate material input	N	1,52E+02	kg	1,07 (1,11;1,2)	Data based on field
Intermediate material input	P205	7,97E+01	kg	1,07 (1,11;1,2)	Data based on field
Intermediate material input	K2O	6,30E+01	kg	1,07 (1,11;1,2)	Data based on field
Intermediate material input	Cadmium	4,13E-03	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Copper	1,23E+02	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Zinc	8,29E+02	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Lead	5,26E-03	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Nickel	1,11E-02	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Intermediate material input	Chromium	2,98E+02	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Dibenzothiofene	6,00E-01	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Mancozeb	1,80E+00	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Copper oxychloride	2,80E+01	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Wettable sulfur	3,20E+00	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Colloidal sulfur	1,80E+00	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Bacillus thuringiensis	4,00E-03	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Chlorpyrifos-methyl	2,40E-00	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Fenazamin	6,00E-01	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Diuron	1,23E+02	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Intermediate material input	Electricity	6,80E+02	Kwh	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Accessory material input	Lubricant oil	2,40E-00	kg	1,14 (3,32;3,2)	Data based on Ribaudo et al. (2017) tab.142.17.4
Output flows					
Type of flow	Flow	Amount	Unit	SD*2 or SD	Description
Product	Grapes	3,06E+04	kg	1,07 (1,11;1,2)	Data based on field
Emission in air	Ammonia	5,57E-03	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in air	Nitrogen oxides	1,77E+00	kg	1,43 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in air	Dinitrogen monoxide	2,55E+00	kg	1,43 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in air	Dibenzothiofene	5,48E-02	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Mancozeb	1,62E-01	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Copper oxychloride	2,52E-01	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Wettable sulfur	2,80E-01	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Colloidal sulfur	1,62E-01	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Bacillus thuringiensis	3,60E-02	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Chlorpyrifos-methyl	2,16E-01	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in air	Fenazamin	5,48E-02	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water (unspecifed)	Nitrate	2,56E-01	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in water (ground water)	Phosphate leaching	7,00E-02	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in water (surface water)	Phosphate run-off	2,10E-01	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in water (unspecifed)	Phosphorus	7,07E-01	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Cadmium	4,28E-05	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Copper	3,05E-03	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Zinc	1,58E-02	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Lead	1,23E-04	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Chromium	1,90E-02	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in water	Dibenzothiofene	6,00E-03	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Mancozeb	1,80E-02	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Copper oxychloride	2,80E-02	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Wettable sulfur	3,20E-02	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Colloidal sulfur	1,80E-02	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Bacillus thuringiensis	4,00E-03	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Chlorpyrifos-methyl	2,40E-02	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in water	Fenazamin	6,00E-01	kg	1,51 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Cadmium	3,48E-03	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Copper	8,60E-03	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Zinc	3,23E-02	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Lead	1,12E-04	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Nickel	7,46E-04	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Chromium	3,17E-04	kg	1,15 (2,33;3,2)	Data based on World Food LCA Database (WFLDB) (2015)
Emission in soil	Dibenzothiofene	5,48E-04	kg	1,22 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Mancozeb	1,62E-04	kg	1,22 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Copper oxychloride	2,52E-04	kg	1,22 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Wettable sulfur	2,80E-04	kg	1,22 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Colloidal sulfur	1,62E-04	kg	1,22 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Bacillus thuringiensis	3,60E-04	kg	1,22 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Chlorpyrifos-methyl	2,16E-04	kg	1,22 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)
Emission in soil	Fenazamin	5,48E-01	kg	1,22 (2,22;2,2)	Data based on Zamponi and Pant (2019) - air (9%), water (1%) and soil (90%)

5 Life Cycle Impact Assessment (using the EF 3.1 methodology)

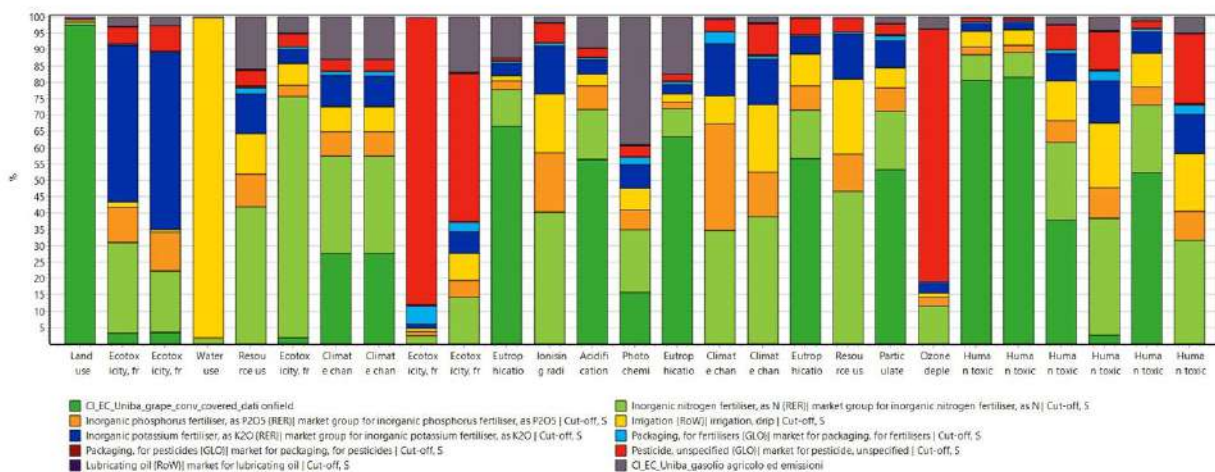
According to the ISO 14040 standard, the environmental impact assessment aims to identify and measure the impacts that the environment undergoes due to the releases and the consumption of resources associated with the analyzed product system. In this phase, data related to emissions and resource use are assigned to specific impact categories, quantifying the contribution of the process to the impacts considered. The ISO 14040 standard establishes that the impact assessment is developed through three main steps:

- Classification, in which the inventory data are assigned to one or more relevant environmental impact categories;
- characterization, which consists of calculating the category indicators and determining the relative contribution of each emitted substance or resource used;
- impact assessment, the final phase of analysis of the results obtained.

The standard also foresees some optional steps, such as normalization, grouping, and weighting, which allow further refinement of the interpretation of results. In this LCA study, the EF 3.1 method was applied, and the outcomes of the different assessment phases are illustrated in the following sections.

5.1 Characterisation

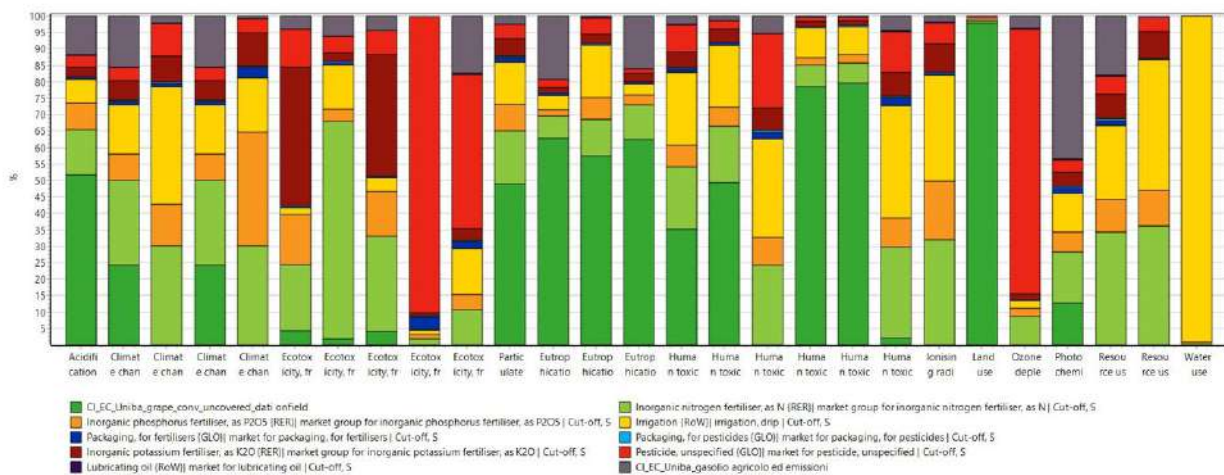
Conventional covered



The graph shows the percentage contribution of the main foreground processes to the EF 3.1 characterisation results for conventional covered table grape production. The impact profile is largely driven by on-field emissions, which dominate land use (97.4%), eutrophication, terrestrial (66.6%), eutrophication, marine (63.4%), eutrophication, freshwater (56.5%), acidification (56.5%), particulate matter (53.4%), human toxicity, non-cancer (80.6%), and human toxicity, cancer – inorganics (52.2%). Irrigation is almost entirely

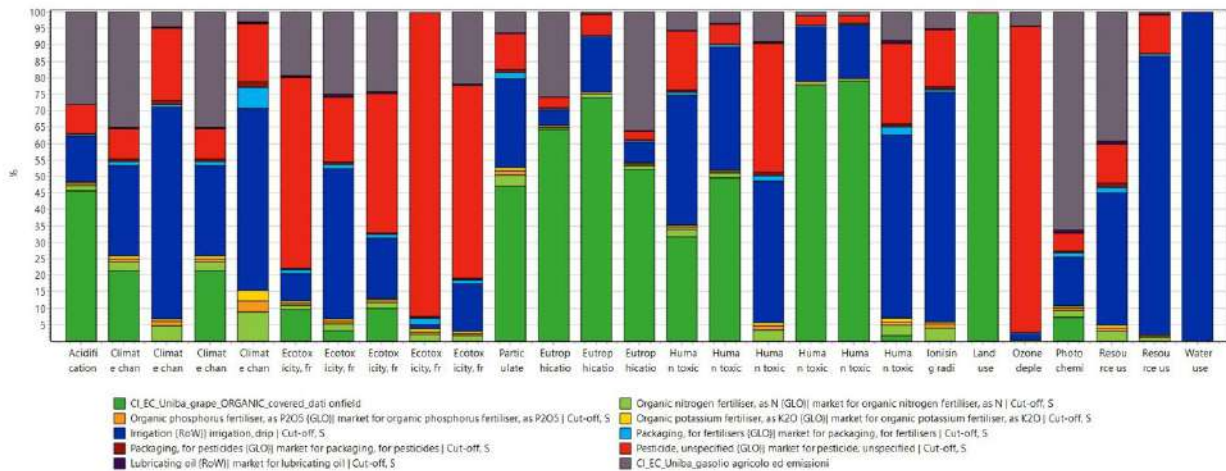
responsible for water use (97.8%) and also contributes to ionising radiation (18.2%) and resource use, minerals and metals (22.9%). Mineral fertilisers are major hotspots in several categories: potassium fertiliser dominates freshwater ecotoxicity – part 1 (54.1%) and freshwater ecotoxicity – inorganics (48.0%), while nitrogen fertiliser is the main contributor to freshwater ecotoxicity – part 2 (73.7%), resource use, fossils (41.9%), climate change (29.7%), and climate change – fossil (29.7%). Pesticide use is the main hotspot for freshwater ecotoxicity – organics p.1 (87.9%) and ozone depletion (77.3%), whereas diesel and related emissions are most relevant for photochemical ozone formation (39.0%). In terms of characterised results, the main category totals include 20.35 Pt for land use, 2.36 m³ depriv. for water use, 1.64 MJ for fossil resource use, and 0.156 kg CO₂ eq for climate change.

Conventional uncovered



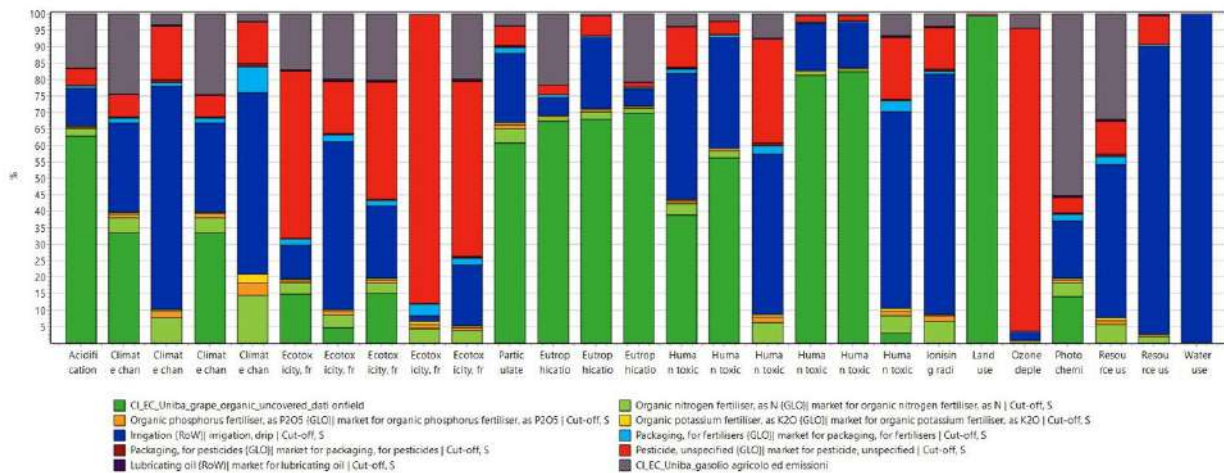
The graph indicates that conventional uncovered cultivation has a contribution pattern similar to the covered conventional system, with on-field emissions representing the main hotspot for land use (98.0%), eutrophication, marine (62.7%), eutrophication, freshwater (57.5%), eutrophication, terrestrial (62.5%), acidification (51.7%), particulate matter (48.9%), human toxicity, non-cancer (78.6%), and human toxicity, cancer – inorganics (49.4%). Irrigation is almost solely responsible for water use (99.0%) and is also important for resource use, minerals and metals (39.7%), human toxicity, cancer – organics (30.1%), human toxicity, non-cancer – organics (34.2%), and ionising radiation (32.3%). Among fertiliser-related processes, potassium fertiliser is the leading contributor to freshwater ecotoxicity – part 1 (42.3%) and freshwater ecotoxicity – inorganics (36.9%), while nitrogen fertiliser dominates freshwater ecotoxicity – part 2 (66.1%) and is the main contributor to climate change (25.8%), climate change – fossil (25.8%), and resource use, fossils (34.2%). Pesticide use is again the dominant hotspot for freshwater ecotoxicity – organics p.1 (90.2%) and ozone depletion (80.8%). Diesel and associated emissions are the main contributor to photochemical ozone formation (43.4%). The highest characterised results for this system are observed for land use (19.32 Pt), water use (3.59 m³ depriv.), fossil resource use (1.39 MJ), and climate change (0.124 kg CO₂ eq).

Organic covered



The graph shows a different hotspot structure for organic covered cultivation, with a reduced role of mineral fertilisers and a greater incidence of irrigation, pesticides, diesel, and on-field emissions. On-field emissions remain dominant for land use (99.5%), eutrophication, freshwater (73.9%), eutrophication, marine (64.3%), eutrophication, terrestrial (52.2%), acidification (45.7%), particulate matter (47.0%), human toxicity, non-cancer (77.8%), and human toxicity, cancer – inorganics (49.6%). Irrigation is the almost exclusive driver of water use (100.0%) and is also the main contributor to resource use, minerals and metals (84.9%), ionising radiation (69.9%), climate change – biogenic (64.3%), climate change – land use and land use change (55.4%), freshwater ecotoxicity – part 2 (45.5%), and several human toxicity subcategories. Pesticide use dominates the ecotoxicity-related categories, in particular freshwater ecotoxicity – organics p.1 (92.4%), freshwater ecotoxicity – organics p.2 (58.6%), freshwater ecotoxicity – part 1 (58.1%), freshwater ecotoxicity – inorganics (42.5%), and ozone depletion (93.1%). Diesel and related emissions are the main contributor to climate change (35.2%), climate change – fossil (35.2%), and photochemical ozone formation (66.4%). This system shows comparatively low characterised results, including 14.68 Pt for land use, 2.25 m³ depriv. for water use, 0.492 MJ for fossil resource use, and 0.042 kg CO₂ eq for climate change.

Organic uncovered



The graph for organic uncovered cultivation confirms the same general structure observed for the organic covered system, although with a stronger contribution from on-field emissions in nutrient-related categories and slightly higher burdens for several impact indicators. On-field emissions dominate land use (99.3%), eutrophication, terrestrial (69.8%), eutrophication, freshwater (68.0%), eutrophication, marine (67.3%), acidification (62.9%), particulate matter (60.8%), human toxicity, non-cancer (81.4%), and human toxicity, cancer – inorganics (56.3%). Irrigation is again almost entirely responsible for water use (100.0%) and is the main hotspot for resource use, minerals and metals (87.5%), ionising radiation (73.0%), climate change – biogenic (67.8%), climate change – land use and land use change (55.3%), freshwater ecotoxicity – part 2 (51.0%), and the organic fractions of human toxicity. Pesticide use remains the dominant contributor to ecotoxicity-related categories, especially freshwater ecotoxicity – organics p.1 (87.8%), freshwater ecotoxicity – organics p.2 (53.5%), freshwater ecotoxicity – part 1 (50.8%), freshwater ecotoxicity – inorganics (35.7%), and ozone depletion (92.0%). Diesel and associated emissions are particularly relevant for photochemical ozone formation (55.3%) and remain important for climate change together with on-field emissions and irrigation. The main characterised results for this system are 16.53 Pt for land use, 3.57 m³ depriv. for water use, 0.676 MJ for fossil resource use, and 0.068 kg CO₂ eq for climate change.

Overall, the characterisation results show a consistent hotspot pattern across the four cultivation systems. On-field emissions are the main contributor to land use, acidification, terrestrial and marine eutrophication, particulate matter, and most human toxicity non-cancer indicators, confirming the central role of direct field emissions in the agricultural phase. Irrigation systematically dominates water use in all systems, with shares ranging from 97.8% to almost 100%, and is also a major hotspot for ionising radiation and resource use, minerals and metals, especially in the organic systems. Pesticide use is the recurrent hotspot for freshwater ecotoxicity – organics and ozone depletion, with contributions generally above 88% and reaching 93.1% in the organic covered system. A clear distinction emerges between production systems: in the conventional

systems, mineral fertilisers, especially nitrogen and potassium, play a major role in climate change, fossil resource use, and freshwater ecotoxicity, whereas in the organic systems the burden shifts more markedly towards irrigation, diesel, and pesticide-related processes. From a comparative perspective, organic covered cultivation generally shows the lowest characterised results for several key categories, including climate change (0.042 kg CO₂ eq), acidification (4.94×10⁻⁴ mol H⁺ eq), fossil resource use (0.492 MJ), and land use (14.68 Pt), while the uncovered systems show the highest water use burdens, equal to 3.59 m³ depriv. for conventional uncovered and 3.57 m³ depriv. for organic uncovered. These results indicate that the main environmental hotspots are associated with field emissions, irrigation demand, agrochemical use, and energy-related inputs, although their relative importance varies according to the cultivation management system.

5.2 Normalization

Conventional covered

	On-field emissions	Inorganic nitrogen fertiliser	Inorganic phosphorus fertiliser	Irrigation	Inorganic potassium fertiliser	Packaging, for fertilisers	Packaging, for pesticides	Pesticide, unspecified	Lubricating oil	Diesel	Total
Water use	0,00E+00	3,27E-06	5,98E-07	2,01E-04	5,09E-07	2,14E-08	5,31E-09	1,08E-08	3,61E-09	2,86E-08	2,05E-04
Ecotoxicity, freshwater	2,23E-06	1,83E-05	7,11E-06	1,17E-06	3,17E-05	3,49E-07	3,46E-08	4,91E-06	4,35E-08	2,01E-06	6,78E-05
Human toxicity, non-cancer	4,73E-05	4,58E-06	1,42E-06	2,84E-06	1,47E-06	1,73E-07	2,40E-08	6,33E-07	1,61E-08	2,37E-07	5,87E-05
Eutrophication, terrestrial	2,91E-05	4,86E-06	1,17E-06	7,17E-07	1,66E-06	2,88E-07	2,82E-08	3,83E-07	9,09E-09	5,48E-06	4,37E-05
Acidification	2,03E-05	5,48E-06	2,58E-06	1,26E-06	1,63E-06	2,46E-07	3,14E-08	1,05E-06	1,52E-08	3,39E-06	3,60E-05
Eutrophication, freshwater	1,98E-05	5,24E-06	2,57E-06	3,39E-06	1,92E-06	1,48E-07	4,25E-08	1,72E-06	2,07E-08	1,57E-07	3,50E-05
Eutrophication, marine	1,65E-05	2,23E-06	5,43E-07	6,32E-07	7,26E-07	2,44E-07	2,51E-08	5,75E-07	8,27E-09	4,56E-06	2,61E-05
Resource use, fossils	0,00E+00	1,06E-05	2,51E-06	3,12E-06	3,11E-06	4,79E-07	1,16E-07	1,23E-06	9,18E-08	4,02E-06	2,53E-05
Land use	2,42E-05	2,29E-07	1,62E-07	3,82E-08	1,38E-07	2,55E-08	2,41E-09	2,02E-08	6,75E-10	1,79E-08	2,48E-05
Particulate matter	1,23E-05	4,04E-06	1,68E-06	1,44E-06	1,87E-06	3,64E-07	6,87E-08	7,72E-07	1,27E-08	4,54E-07	2,30E-05
Resource use, minerals and metals	0,00E+00	9,74E-06	2,39E-06	4,79E-06	2,91E-06	9,75E-08	1,65E-08	8,76E-07	1,92E-08	4,73E-08	2,09E-05
Climate change	5,71E-06	6,11E-06	1,56E-06	1,57E-06	1,92E-06	2,86E-07	5,21E-08	6,99E-07	2,10E-08	2,66E-06	2,06E-05
Photochemical ozone formation	2,69E-06	3,31E-06	1,02E-06	1,12E-06	1,24E-06	3,99E-07	4,35E-08	5,65E-07	7,18E-08	6,69E-06	1,71E-05
Human toxicity, cancer	2,01E-06	1,25E-06	3,53E-07	6,55E-07	4,32E-07	7,09E-08	1,18E-08	3,97E-07	4,32E-09	1,22E-07	5,31E-06
Ionising radiation	0,00E+00	6,21E-07	2,79E-07	2,80E-07	2,26E-07	1,13E-08	4,31E-09	9,13E-08	1,65E-09	2,73E-08	1,54E-06
Ozone depletion	0,00E+00	2,59E-08	5,91E-09	2,82E-09	7,31E-09	6,57E-10	8,47E-11	1,73E-07	1,15E-10	8,11E-09	2,24E-07

The normalized results for conventional covered table grape production show that water use is the most relevant impact category, with a normalized value of 2.05E-04, almost entirely driven by irrigation. The second most relevant category is freshwater ecotoxicity (6.78E-05), mainly associated with potassium fertiliser inputs, followed by human toxicity, non-cancer (5.87E-05), which is largely attributable to on-field emissions. High normalized contributions are also observed for eutrophication, terrestrial (4.37E-05), acidification (3.60E-05), and eutrophication, freshwater (3.50E-05), again mainly linked to direct field emissions and fertiliser use. Overall, the normalized profile highlights irrigation demand, ecotoxicity-related effects, and nutrient emissions as the main environmental hotspots of this cultivation system.

Conventional uncovered

	On-field emissions	Inorganic nitrogen fertiliser	Inorganic phosphorus fertiliser	Irrigation	Packaging, for fertilisers	Packaging, for pesticides	Inorganic potassium fertiliser	Pesticide, unspecified	Lubricating oil	Diesel	Total
Acidification	1,41E-05	3,79E-06	2,18E-06	1,95E-06	1,69E-07	3,00E-08	8,28E-07	1,00E-06	1,45E-08	3,2308E-06	2,73E-05
Climate change	3,98E-06	4,23E-06	1,32E-06	2,43E-06	1,96E-07	4,98E-08	9,77E-07	6,68E-07	2,01E-08	2,543E-06	1,64E-05
Ecotoxicity, freshwater	1,75E-06	1,26E-05	6,03E-06	1,80E-06	2,39E-07	3,31E-08	1,61E-05	4,69E-06	4,16E-08	1,9155E-06	4,52E-05
Particulate matter	8,53E-06	2,80E-06	1,43E-06	2,23E-06	2,50E-07	6,56E-08	9,50E-07	7,37E-07	1,21E-08	4,3285E-07	1,74E-05
Eutrophication, marine	1,42E-05	1,55E-06	4,60E-07	9,76E-07	1,67E-07	2,40E-08	3,69E-07	5,49E-07	7,90E-09	4,3518E-06	2,27E-05
Eutrophication, freshwater	1,89E-05	3,63E-06	2,18E-06	5,23E-06	1,01E-07	4,06E-08	9,74E-07	1,64E-06	1,98E-08	1,5032E-07	3,28E-05
Eutrophication, terrestrial	2,02E-05	3,37E-06	9,89E-07	1,11E-06	1,97E-07	2,69E-08	8,45E-07	3,66E-07	8,69E-09	5,2307E-06	3,23E-05
Human toxicity, cancer	1,60E-06	8,69E-07	2,99E-07	1,01E-06	4,85E-08	1,12E-08	2,19E-07	3,79E-07	4,13E-09	1,167E-07	4,56E-06
Human toxicity, non-cancer	3,85E-05	3,17E-06	1,20E-06	4,39E-06	1,19E-07	2,29E-08	7,47E-07	6,05E-07	1,53E-08	2,2629E-07	4,90E-05
Ionising radiation	0,00E+00	4,30E-07	2,36E-07	4,32E-07	7,72E-09	4,11E-09	1,15E-07	8,72E-08	1,58E-09	2,6021E-08	1,34E-06
Land use	2,31E-05	1,59E-07	1,37E-07	5,91E-08	1,74E-08	2,30E-09	7,01E-08	1,93E-08	6,45E-10	1,7103E-08	2,36E-05
Ozone depletion	0,00E+00	1,79E-08	5,01E-09	4,36E-09	4,50E-10	8,09E-11	3,71E-09	1,65E-07	1,10E-10	7,7421E-09	2,05E-07
Photochemical ozone formation	1,87E-06	2,29E-06	8,65E-07	1,73E-06	2,73E-07	4,16E-08	6,30E-07	5,40E-07	6,86E-08	6,3814E-06	1,47E-05
Resource use, fossils	0,00E+00	7,32E-06	2,13E-06	4,82E-06	3,28E-07	1,11E-07	1,58E-06	1,18E-06	8,77E-08	3,8376E-06	2,14E-05
Resource use, minerals and metals	0,00E+00	6,74E-06	2,02E-06	7,40E-06	6,68E-08	1,58E-08	1,48E-06	8,37E-07	1,84E-08	4,5147E-08	1,86E-05
Water use	0,00E+00	2,26E-06	5,07E-07	3,10E-04	1,47E-08	5,07E-09	2,59E-07	1,03E-08	3,45E-09	2,7309E-08	3,13E-04

For conventional uncovered cultivation, the normalized profile is again dominated by water use, which reaches 3.13E-04, with irrigation accounting for nearly the entire result. The next most relevant categories are human toxicity, non-cancer (4.90E-05) and freshwater ecotoxicity (4.52E-05). The former is mainly driven by on-field emissions, whereas the latter is largely associated with potassium fertiliser. Additional relevant categories include eutrophication, freshwater (3.28E-05), eutrophication, terrestrial (3.23E-05), and acidification (2.73E-05), all primarily linked to field emissions and fertiliser-related processes. Compared with the covered conventional system, the normalized burden of water use is markedly higher.

Organic covered

	On-field emissions	Organic nitrogen fertiliser	Organic phosphorus fertiliser	Organic potassium fertiliser	Irrigation	Packaging, for fertilisers	Packaging, for pesticides	Pesticide, unspecified	Lubricating oil	Diesel	Total
Acidification	4,06E-06	1,42E-07	5,20E-08	3,24E-08	1,23E-06	6,61E-08	2,31E-08	7,74E-07	1,12E-08	2,49E-06	8,89E-06
Climate change	1,18E-06	1,56E-07	5,78E-08	4,09E-08	1,53E-06	7,67E-08	3,84E-08	5,16E-07	1,55E-08	1,96E-06	5,58E-06
Ecotoxicity, freshwater	5,85E-07	1,21E-07	4,60E-08	4,48E-08	1,14E-06	9,37E-08	2,55E-08	3,62E-06	3,22E-08	1,48E-06	7,18E-06
Particulate matter	2,46E-06	1,78E-07	6,61E-08	5,00E-08	1,41E-06	9,78E-08	5,06E-08	5,69E-07	9,38E-09	3,34E-07	5,22E-06
Eutrophication, marine	8,35E-06	8,14E-08	3,07E-08	2,69E-08	6,16E-07	6,55E-08	1,85E-08	4,24E-07	6,11E-09	3,36E-06	1,30E-05
Eutrophication, freshwater	1,44E-05	2,09E-07	7,53E-08	3,42E-08	3,31E-06	3,97E-08	3,14E-08	1,27E-06	1,53E-08	1,16E-07	1,95E-05
Eutrophication, terrestrial	5,82E-06	1,29E-07	4,81E-08	3,55E-08	6,99E-07	7,73E-08	2,08E-08	2,82E-07	6,72E-09	4,04E-06	1,12E-05
Human toxicity, cancer	5,14E-07	3,40E-08	1,27E-08	9,56E-09	6,39E-07	1,90E-08	8,68E-09	2,92E-07	3,19E-09	9,01E-08	1,62E-06
Human toxicity, non-cancer	1,28E-05	9,90E-08	3,66E-08	2,63E-08	2,77E-06	4,65E-08	1,77E-08	4,67E-07	1,19E-08	1,75E-07	1,64E-05
Ionising radiation	0,00E+00	1,50E-08	5,40E-09	2,38E-09	2,73E-07	3,03E-09	3,18E-09	6,73E-08	1,22E-09	2,01E-08	3,90E-07
Land use	1,78E-05	1,09E-08	4,09E-09	3,55E-09	3,73E-08	6,84E-09	1,78E-09	1,49E-08	4,99E-10	1,32E-08	1,79E-05
Ozone depletion	0,00E+00	2,21E-10	8,38E-11	8,21E-11	2,75E-09	1,77E-10	6,25E-11	1,28E-07	8,49E-11	5,98E-09	1,37E-07
Photochemical ozone formation	5,38E-07	1,51E-07	5,68E-08	4,71E-08	1,09E-06	1,07E-07	3,21E-08	4,17E-07	5,30E-08	4,93E-06	7,42E-06
Resource use, fossils	0,00E+00	2,18E-07	8,12E-08	6,25E-08	3,05E-06	1,29E-07	8,56E-08	9,08E-08	6,79E-08	2,96E-06	7,56E-06
Resource use, minerals and metals	0,00E+00	6,01E-08	2,22E-08	1,52E-08	4,67E-06	2,62E-08	1,22E-08	6,46E-07	1,42E-08	3,48E-08	5,50E-06
Water use	0,00E+00	1,00E-08	3,67E-09	2,34E-09	1,96E-04	5,76E-09	3,92E-09	7,95E-09	2,67E-09	2,11E-08	1,96E-04

In the organic covered system, water use remains the dominant normalized category, with a value of 1.96E-04, almost completely due to irrigation. The following categories are eutrophication, freshwater (1.95E-05), land use (1.79E-05), and human toxicity, non-cancer (1.64E-05), all mainly driven by on-field emissions. Eutrophication, marine (1.30E-05) and eutrophication, terrestrial (1.12E-05) are also relevant, confirming the importance of nutrient-related emissions. Compared with the conventional systems, the normalized values are generally lower for most categories, while water use remains the main hotspot.

Organic uncovered

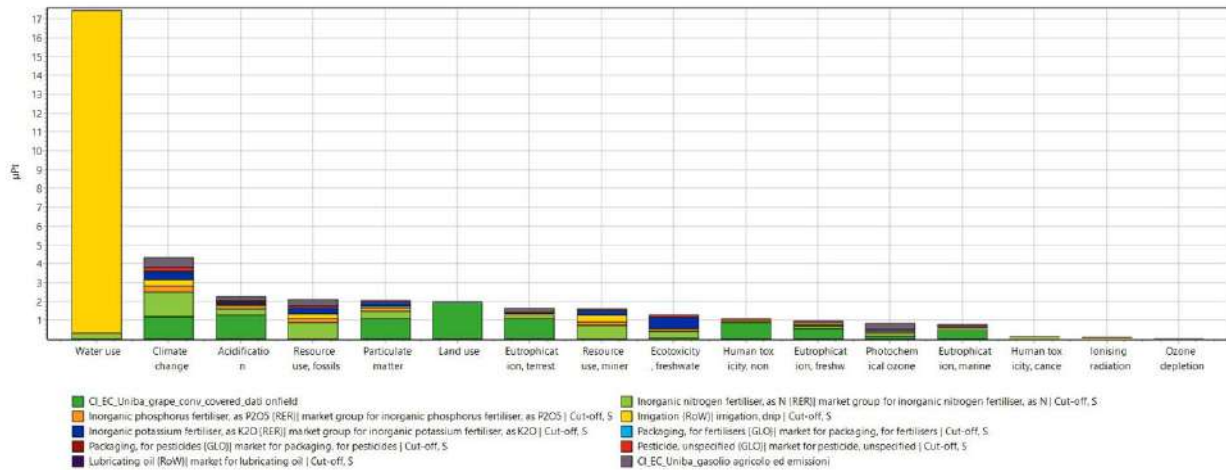
	On-field emissions	Organic nitrogen fertiliser	Organic phosphorus fertiliser	Organic potassium fertiliser	Irrigation	Packaging, for fertilisers	Packaging, for pesticides	Pesticide, unspecified	Lubricating oil	Diesel	Total
Acidification	1,07E-05	3,71E-07	8,94E-08	4,25E-08	1,95E-06	1,28E-07	2,60E-08	8,70E-07	1,26E-08	2,80E-06	1,70E-05
Climate change	3,02E-06	4,10E-07	9,93E-08	5,36E-08	2,44E-06	1,48E-07	4,32E-08	5,79E-07	1,74E-08	2,21E-06	9,01E-06
Ecotoxicity, freshwater	1,19E-06	3,17E-07	7,90E-08	5,88E-08	1,81E-06	1,81E-07	2,87E-08	4,07E-06	3,61E-08	1,66E-06	9,43E-06
Particulate matter	6,44E-06	4,65E-07	1,13E-07	6,57E-08	2,24E-06	1,89E-07	5,69E-08	6,40E-07	1,05E-08	3,75E-07	1,06E-05
Eutrophication, marine	1,17E-05	2,13E-07	5,27E-08	3,53E-08	9,79E-07	1,27E-07	2,08E-08	4,76E-07	6,86E-09	3,77E-06	1,74E-05
Eutrophication, freshwater	1,63E-05	5,46E-07	1,29E-07	4,49E-08	5,25E-06	7,68E-08	3,52E-08	1,43E-06	1,72E-08	1,30E-07	2,39E-05
Eutrophication, terrestrial	1,53E-05	3,39E-07	8,26E-08	4,66E-08	1,11E-06	1,49E-07	2,34E-08	3,17E-07	7,54E-09	4,54E-06	2,19E-05
Human toxicity, cancer	1,03E-06	8,91E-08	2,17E-08	1,25E-08	1,02E-06	3,68E-08	9,76E-09	3,29E-07	3,59E-09	1,01E-07	2,65E-06
Human toxicity, non-cancer	2,46E-05	2,59E-07	6,29E-08	3,46E-08	4,41E-06	8,99E-08	1,99E-08	5,24E-07	1,33E-08	1,96E-07	3,02E-05
Ionising radiation	0,00E+00	3,92E-08	9,27E-09	3,12E-09	4,34E-07	5,85E-09	3,57E-09	7,56E-08	1,37E-09	2,26E-08	5,94E-07
Land use	2,00E-05	2,85E-08	7,02E-09	4,66E-09	5,93E-08	1,32E-08	2,00E-09	1,67E-08	5,60E-10	1,48E-08	2,02E-05
Ozone depletion	0,00E+00	5,78E-10	1,44E-10	1,08E-10	4,38E-09	3,41E-10	7,02E-11	1,44E-07	9,54E-11	6,72E-09	1,56E-07
Photochemical ozone formation	1,41E-06	3,96E-07	9,75E-08	6,17E-08	1,74E-06	2,07E-07	3,61E-08	4,69E-07	5,96E-08	5,54E-06	1,00E-05
Resource use, fossils	0,00E+00	5,72E-07	1,39E-07	8,20E-08	4,84E-06	2,49E-07	9,62E-08	1,02E-06	7,62E-08	3,33E-06	1,04E-05
Resource use, minerals and metals	0,00E+00	1,57E-07	3,80E-08	2,00E-08	7,42E-06	5,06E-08	1,37E-08	7,26E-07	1,59E-08	3,92E-08	8,48E-06
Water use	0,00E+00	2,62E-08	6,31E-09	3,07E-09	3,11E-04	1,11E-08	4,40E-09	8,94E-09	2,99E-09	2,37E-08	3,12E-04

The normalized results for organic uncovered table grape production show water use as the clearly dominant category, with a value of 3.12E-04, almost entirely attributable to irrigation. The second most relevant category is human toxicity, non-cancer (3.02E-05), followed by eutrophication, freshwater (2.39E-05), eutrophication, terrestrial (2.19E-05), and land use (2.02E-05). These categories are mainly influenced by on-field emissions, while the contribution of fertiliser-related processes is more limited than in the conventional systems. The normalized profile therefore confirms the central role of irrigation and direct agricultural emissions in the environmental performance of the organic uncovered system.

The normalization results confirm the trends already observed in the characterisation phase, while making the relative importance of the impact categories more explicit. Across all four cultivation systems, water use is the most relevant normalized category and is consistently dominated by irrigation. The highest normalized water use values are observed in the uncovered systems (3.13E-04 for conventional uncovered and 3.12E-04 for organic uncovered), whereas the covered systems show lower values. In the conventional systems, the normalized profile is also strongly influenced by freshwater ecotoxicity, human toxicity, non-cancer, and eutrophication-related categories, with a more evident role of mineral fertilisers, especially potassium fertiliser in ecotoxicity. In the organic systems, the normalized burdens are generally lower, and the most relevant categories after water use are mainly associated with on-field emissions, particularly eutrophication, land use, and human toxicity, non-cancer. Overall, normalization confirms that the main environmental hotspots are linked to irrigation demand, direct field emissions, and, in conventional management, fertiliser-related inputs.

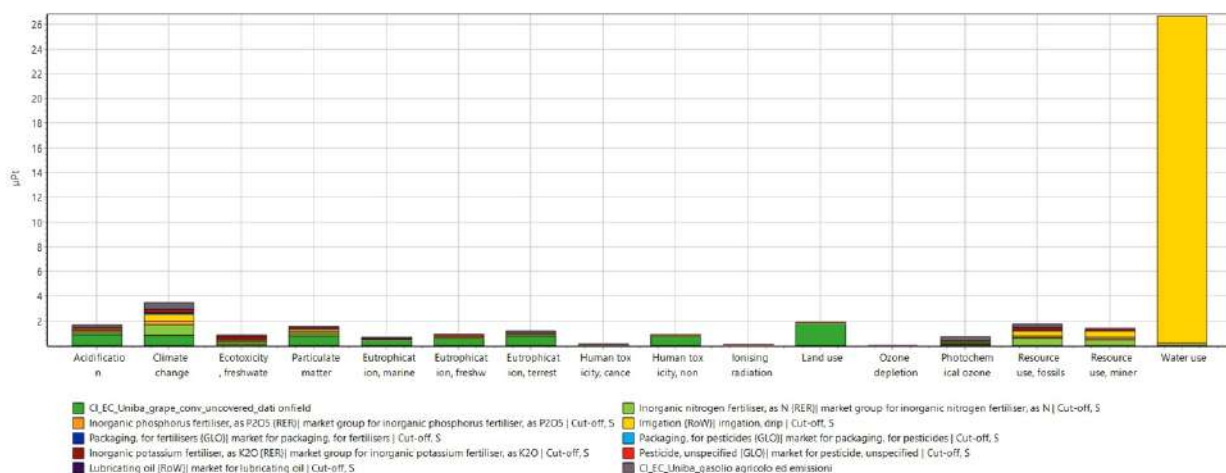
5.3 Assessment

Conventional covered



The weighted results for conventional covered table grape production confirm water use as the dominant impact category, with a score of 17.48 μPt , accounting for nearly half of the total weighted result (38.53 μPt). This burden is almost entirely driven by irrigation (17.10 μPt). The second most relevant category is climate change (4.34 μPt), mainly associated with inorganic nitrogen fertiliser (1.29 μPt) and on-field emissions (1.20 μPt). Other relevant weighted categories are acidification (2.23 μPt), resource use, fossils (2.10 μPt), particulate matter (2.06 μPt), and land use (1.97 μPt). Overall, the weighting step highlights irrigation, mineral fertilisation, and field emissions as the main contributors to the aggregated environmental burden.

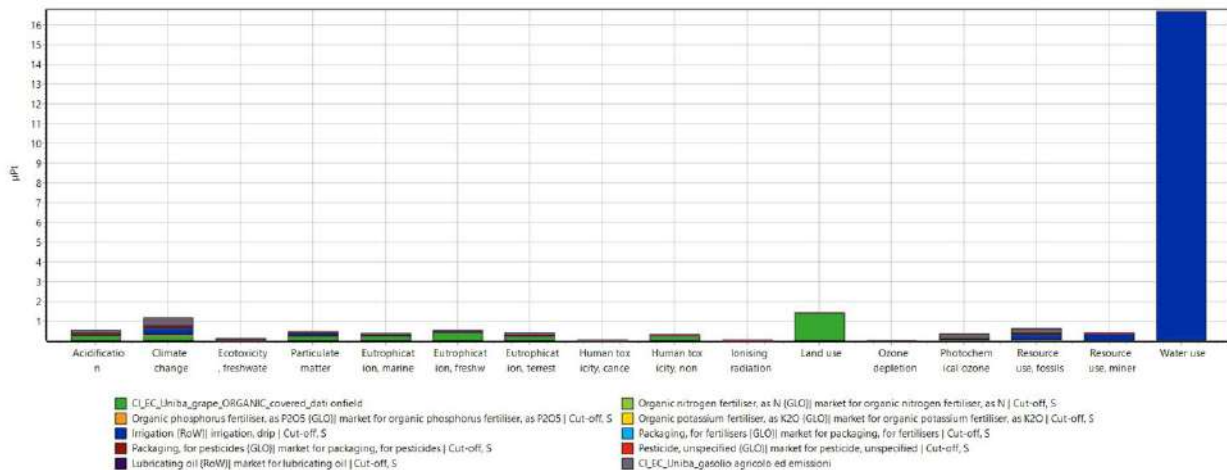
Conventional uncovered



For conventional uncovered production, the weighted profile is again clearly dominated by water use, which reaches 26.67 μPt out of a total of 43.88 μPt , with irrigation contributing 25.94 μPt . The second most relevant category is climate change (3.46 μPt), followed by land use (1.87 μPt), resource use, fossils (1.78 μPt), and resource use, mineral (1.78 μPt).

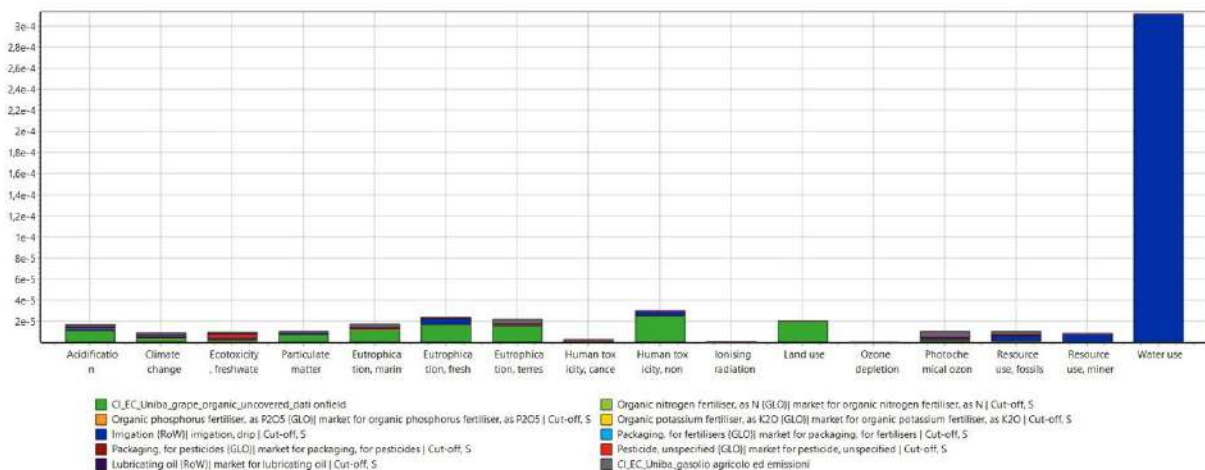
acidification (1.69 μ Pt), and particulate matter (1.56 μ Pt). As in the covered conventional system, inorganic nitrogen fertiliser is the main driver of climate change, while on-field emissions dominate land use and most eutrophication- and emission-related categories. The weighting results therefore confirm the strong incidence of irrigation demand in the uncovered conventional system.

Organic covered



The weighted results for organic covered cultivation show a lower total score (23.55 μ Pt) than both conventional systems. Water use remains the dominant category, with 16.69 μ Pt, almost entirely attributable to irrigation (16.23 μ Pt). The next most relevant categories are land use (1.42 μ Pt) and climate change (1.17 μ Pt). In this case, climate change is mainly driven by diesel-related processes (0.41 μ Pt) and irrigation (0.32 μ Pt), whereas the role of fertiliser inputs is limited. Other relevant categories are resource use, fossils (0.63 μ Pt), acidification (0.55 μ Pt), and eutrophication, freshwater (0.55 μ Pt). Overall, the weighting results confirm that the organic covered system has the lowest aggregated burden among the four cultivation types.

Organic uncovered

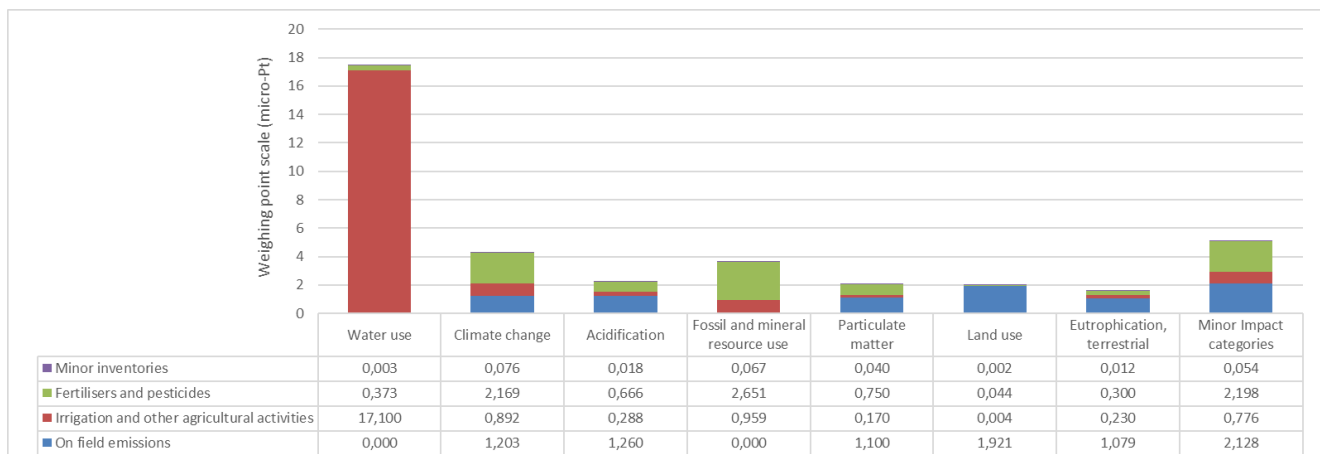


For organic uncovered cultivation, the total weighted result is 36.83 μ Pt, with water use again representing the main hotspot (26.51 μ Pt), almost entirely due to irrigation (25.90 μ Pt). The second most relevant category is climate change (1.90 μ Pt), followed by land use (1.60 μ Pt), acidification (1.05 μ Pt), particulate matter (0.95 μ Pt), and resource use, fossils (0.87 μ Pt). Compared with the organic covered system, the higher total score is mainly due to the increase in water use and the higher contribution of on-field emissions and diesel-related processes in climate change and air emission categories. The weighted profile therefore confirms a less favourable performance for the uncovered organic system.

The weighting results make the hierarchy of environmental relevance particularly clear. In all four cultivation systems, water use is by far the dominant contributor to the single-score result, always driven almost entirely by irrigation. This contribution is especially high in the uncovered systems, where water use reaches 26.67 μ Pt in the conventional case and 26.51 μ Pt in the organic case. After water use, the most relevant weighted categories are generally climate change, land use, acidification, particulate matter, and resource use, fossils, although their relative importance varies across systems. In the conventional systems, the weighted burden of climate change and fossil resource use is more strongly linked to mineral fertilisers, especially inorganic nitrogen fertiliser, while in the organic systems the contribution shifts mainly towards irrigation, diesel-related processes, and on-field emissions. From a comparative perspective, organic covered cultivation shows the lowest total weighted score (23.55 μ Pt), whereas conventional uncovered cultivation shows the highest (43.88 μ Pt). Overall, the weighting step confirms that irrigation demand is the main driver of the aggregated environmental footprint of table grape production, with additional contributions from field emissions, fertilisation, and energy use depending on the cultivation system.

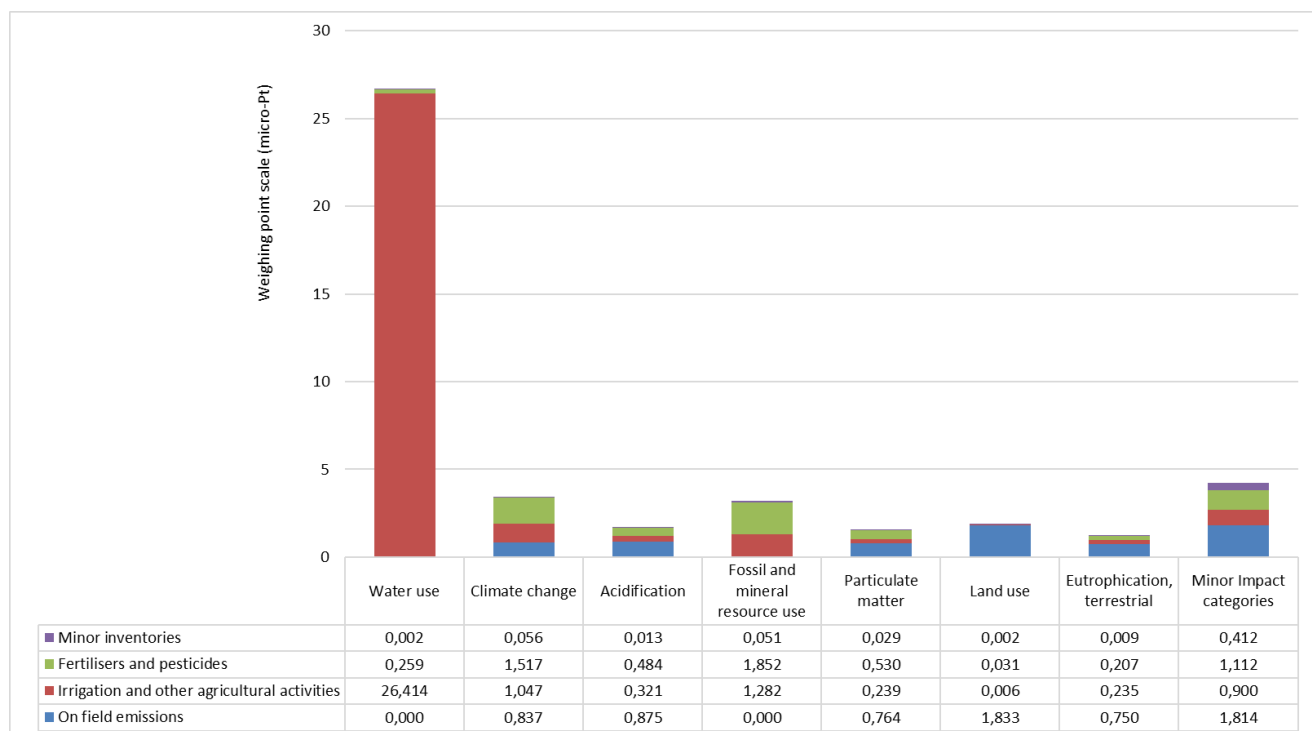
5.4 Contribution analysis of the most burdening processes to the most relevant impact categories

Conventional covered



The contribution analysis for conventional covered table grape production shows a differentiated hotspot structure across the most relevant weighted impact categories. Water use is almost entirely attributable to irrigation and other agricultural activities (17.100 μ Pt out of 17.476 μ Pt), confirming irrigation as the dominant driver of the overall score. Climate change is mainly associated with fertilisers and pesticides (2.169 μ Pt), followed by on-field emissions (1.203 μ Pt) and irrigation and other agricultural activities (0.892 μ Pt). A similar pattern is observed for fossil and mineral resource use, where fertilisers and pesticides provide the largest contribution (2.651 μ Pt), ahead of irrigation-related activities (0.959 μ Pt). By contrast, on-field emissions dominate acidification (1.260 μ Pt), particulate matter (1.100 μ Pt), land use (1.921 μ Pt), and eutrophication, terrestrial (1.079 μ Pt). Minor inventories remain negligible in all major categories. Overall, the system is characterised by a dual pattern in which irrigation dominates water use, fertiliser and pesticide inputs drive climate- and resource-related burdens, and on-field emissions prevail in emission-related categories.

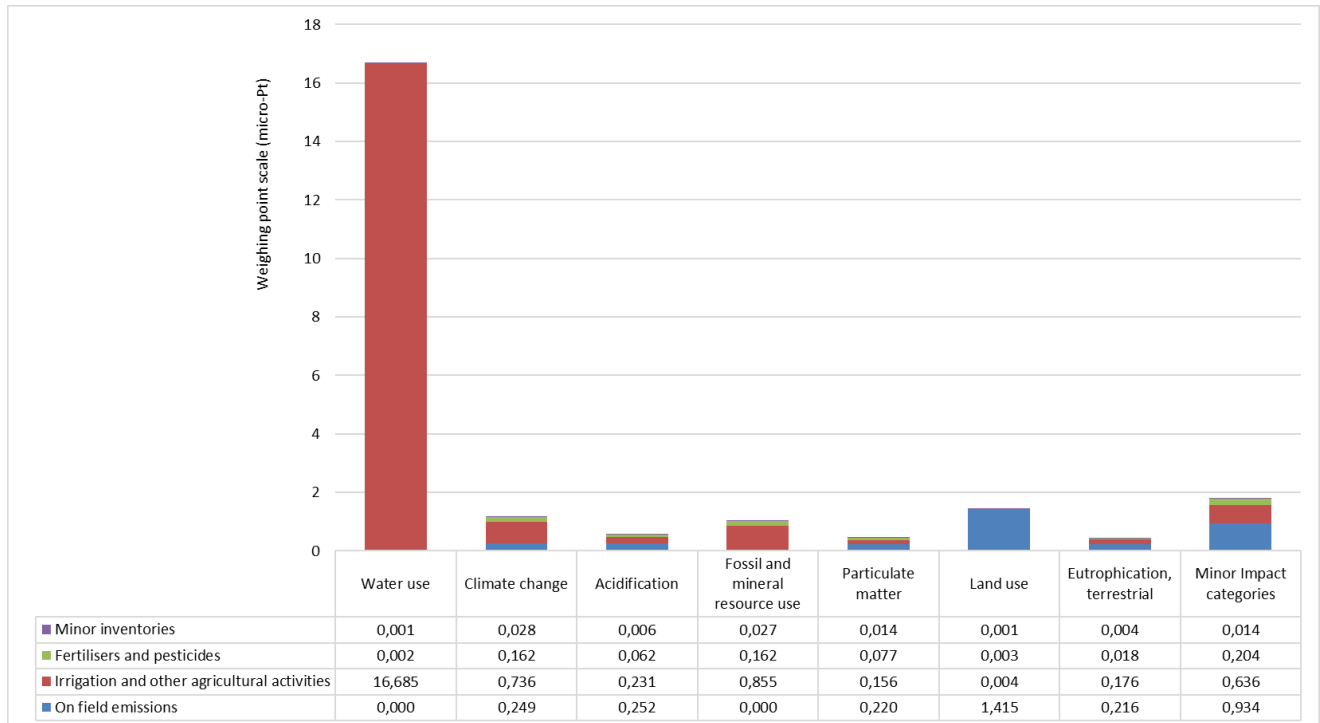
Conventional uncovered



For conventional uncovered cultivation, irrigation and other agricultural activities remain the dominant contributor to water use, accounting for 26.414 μ Pt out of 26.675 μ Pt. Climate change is again mainly driven by fertilisers and pesticides (1.517 μ Pt), followed by irrigation and other agricultural activities (1.047 μ Pt) and on-field emissions (0.837 μ Pt). The same applies to fossil and mineral resource use, where fertilisers and pesticides represent the main hotspot (1.852 μ Pt), with an additional contribution from irrigation-related activities (1.282 μ Pt). Conversely, on-field emissions dominate acidification (0.875 μ Pt), particulate matter (0.764 μ Pt), land use (1.833 μ Pt), and eutrophication, terrestrial (0.750 μ Pt). Compared with the covered

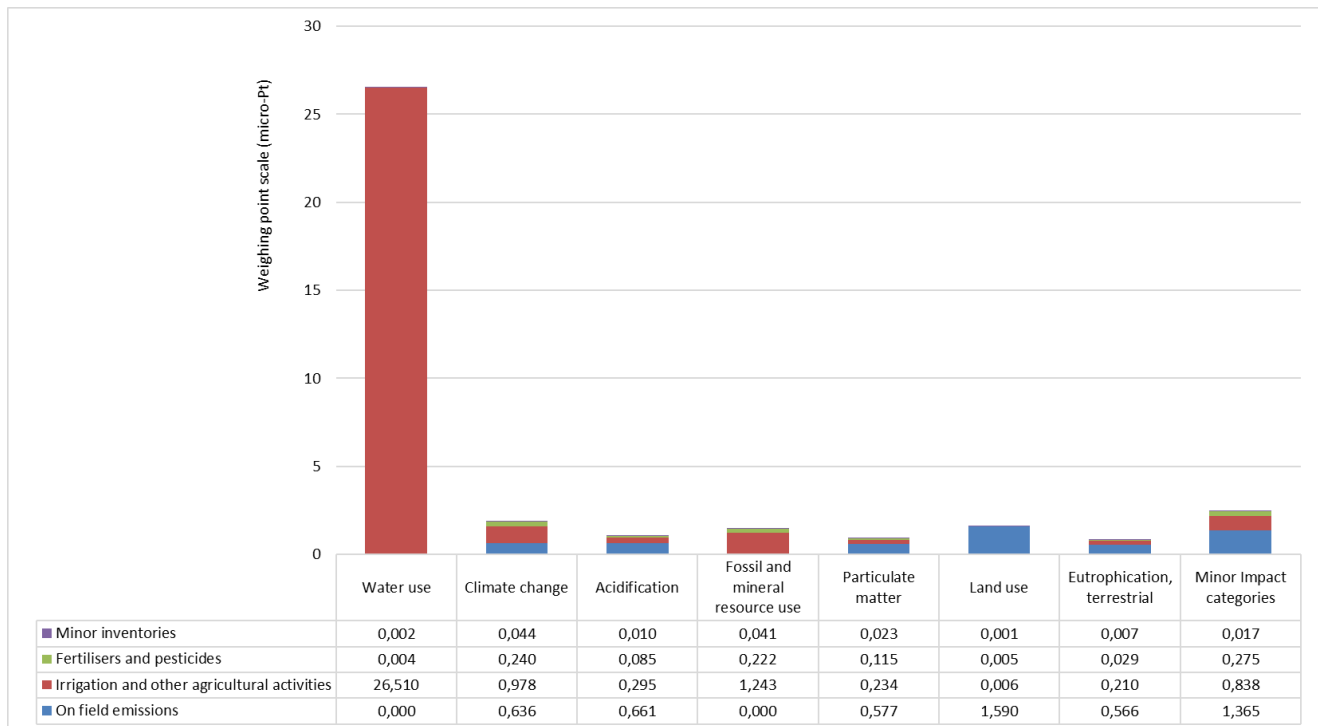
conventional system, the contribution pattern is broadly similar, but the burden associated with irrigation is markedly higher, especially for water use and, to a lesser extent, climate change and resource use.

Organic covered



In the organic covered system, irrigation and other agricultural activities are clearly the main hotspot for water use, contributing 16.685 μ Pt out of 16.688 μ Pt, and they also provide the largest share of climate change (0.736 μ Pt) and fossil and mineral resource use (0.855 μ Pt). On-field emissions remain the dominant contributor to land use (1.415 μ Pt) and are slightly higher than irrigation-related activities in acidification (0.252 μ Pt vs 0.231 μ Pt). The contribution of fertilisers and pesticides is comparatively limited, although it remains relevant for climate change and fossil and mineral resource use (both 0.162 μ Pt). Particulate matter and eutrophication, terrestrial are more evenly distributed between on-field emissions and irrigation-related activities, with a moderate contribution from fertilisers and pesticides. Overall, the organic covered system shows a simpler hotspot pattern, dominated by irrigation-related processes for water and resource use, and by on-field emissions for land use and air emission-related categories.

Organic uncovered



For organic uncovered cultivation, irrigation and other agricultural activities dominate water use (26.510 μ Pt out of 26.516 μ Pt) and also represent the largest contribution to climate change (0.978 μ Pt) and fossil and mineral resource use (1.243 μ Pt). On-field emissions remain the main hotspot for land use (1.590 μ Pt), acidification (0.661 μ Pt), particulate matter (0.577 μ Pt), and eutrophication, terrestrial (0.566 μ Pt). The contribution of fertilisers and pesticides is again secondary but not negligible, especially for climate change (0.240 μ Pt) and fossil and mineral resource use (0.222 μ Pt). Compared with the organic covered system, the same hotspot pattern is observed, but with systematically higher contributions from both irrigation-related activities and on-field emissions. This confirms the less favourable weighted performance of the uncovered organic cultivation.

Across all four cultivation systems, the contribution analysis highlights three recurring hotspot groups. First, irrigation and other agricultural activities overwhelmingly dominate water use in every system, with contributions ranging from 16.685 μ Pt in organic covered to 26.510 μ Pt in organic uncovered. Second, on-field emissions are the main contributors to land use, acidification, particulate matter, and eutrophication, terrestrial, confirming their central role in the emission-related impact profile of grape production. Third, fertilisers and pesticides are especially relevant in the conventional systems, where they drive climate change and fossil and mineral resource use, while in the organic systems these categories are more strongly influenced by irrigation and other agricultural activities. From a comparative perspective, the uncovered systems show higher irrigation-related burdens than the covered systems, particularly for water use, whereas the organic systems display a lower contribution from fertilisers and pesticides. Overall, the results indicate

that the main weighted hotspots are associated with irrigation demand, direct field emissions, and, depending on the management system, agrochemical inputs.

5.5 Contribution analysis of the most burdening substances to the most relevant impact categories

Conventional covered

Total damage (161 nPt)	Emitted substance	Consumed natural and primary energy resources	Emission compartment	Associated damage
				micro-Pt
Water Use (17.5 micro-Pt)				
Water turbine use, unspecified natural origin		x		20,3
Water river		x		10,5
Water, well		x		6,63
Water, unspecified	x		water	-20,5
Climate Change (4.34 micro-Pt)				
Carbon dioxide, fossil	x		air	2,72
Dinitrogen monoxide	x		air	1,31
Methane fossil	x		air	0,296
Fossil and mineral resource use (3.68 micro-Pt)				
Gas, natural		x		1,07
Tellurium		x		0,748
Crude oil		x		0,683
Gold		x		0,314
Copper		x		0,185
Coal hard		x		0,164
Acidification, Particulate matter, and Terrestrial Eutrophication (2.23, 2.060, e 1.62 micro-Pt)				
Ammonia	x		air	3,8
Particulate matter (2.060 micro-Pt)				
Particulates, with grain size < 2.5 micron	x		air	0,362
Land use (1.97 micro-Pt)				

Occupation, permanent crop, irrigated, intensive		x		1,92
Terrestrial Eutrophication (1.62 micro-Pt)				
Nitrogen oxides	x		air	0,455

For conventional covered table grape production, the substance-level contribution analysis shows that water use (17.5 μ Pt) is mainly determined by the balance of irrigation-related water withdrawals and return flows. The category result is associated with withdrawals from natural sources, particularly turbine water, river water, and well water, partially offset by water returned to the water compartment. Climate change (4.34 μ Pt) is mainly driven by carbon dioxide, fossil (2.72 μ Pt) and dinitrogen monoxide (1.31 μ Pt), while methane, fossil has a smaller contribution (0.296 μ Pt). Fossil and mineral resource use (3.68 μ Pt) is primarily associated with the consumption of natural gas (1.07 μ Pt), tellurium (0.748 μ Pt), and crude oil (0.683 μ Pt). For the air-emission-related categories, ammonia to air is the main hotspot, contributing 3.8 μ Pt across acidification, particulate matter, and terrestrial eutrophication; additional contributions are associated with particulates <2.5 μ m (0.362 μ Pt) and nitrogen oxides (0.455 μ Pt). Land use is almost entirely attributable to occupation, permanent crop, irrigated, intensive (1.92 μ Pt).

Conventional uncovered

Total damage (161 nPt)	Emitted substance	Consumed natural and primary energy resources	Emission compartment	Associated damage
				micro-Pt
Water Use (26.67 micro-Pt)				
Water turbine use, unspecified natural origin		x		22,3
Water river		x		16,2
Water, well		x		10,2
Water, unspecified	x		water	-22,5
Climate Change (3.46 micro-Pt)				
Carbon dioxide, fossil	x		air	2,28
Dinitrogen monoxide	x		air	0,915
Methane fossil	x		air	0,25
Fossil and mineral resource use (3.19 micro-Pt)				
Gas, natural		x		0,825
Tellurium		x		0,708
Crude oil		x		0,642
Gold		x		0,232

Copper		x		0,174
Coal hard		x		0,153
Acidification, Particulate matter, and Terrestrial Eutrophication (1.69, 1.56, e 1.2 micro-Pt)				
Ammonia	x		air	2,634
Particulate matter (1.56 micro-Pt)				
Particulates, with grain size < 2.5 micron	x		air	0,339
Land use (1.87 micro-Pt)				
Occupation, permanent crop, irrigated, intensive		x		1,83
Terrestrial Eutrophication (1.2 micro-Pt)				
Nitrogen oxides	x		air	0,391

For conventional uncovered cultivation, water use (26.67 μ Pt) is again mainly related to the balance of irrigation-related withdrawals and return flows, with a higher overall burden than in the covered conventional system. The result is associated with water withdrawn from natural sources, especially turbine water, river water, and well water, partly compensated by water returned to the water compartment. Climate change (3.46 μ Pt) is mainly driven by carbon dioxide, fossil (2.28 μ Pt) and dinitrogen monoxide (0.915 μ Pt), while methane, fossil contributes 0.25 μ Pt. In fossil and mineral resource use (3.19 μ Pt), the main consumed resources are natural gas (0.825 μ Pt), tellurium (0.708 μ Pt), and crude oil (0.642 μ Pt). As in the previous system, ammonia to air is the dominant substance for acidification, particulate matter, and terrestrial eutrophication, with an associated damage of 2.634 μ Pt, while particulates <2.5 μ m account for 0.339 μ Pt in particulate matter and nitrogen oxides for 0.391 μ Pt in terrestrial eutrophication. Land use is again almost entirely attributable to occupation, permanent crop, irrigated, intensive (1.83 μ Pt).

Organic covered

Total damage (161 nPt)	Emitted substance	Consumed natural and primary energy resources	Emission compartment	Associated damage
				micro-Pt
Water Use (16.7 micro-Pt)				
Water turbine use, unspecified natural origin		x		10,7

Water river		x		10,2
Water, well		x		6,47
Water, unspecified	x		water	-10,8
Climate Change (1.17 micro-Pt)				
Carbon dioxide, fossil	x		air	0,821
Dinitrogen monoxide	x		air	0,259
Methane fossil	x		air	0,25
Fossil and mineral resource use (1.045 micro-Pt)				
Gas, natural		x		0,133
Tellurium		x		0,241
Crude oil		x		0,374
Gold		x		0,0282
Copper		x		0,0576
Coal hard		x		0,0704
Acidification, Particulate matter, and Terrestrial Eutrophication (0.551, 0.468, e 0.414 micro-Pt)				
Ammonia	x		air	0,666
Acidification (0.551 micro-Pt)				
Sulphur dioxide	x		air	0,115
Particulate matter (0.468 micro-Pt)				
Particulates, with grain size < 2.5 micron	x		air	0,153
Land use (1.42 micro-Pt)				
Occupation, permanent crop, irrigated, intensive		x		1,42
Terrestrial Eutrophication (0.414 micro-Pt)				
Nitrogen oxides	x		air	0,408

In the organic covered system, water use (16.7 μ Pt) remains mainly associated with irrigation-related water withdrawals and return flows, but with a lower overall burden than in the uncovered systems. The category result reflects the balance between withdrawals from natural sources and water returned to the water compartment. Climate change (1.17 μ Pt) is mainly influenced by carbon dioxide, fossil (0.821 μ Pt), followed by dinitrogen monoxide (0.259 μ Pt) and methane, fossil (0.25 μ Pt). Fossil and mineral resource use (1.045 μ Pt) is associated primarily with crude oil (0.374 μ Pt) and tellurium (0.241 μ Pt), while natural gas is less relevant (0.133 μ Pt). In the air-emission-related categories, ammonia remains the main hotspot, contributing 0.666 μ Pt across acidification, particulate matter, and terrestrial eutrophication. Additional contributions are given by sulphur dioxide for acidification (0.115 μ Pt), particulates <2.5 μ m for particulate matter (0.153 μ Pt), and nitrogen oxides for terrestrial eutrophication (0.408 μ Pt). Land use is again almost fully explained by occupation, permanent crop, irrigated, intensive (1.42 μ Pt).

Organic uncovered

Total damage (161 nPt)	Emitted substance	Consumed natural and primary energy resources	Emission compartment	Associated damage
				micro-Pt
Water Use (26.5 micro-Pt)				
Water turbine use, unspecified natural origin		x		16,7
Water river		x		16,2
Water, well		x		10,3
Water, unspecified	x		water	-16,9
Climate Change (1.9 micro-Pt)				
Carbon dioxide, fossil	x		air	1,12
Dinitrogen monoxide	x		air	0,648
Methane fossil	x		air	0,125
Fossil and mineral resource use (1.506 micro-Pt)				
Gas, natural		x		0,193
Tellurium		x		0,375
Crude oil		x		0,486
Gold		x		0,406
Copper		x		0,0896
Coal hard		x		0,108
Acidification, Particulate matter, and Terrestrial Eutrophication (1.05, 0.95, and 0.812 micro-Pt)				
Ammonia	x		air	1,731
Acidification (1.05 micro-Pt)				
Sulphur dioxide	x		air	0,161
Particulate matter (0.95 micro-Pt)				
Particulates, with grain size < 2.5 micron	x		air	0,236
Land use (1.59 micro-Pt)				
Occupation, permanent crop, irrigated, intensive		x		1,59
Acidification and Terrestrial Eutrophication (1.05 and 0.812 micro-Pt)				
Nitrogen oxides	x		air	0,554

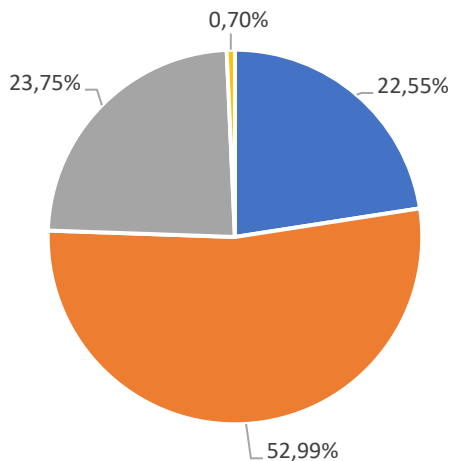
For organic uncovered cultivation, water use (26.5 μ Pt) is again mainly determined by irrigation-related withdrawals and return flows, confirming the strong incidence of water demand in the uncovered system. The result is associated with water withdrawn from natural sources, partly offset by water returned to the water compartment. Climate change (1.9 μ Pt) is mainly determined by carbon dioxide, fossil (1.12 μ Pt) and dinitrogen monoxide (0.648 μ Pt), while methane, fossil contributes 0.125 μ Pt. For fossil and mineral resource

use (1.506 μ Pt), the main contributors are crude oil (0.486 μ Pt), gold (0.406 μ Pt), and tellurium (0.375 μ Pt), followed by natural gas (0.193 μ Pt). Ammonia to air remains the dominant substance for acidification, particulate matter, and terrestrial eutrophication, with an associated damage of 1.731 μ Pt. The contribution of sulphur dioxide to acidification is 0.161 μ Pt, particulates <2.5 μ m contribute 0.236 μ Pt to particulate matter, and nitrogen oxides contribute 0.554 μ Pt to terrestrial eutrophication. Land use is almost entirely associated with occupation, permanent crop, irrigated, intensive (1.59 μ Pt).

Across all cultivation systems, the contribution analysis of substances highlights a consistent pattern in the most relevant impact categories. Water use is primarily determined by the balance of irrigation-related water withdrawals and return flows, and its burden is markedly higher in the uncovered systems than in the covered ones. Climate change is mainly driven by carbon dioxide, fossil and dinitrogen monoxide, confirming the importance of both energy-related emissions and nitrogen-related direct emissions. Fossil and mineral resource use is systematically associated with the consumption of natural gas, crude oil, and selected mineral resources such as tellurium, with a more visible contribution of gold in the organic uncovered system. For the air-emission-related categories, ammonia to air is the recurring dominant hotspot in acidification, particulate matter, and terrestrial eutrophication, while nitrogen oxides, sulphur dioxide, and primary particulates <2.5 μ m provide secondary contributions. Land use is almost entirely driven by occupation, permanent crop, irrigated, intensive in all four systems. Overall, the substance-level analysis confirms that irrigation-related water demand, combustion- and fertilisation-related emissions, and agricultural land occupation are the main drivers of the most relevant weighted impact categories.

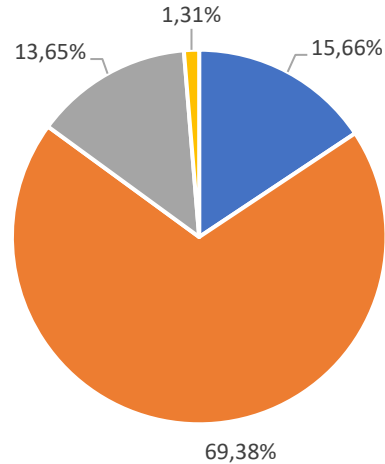
5.6 Contribution analysis of the most burdening processes to the eco-indicator

Conventional covered



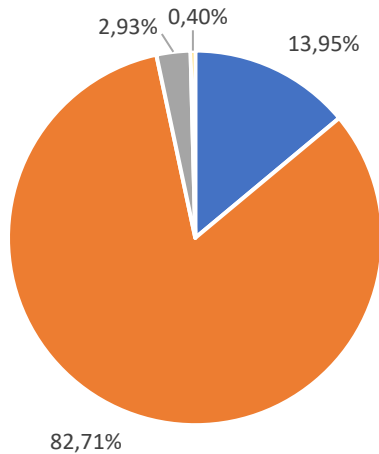
- On field emissions
- Irrigation and other agricultural activities
- Fertilisers and pesticides
- Minor inventories

Conventional uncovered



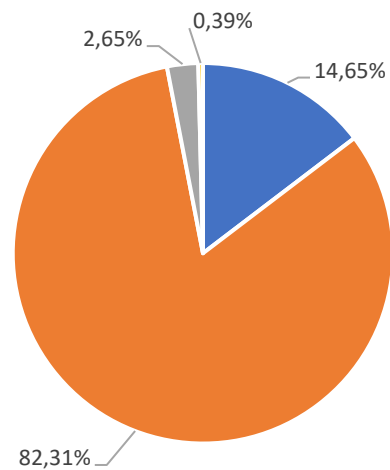
- On field emissions
- Irrigation and other agricultural activities
- Fertilisers and pesticides
- Minor inventories

Organic covered



- On field emissions
- Irrigation and other agricultural activities
- Fertilisers and pesticides
- Minor inventories

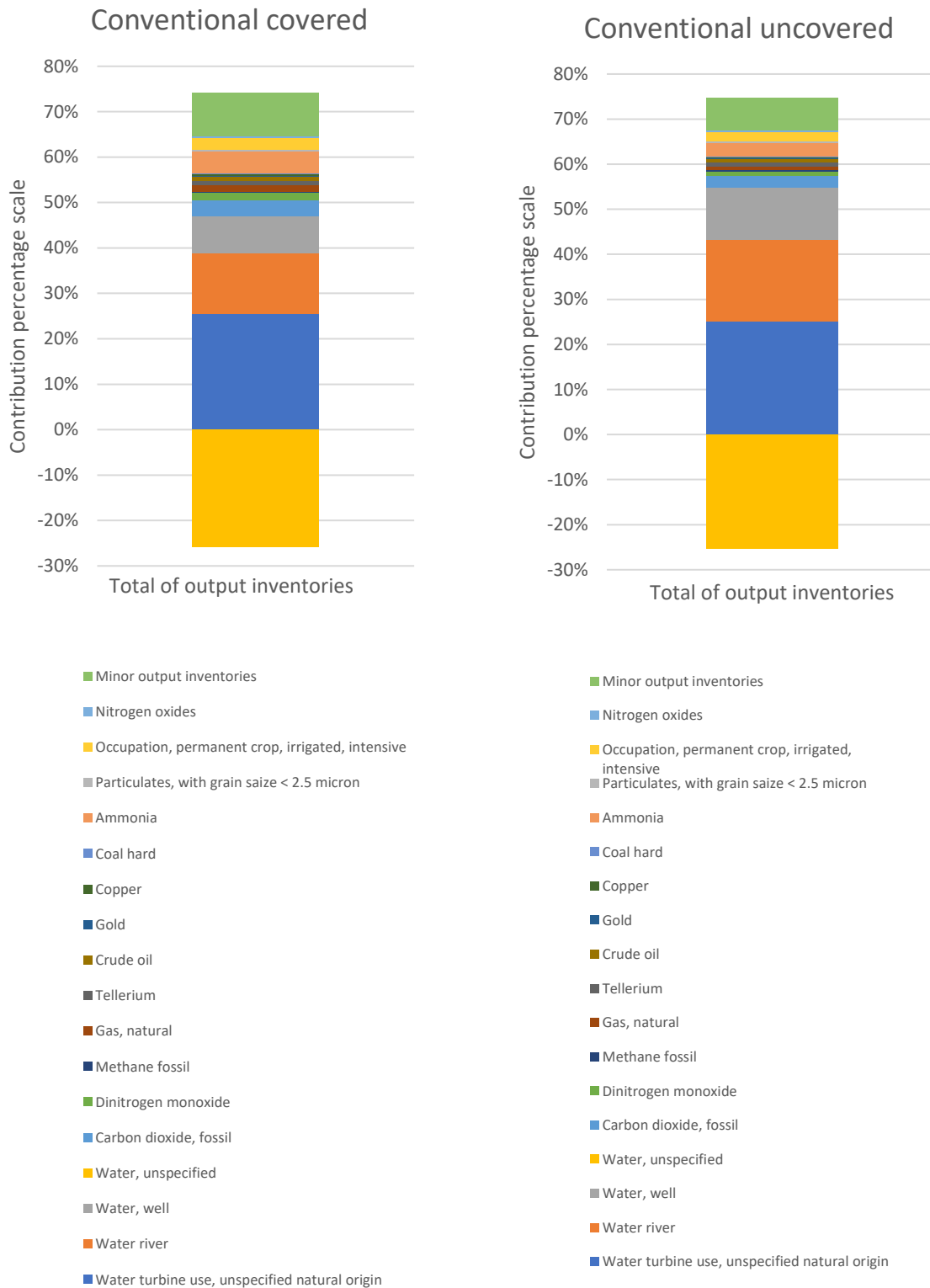
Organic uncovered

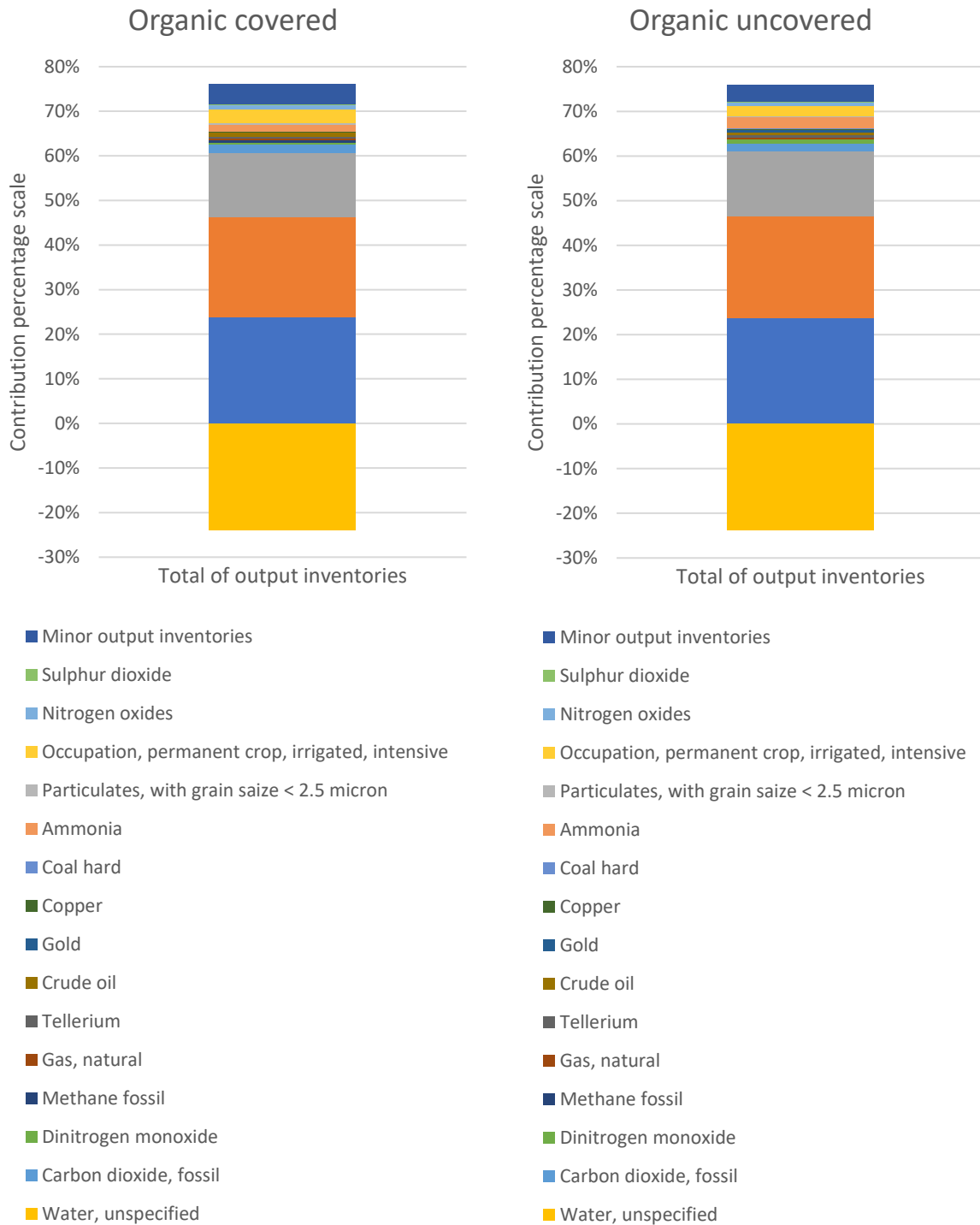


- On field emissions
- Irrigation and other agricultural activities
- Fertilisers and pesticides
- Minor inventories

The endpoint-based contribution analysis shows that irrigation and other agricultural activities are the main contributors to the eco-indicator in all four cultivation systems, accounting for 53.0% of the total endpoint value in conventional covered cultivation (20.420 out of 38.532), 69.4% in conventional uncovered (30.444 out of 43.882), 82.7% in organic covered (19.479 out of 23.551), and 82.3% in organic uncovered (30.312 out of 36.827). On-field emissions represent the second most relevant process group in all cases, contributing 22.6% in conventional covered, 15.7% in conventional uncovered, 14.0% in organic covered, and 14.7% in organic uncovered. The role of fertilisers and pesticides is more pronounced in the conventional systems, where they account for 23.7% of the endpoint value in the covered system and 13.6% in the uncovered system, whereas their contribution becomes marginal under organic management, decreasing to 2.9% in organic covered and 2.6% in organic uncovered cultivation. Minor inventories are negligible in all systems, remaining below 1.5% of the total endpoint value. Overall, the eco-indicator profile highlights a clear distinction between management systems: the conventional scenarios show a more distributed contribution among irrigation, on-field emissions, and agrochemical inputs, while the organic scenarios are much more strongly dominated by irrigation-related processes; in addition, the uncovered systems exhibit higher absolute endpoint values than the corresponding covered systems, mainly due to the greater contribution of irrigation and other agricultural activities.

5.7 Contribution analysis of the most burdening substances to the eco-indicator





The contribution analysis of substances to the eco-indicator shows a consistent dominance of irrigation-related water flows across all cultivation systems, with a particularly strong incidence in the uncovered scenarios. In conventional covered cultivation, the endpoint result is mainly associated with water turbine use, unspecified natural origin (20.3 μ Pt; 52.7% of the total eco-indicator), water river (10.5 μ Pt; 27.2%), and water, well (6.63 μ Pt; 17.2%), partially offset by water, unspecified (–20.5 μ Pt; –53.2%). The most relevant non-water contributions are minor output inventories (7.576 μ Pt; 19.7%), ammonia (3.800 μ Pt; 9.9%), carbon

dioxide, fossil (2.72 μPt ; 7.1%), and occupation, permanent crop, irrigated, intensive (1.92 μPt ; 5.0%). A similar structure is observed in conventional uncovered cultivation, where the overall endpoint value is higher and irrigation-related water flows account for an even larger burden, with water turbine use, unspecified natural origin contributing 22.3 μPt (50.8%), water river 16.2 μPt (36.9%), and water, well 10.2 μPt (23.2%), partly compensated by water, unspecified (-22.5 μPt ; -51.3%). The main additional contributors are minor output inventories (6.310 μPt ; 14.4%), ammonia (2.634 μPt ; 6.0%), carbon dioxide, fossil (2.28 μPt ; 5.2%), and occupation, permanent crop, irrigated, intensive (1.83 μPt ; 4.2%). In organic covered cultivation, the same hotspot pattern is retained, although with lower absolute values: the eco-indicator is mainly associated with water turbine use, unspecified natural origin (10.7 μPt ; 45.4%), water river (10.2 μPt ; 43.3%), and water, well (6.47 μPt ; 27.5%), partially offset by water, unspecified (-10.8 μPt ; -45.9%). The most relevant non-water contributors are minor output inventories (1.985 μPt ; 8.4%), occupation, permanent crop, irrigated, intensive (1.42 μPt ; 6.0%), carbon dioxide, fossil (0.821 μPt ; 3.5%), and ammonia (0.666 μPt ; 2.8%). In organic uncovered cultivation, irrigation-related flows again dominate the eco-indicator, with water turbine use, unspecified natural origin contributing 16.7 μPt (45.3%), water river 16.2 μPt (44.0%), and water, well 10.3 μPt (28.0%), partly balanced by water, unspecified (-16.9 μPt ; -45.9%). The main additional contributors are minor output inventories (2.705 μPt ; 7.3%), ammonia (1.731 μPt ; 4.7%), occupation, permanent crop, irrigated, intensive (1.59 μPt ; 4.3%), and carbon dioxide, fossil (1.12 μPt ; 3.0%). Overall, the eco-indicator is consistently driven by irrigation-related water withdrawals and return flows, while the main secondary contributions are associated with air emissions, particularly ammonia and fossil carbon dioxide, and with agricultural land occupation. Compared with the conventional systems, the organic systems show a lower contribution from non-water substances, whereas the uncovered systems exhibit higher endpoint values mainly due to the stronger incidence of irrigation-related flows.

5.8 Concluding remarks on the Life Cycle Impact Assessment

The Life Cycle Impact Assessment performed with the EF 3.1 methodology shows a consistent environmental profile across the four table grape production systems, while also highlighting clear differences related to management type and cultivation conditions. Overall, the results indicate that the main environmental pressures are associated with irrigation demand, direct field emissions, and, to a lesser extent, input-related processes such as fertiliser, pesticide, and energy use.

Across the characterisation, normalization, and weighting steps, water use emerges as the most relevant impact area in all systems, confirming the central role of irrigation in shaping the overall environmental footprint of table grape production. This aspect is particularly evident in the uncovered systems, which

generally show a higher burden than the corresponding covered systems. In parallel, on-field emissions are a recurrent hotspot for categories related to acidification, eutrophication, particulate matter, and part of the toxicity-related impacts, confirming the importance of emissions generated directly during the agricultural phase.

The comparison between management systems shows that the conventional systems are more influenced by the contribution of fertilisers and pesticides, especially in impact categories linked to climate change and resource use, whereas in the organic systems the relative importance shifts more clearly towards irrigation-related activities, diesel use, and field emissions. In general, the organic covered system shows the most favourable environmental profile among the four scenarios, while the uncovered systems tend to be more burdening, mainly because of the stronger relevance of irrigation.

The contribution analyses carried out at both process and substance level confirm these patterns. At process level, the dominant contributors are consistently irrigation and other agricultural activities, followed by on-field emissions, while agrochemical inputs are more relevant in the conventional systems than in the organic ones. At substance level, the results show that the eco-indicator is largely driven by water-related flows, with secondary contributions associated with air emissions, particularly nitrogen-related compounds and fossil carbon dioxide, as well as with land occupation.

Taken together, these findings indicate that the environmental performance of table grape production is mainly determined by a limited number of recurring hotspots. This provides a clear basis for improvement priorities, which should focus primarily on optimizing irrigation management, reducing direct field emissions, and improving the efficiency of input use, especially under conventional cultivation. Overall, the assessment confirms that the cultivation system and field management practices play a decisive role in the environmental footprint of table grapes under the EF 3.1 framework.

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