Chapter

The Industrial Symbiosis of Wineries: An Analisys of the Wine Production Chain According to the Preliminary LCA Model

Agata Matarazzo, Fabio Copani, Matteo Leanza, Aldo Carpitano, Alessandro Lo Genco and Graziano Nicosia

Abstract

The circular economy refers to a term that defines an economy designed to be able to regenerate itself. Agri-food is one of the areas where the tools and strategies of the circular economy are implemented. The wine sector involving numerous stages of production and processing causes many impacts on the environment. Starting from the transport, to the distribution of wine products, there are several impacting processes on the environment. For the assessment of negative results although not of every product production process, the circular economy provides a more than suitable tool: the LCA (Life Cycle Assessment) has been implemented on the whole production chain of the product "Lenza di Munti", a bottle of wine by "Nicosia S.p.A.". The grapes used in the production of red wine are Nerello Mascalese and Nerello Cappuccio; instead of Carricante and Catarratto grapes used for white wine. This chapter provides a complete picture of the interactions between the product and the environment, to understand the environmental consequences and to provide the necessary information to define the best solutions.

Keywords: circular economy, LCA, agri-food, wine sector, Sicilian economy

1. Introduction

In recent years, along with the continuous development of the binomial environment industry, strong critical attention and assessment in the risks and impacts on the environment has matured. In the agri-food sector, it becomes very important to define carefully what are the environmental impacts and evaluate their weight, in order to improve or consolidate the quality of the production process. In the past, corporate objectives had little to do with the assessment of environmental impacts, rather they aimed almost exclusively at maximizing the quantity produced, remaining unrelated to everything that the production process caused. Today, it is essential to know more fully "what" is used in the production processes of agricultural products and "how" is used. In line with this trend, in the wine sector, in Italy, in recent years, we aim to produce quality wines, putting

the quantity in the background; this allowed small producers to enter the market, thanks to the production of quality wines [1]. However, there is a change in trends regarding the size of producers: from small companies to large industrial companies. As a consequence this means more consumption, therefore higher emissions and impacts. The food industry disproportionately contributes to many global environmental problems. The production of wine is not an exception to the rule: it contributes to a variety of environmental burdens, mainly related to the use of pesticides and fertilizers in the vineyard and to the production of glass bottles. Target markets nowadays are more aware of ecological concerns than ever before; which means that costumers are increasingly more conscious of the products they are willing to buy and companies have to deal with this new context. The concept of sustainability is taken into account seriously in the Italian wine sector. The total vineyard area in Italy is approximately 656,000 hectares, and it is the third most important country per vineyard area in the world [2]. Moreover, the wine industry is an important contributor to the Italian economy, as it registers a sales volume of 9.5 billion euros. Sicily, in particular, widely contributes to the Italian wine industry: it is the region with the largest area of vineyards (for a total of 111,000 hectares), corresponding to around 17% of the overall Italian vineyard area and to 10.4% of the Italian total grapes production [3].

For this reason, this study will analyze a proactive company in the field, Nicosia S.p.A. To this end, the European Union has identified an instrument that evaluates and analyzes the entire life cycle of a product, from its cradle to its grave: the life cycle assessment. Thanks to this tool, companies can take steps toward the Green Economy road implemented by industrial symbiosis, also called industrial ecology. Industrial symbiosis, provided by industrial ecology, is an integrated management tool, which designs industrial infrastructures as if they were a series of interconnected ecosystems interfaced with the industrial ecosystem. It involves traditionally separate industries through an integrated approach aimed at promoting competitive advantages through the exchange of matter, energy, water, and/or by-products. The basis of this process is collaboration and the opportunity for synergy between companies. For example, in the case of Cantine Nicosia, the residual vinecce from the vinification process are reused for the production of spirits; this is the demonstration of how relationships, albeit simple, are able to constitute examples of industrial symbiosis. In particular, the study will focus on the inventory of a bottle of wine, the Lenza di Munti, by Nicosia S.p.A., in order to highlight any introduction in the process of any type of input, and to take note of the weight it has on the environment the output produced. The inventory is a real phase of the LCA, and in reference to the inherent standard [4, 5], this consists in the quantitative description of all the flows of materials and energy that cross the boundaries of the business system, both incoming and outgoing. Specifically, flow charts and data collection tables are used to prepare, with certainty of particulars, a complete and representative inventory of the product. In this study, each type of impact will be described, but above all that of CO_2 emissions. In this regard, many studies have highlighted what are the sources of CO_2 emissions in the wine sector, and they are: the phase of transport of inputs and outputs and waste management process and post process [6]. It will highlight the inter-company and inter-company functional relationships, representing those that are the subjects of the activity studied and the main actors, understanding those that are the bonds and relationships that exist between them.

The main actors involved in the activity studied are the company and its respective internal and external stakeholders including suppliers and customers.

The subject of the study is the wine sector and specifically the set of interactions that exist between the products and the environment and therefore the environmental impacts that arise from these interactions.

2. Materials and methods

As customers of goods and services we often don't think about all the consequences, it has got on what surrounds us: the environment and ecosystem in which we live are submitted to continuous stress and that determines its deterioration.

Companies of any dimensions are trying to modify their actions to handle their impact, to protect their reputation, and get prepared for stricter rules [5].

Using the LCA as an assessment tool of the impact of the wine sector sets some difficulties; in order to produce a bottle of wine several resources are needed, not only for the materials used for bottling but also we can have a great impact on the environment and also on mankind during the process of cultivation and treatment of grapes. Until a decade ago, producers used to think that a moderate use of pesticides and fertilizers gave a higher quality of wine. Indeed, during the last years, different choices have been made like leaving vines to their natural process without adopting solutions intrusive for the environment as the use of pesticides. In some particular cases, like Etna's vines, even irrigate is forbidden, if not in case of necessity, ensuring the natural growing process of grapes of wine.

The production sector begins by taking care of the vine which generally causes dangerous emissions neither for the environment nor for mankind unless pesticides are used; then during the harvest, it is time to harvest grapes in plastic containers with a useful life of 3 years. The harvest is then carried by trucks from the vine to the factory; once in there, the product is processed by a mechanic wine press which extracts juice and pulp from grapes creating in this way the must that has to be then transformed in wine. It is a particular and delicate operation that must be performed carefully. It is essential that the grapes have not been pressed by crushing during the transport because that could cause unwanted fermentation.

Subsequently or simultaneously with the pressing, the grapes are placed in a special automatic crusher-stemmer that separates the skeleton of the bunches, or the green part, from the berries. The result will be the destemmed crushed grapes, consisting of 80% of pulp, 15% of skins, and 5% of grape seeds, while the must has a composition of about 70–80% of water, 10–30% of sugars, and other substances.

Once the must is obtained, it is left to ferment in special containers; the aim of this phase is to transform the sugars into alcohol and give the wine the desired features and smells; depending on the type of vinification, in white or red, the skins are removed from the must (draining phase).

The duration of this phase varies from 5 to 15 days, and the main source of emission is that of CO_2 by the fermenter.

Once the fermentation days have passed, we proceed with the racking, in which the yeasts and the solid parts are separated from the wine. From this apparent waste, it is possible to obtain a second raw material, the marc, which is a primary part of the production process of some distillates such as grappa.

Once the racking is finished, the wine is subjected to the refining phase and at the right moment, the product is finished with the most invasive phase from an environmental point of view, which is bottling.

The use of LCA in environmental management and sustainability has grown in recent years as seen in the steadily increasing number of published papers on

LCA methodology and on case studies that have been performed to use LCA [7]. In many cases, these studies show that the most polluting phases of a food production system consist in the agricultural ones. Therefore, the research about innovations and environmental improvements should be addressed, above all, to the agricultural stages, also taking into consideration the economic feasibility [8]. Life cycle assessment is the factual analysis of a product's entire life cycle in terms of sustainability and allows the determination of input factors and output of the lifecycle of each product, evaluating the consequent environmental impact. This tool allows the phases where environmental issues are focused on to be identified as well as those who are responsible for the burden. LCA is a standardized methodology, which gives it its reliability and transparency. The standards provided by the International Organization for Standardization (ISO) describe the four main phases of an LCA: "goal and scope", "inventory analysis", "impact assessment," and "interpretation." These standards have been developed by the ISO/TC 207 Technical Committee and they are: UNI EN ISO 14040 (1998) [2, 3], by which the principles and the requirements for an LCA study are established; UNI EN ISO 14041 (1999), in which the objective and the field of application are defined and an inventory analysis is performed; UNI EN ISO 14042 (2000), that evaluates impacts: in particular, the main impact categories to be taken into consideration are the use of resources, human health, and ecological consequences; finally, with the UNI EN ISO 14043 (2000), improvements are analyzed. According to the ISO standards on LCA, it can assist in: identifying opportunities to improve the environmental features of products at various points in their life cycle; decision making in industry, governmental or nongovernmental organizations (e.g., strategic planning, priority setting, product and process design or redesign); selection of relevant indicators of environmental performance, including measurement techniques; and marketing (e.g., an environmental claim, eco-labeling scheme, or environmental product declarations). Lately, research about LCA shows how the concept of "economic sustainability" is spreading, and how helpful this tool is to achieve this objective. The agricultural sector provides a lot of examples about this usefulness: in Australia, for example, the GHG emissions from agricultural sector will continue to increase as Australia's agricultural export production is predicted to double over the next decade and the population is to reach 42.5 million by 2056. An LCA compiles the inputs and outputs from a production system, and in turn evaluates their potential environmental impacts, for example, GHG emissions [9]. Thus, the current research focuses on the determination of global warming impact or carbon footprint, that is, life cycle GHG emissions of horticultural products and identifies "hotspots" requiring mitigation strategies to reduce GHG emissions from the production and delivery of three important producers in Australia [10]. But it is not necessary to go far away from Catania; in less than 100 km, the environmental impacts of olive oil production have been studied by using the LCA. The Italian olive-growing sector has to face both the growing competition on the international olive oil market and the shift of the common agricultural policy (CAP) from market and price policies toward direct aids decoupled from production. A possible strategy to address this highly competitive scenario could be the renewal of olive groves through the adoption of innovative olive-growing models able to reduce production costs without worsening environmental sustainability. Two innovative olive-growing models are considered: the "High Density" (HDO) and the "Super High Density" (SHDO) olive orchards. From the environmental point of view, goal of the LCA is to build up the environmental profile of the two systems, in order to assess them and to identify their hot spots [8]. Depending on the complexity of the problem that a company wants to face, it is possible to choose between different types of LCA, each of which allows an in-depth solution to be found. These instruments are: LCA conceptual, preliminary LCA, and complete LCA. The first one is used only in the first phases, so that it often does not

consider numerous aspects of the product lifecycle and does not make a comparison with other products. The second one, even if it does not consider the entire lifecycle of the product, allows the comparison between different products. The last one is the best methodology used to provide product improvements. A similar instrument to the LCA is the LCCA (lifecycle cost analysis). It is a methodology used for the economical evaluation of projects, in which the costs that come from owning, using, maintaining, and disposing of a certain product are considered vital to take a decision. In the end, this tool allows the determination of the overall cost of a certain product, considering its entire lifecycle [11].

3. Case study: Cantine Nicosia

Cantine Nicosia was founded in 1898 when Francesco Nicosia, the great-grandfather of the current owner, decided to open the first wine shop in Trecastagni, on the eastern side of Etna. The decisive entrepreneurial turnaround took place at the end of the twentieth century, thanks to the tenacity and innovative spirit of the current owner, Carmelo Nicosia, who, investing in the expansion and renovation of the vineyards and in the construction of a modern winery, will bring the family business to be the protagonist of the rebirth of Sicilian wine.

Today, Cantine Nicosia is a dynamic, modern, and efficient company, capable of looking to the future with full respect for tradition. The Trecastagni winery is the place where tradition combines with the most advanced technology. In the covered area of 4000 m^2, on a total surface of 27,000 m^2, between the wide winemaking area, the analysis laboratory, the modern bottling line, and the underground barrel cellar, the heart of the company pulsates.

Cantine Nicosia produces prestigious autochthonous wines, promoting the territory in full respect of the environment and enhancing the raw materials. In relation to this goal, the company has fully embraced the cause of organic and biological and sustainability, to combine environmental protection and food safety, with the aim of bringing to the tables of consumers a "zero impact" wine. Over the years, several milestones have been achieved in terms of international environmental certifications: from UNI EN ISO 9001:2015 to UNI EN ISO 14001:2015 Environmental Certification, from BRC Food & Beverage to the International Food Standard (IFS). Also recent is the achievement of an international "ethical" certification issued by SEDEX (Supplier Ethical Data Exchange), thanks to the environmental, biological, and vegan certifications. The company's future goal is the achievement of further certifications such as carbon footprint, water footprint, and LCA. Cantine Nicosia is a sustainable company actively involved in the protection of natural resources, and the optimal management of water resources is one of the essential points. Cellar work involves a high consumption of water, especially for cleaning and sanitation. In order to limit consumption, a system is implemented which, through the collection of both rainwater and reverse osmosis waste water, allows irrigation of farm lawns.

3.1 Functional unit

The subject of this study is a bottle of Lenza di Munti. It is necessary to list what the components of the bottle itself are: the glass bottle, the cork stopper, the label, and the aluminum cap. The supplier of glass bottles is O-I SALES. The cargo route starts from Vufflens-la-Ville (Switzerland), moves on to Aprilia (LT), and from there to Marsala (TP). At this point, the load will reach the Nicosia estates by road transport. The cork stoppers come from the Colombin company, located

in Trieste. The company is certified: the used cork comes from Portuguese forests certified FSC. The transport of the caps takes place through the sea. The label is supplied by the company Moduli Continui s.r.l. (Padua), and transport is by road vehicles. The capsule is supplied by Enoplastic S.p.A. located in Bodio (VA); the delivery is carried out by road transport. Below, we will describe the uses and consumption of the listed parts. The final packaging consists of two elements: the cardboard containing the bottles and the packaging cellophane. The first is provided by the AICO company, Mascalucia (CT); the second, purchased in reels, is supplied by the company VIRAPACK, Acireale (CT). The Lenza di Munti is a wine intended for large retailers. Its winemaking process takes place in red and white. The first one is obtained from Nerello Mascalese and Nerello Cappuccio vines (80–20%); the second one is obtained from Carricante and Catarratto vines (60–40%). The analysis will focus on both vinification methods, generalizing the related consumption.

4. Results and discussion

Before moving on to the data collection, creating a flowchart in order to summarize and outline the production plant, in order to better understand which phases of the process we should analyze, according to our interests turned to be a useful practice. This study has, therefore, highlighted the main phases of the production plant, namely the ones which need an attentive analysis of the consumption (**Figure 1**; **Tables 1** and **2**).

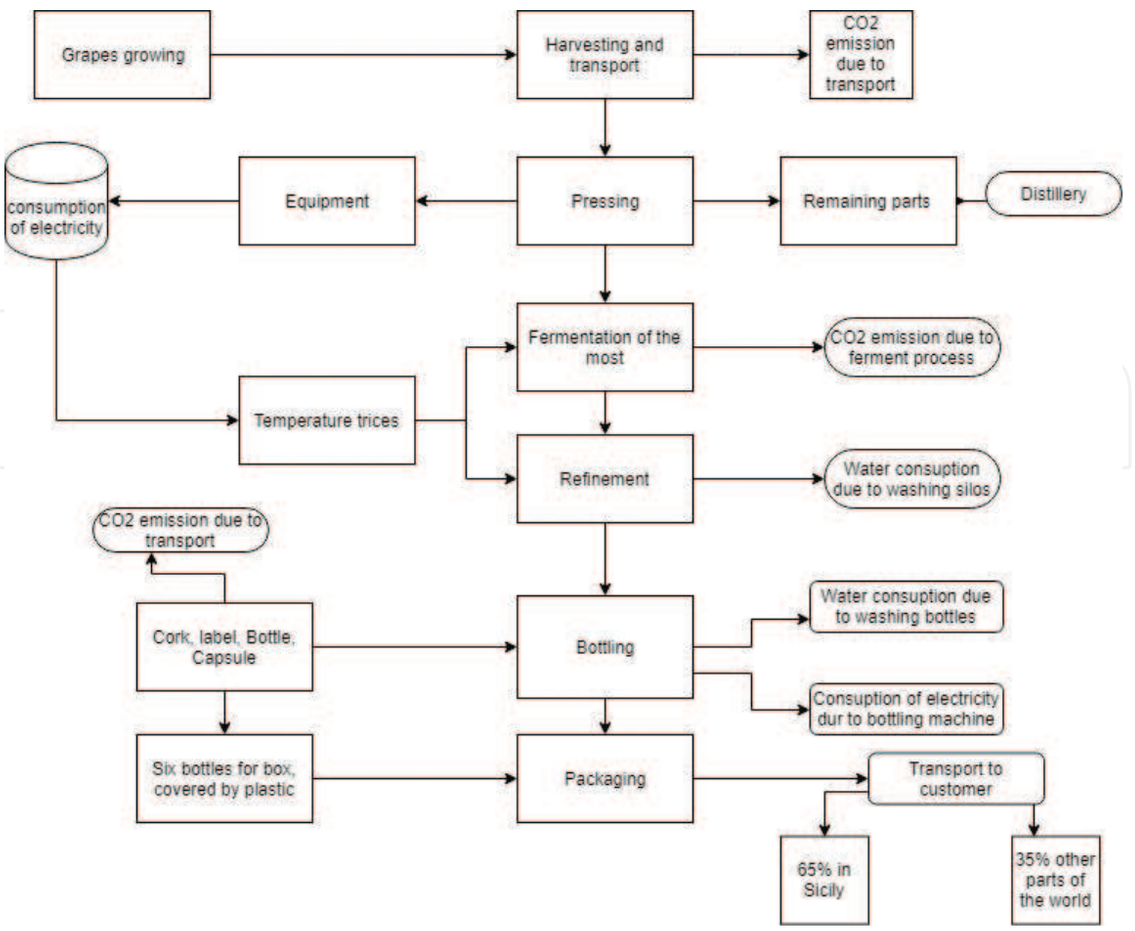

Figure 1.
Flowchart of the production plant.

Week activities	Per day	Per week	Per year
Microfiltration plant		3300.00	
Cross-flow filtration equipment (in Italian Filtro Tangenziale)		2700.00	
Total amount		12,000.00	624,000
Water consumption for winemaking (about 60 days per year)	4500.00		270,000.00
Total amount of the water consumption per year			2,376,000.000

Table 1.
Water consumption.

The data collection concerning any kind of consumption of the production plant makes it possible to make a list of the values about the main Nicosia S.p.A. water and energy consumption, noticing the related impacts. As far as water consumption is concerned, it is possible to distinguish consumption in three macro consumption areas:

Microfiltration plant;
Cross-flow filtration equipment;
General consumption of winemaking.

It is possible to notice that water consumption is closely connected to winemaking, since the daily consumption represents a larger amount than the week consumption of the other two activities which take advantage of water, namely microfiltration and cross-flow filtration equipment. Microfiltration is a filtration process, which removes solid particles from a fluid or from a gas, making them pass through a micro-porous membrane. Typically, the diameter of the small holes of these membranes is between 0.1 and 10 μm. In the field of winemaking, it is a process which is used in order to separate wine from all undesired substances; while, cross-flow filtration, which represents one of the most innovative processes in the field of filtration, improves the performance, not possible by any of the other processes concerning solid-liquid separation. In the field of drinks and winemaking,

Months	kW
Jan	33,680
Feb	34,499
Mar	36,453
Apr	43,353
May	37,309
June	41,259
July	36,792
Aug	30,139
Sep	29,307
Oct	30,457
Nov	29,241
Dec	33,141
Tot	415,630

Table 2.
Energy consumption.

this process aims at making perfectly transparent the product, stabilizing it microbiologically and, in case, it is necessary, eliminating partially colloides and oxidant enzymes, all in one phase. Doing so, all the following filtrations (included the centrifuge), pasteurization, and an improvement in the processes of stabilization of the product would be eliminated. This would lead to a lesser loss and manipulation of the product, saving on coadjuvants and on the cost of labour, with an overall reduction of the costs and a greater protection of the initial qualities of the product.

Concerning energy consumption, and, consequently, the related impacts, this study as made a list of the kW consumed per month by the production plant. The consumption values highlighted are between 29,000 and 43,000 kW (specifically, the month with the minor consumption was November, while the one with the most consumption was April). The total amount of energy consumption is high and amount to about 413,000 kW per year.

In order to finish the product, thus producing the bottle of wine ready to be delivered to the consumer, it is necessary to put together some components, coming from different geographical areas.

Consequently, this study cannot end just with the water and energy consumption. In order to have an overall view of how much impact the production of a bottle of wine has, this study has to calculate the kilometers which exist between the different components of the containers and the place where the product is bottled.

Inside an enterprise, the production of an item is not all produced by the enterprise; taking into consideration the case of Nicosia S.p.A., the main suppliers come from different regions and, in some cases, the first phase of the production of the item starts abroad (**Table 3**).

As far as the cork concerns, the raw material comes from Portugal, from certified FSC forests, that is an international certification, an independent and of third party, specific for forests and the products—wooden and nonwooden ones—derived from the forests. Specifically, not only is the forest certified but also the producer located in Trieste is, in particular for the chain of custody, the certification which ensures and makes the product trackable.

The transport of the bottle's components is made by tir from many parts of Italy to Trecastagni (CT). It is important to show the table of EURO Regulation referred to the emission limits of gas and fine dust. This case study takes into consideration an EURO 5 tir (**Table 4**).

The index (g/kWh) is a unit of measurement which could be considered as both an emission or a consumption index. In particular, it measures the grams of fuel for kW in an hour of the working system in full power.

In the years, the evolution of the EURO Regulation has entailed an increase of emission limits; in particular from EURO 5 to EURO 6, the limits of NOx emission

Component	From	km covered by the tir (km)	Hours of transport
Cork	Trieste	1437	15
Label	Padova	1256	13
Capsule	Bodio Lomnago Varese	1395	14
Bottle of glass	Marsala	352	4
Corrugated paper	Mascalucia	8.3	14 min
Plastics	Acireale	12.4	25 min
		4460.7	46 h and 39 min

Table 3.
Distance and fuel consumption.

EURO	NOx (g/kWh)	Particulate (g/kWh)
Euro 5	2.0	0.02
Euro 6	0.4	0.01

Table 4.
EURO norm.

Average of kW developed by a TIR	Total hours of transport	Emission of NOx	Emission of particulate and fine dust
330	46 h and 39 min	30,789	307.89

Table 5.
Transport emission.

passed from 2.0 to 0.4 g/kWh, and particulate emission in EURO 6 foresees 50% less than EURO 5 (**Table 5**).

It is easy to see that the major impact on the environment is due to the NOx and particulate emissions which increase the greenhouse effect.

5. Results and discussion

The quality of the waters is constantly monitored with analysis and controls. It also has a purifier for the waste waters of the cellar to re-insert clean water into the strata. The company also embraces three pivotal points on which the concept of sustainable development is based: economic, environmental, and social. Regarding the first aspect, the main aim is to increase the local economy through local suppliers and workers—a motivated choice also to reduce CO_2 emissions in a transversal way. The second aspect is the protection of the environment, which is why the terraces in the Monte Gorna vineyards as well as dampen the impact of the water—thus reducing the possible hydrogeological risks—enhance and protect the old technique of dry lava stone walls.

The choice of using cork stoppers is important. Thanks to this use, the demand is kept high, as following a lower demand for plugs, due to the greater use of alternative closures (synthetic and aluminum screw), there would be a sudden deforestation because the economic value of those trees it is only linked to the cork industry and to the production of corks. The cork, unlike alternative closures, is 100% sustainable, recyclable, and renewable, and it should not be forgotten that in the process of removing the bark, from which the corks are obtained, no tree is cut. A cork oak can live up to 250 years with decortic interventions every 9 years. Deforestation would also cause extensive damage to its huge ecosystem of 135 species of plants, 24 of reptiles and amphibians, 160 of birds, and 37 of mammals.

Last but not least is the environmental aspect. For 8 years, now the company has managed the care of the green in two roundabouts of the urban area of Trecastagni. The goal is to sensitize the population in the care of the common good.

6. Conclusion

It is estimated that winemaking industry involves an increase of gases in atmosphere:

152 kg of CO_2/ton (for the winemaking activity).

235 kg of CO_2/ton (for cellar activity).

Europe represents 60% of wine production in the world, in particular in Spain, Portugal, Italy, and France, which have a perfect climate allowing the growth of the grapes. The data of Nicosia S.p.A. represent an evident example of how it is possible to reduce impacts made by the wine production field over the environment. The company is proactive in all the chain of production. The solution is using innovative systems like cross-flow filtration equipment and cork certificated by FSC (Forest Stewardship Council).

It is clear too that there are some sources of air pollution, in particular the NOx and the particulate emitted by tir during the transports.

A solution could be using means of transport "eco-friendly" which pollute less, like tir powered by GPL, metan or electricity.

Author details

Agata Matarazzo[1*], Fabio Copani[1], Matteo Leanza[1], Aldo Carpitano[2], Alessandro Lo Genco [1] and Graziano Nicosia[2]

1 Department of Economics and Business, University of Catania, Catania, Italy

2 Nicosia S.p.A., Catania, Italy

*Address all correspondence to: amatara@unict.it

IntechOpen

References

[1] Iannone R, Miranda S, Riemma S, De Marco I. Improving environmental performances in wine production by a life cycle assessment analysis. Journal of Cleaner Production. 2016;**111**:172-180

[2] Roy P, Nei D, Orikasa T, Xu Q , Okadome H, Nakamura N, et al. A review of life cycle assessment (LCA) on some food products. Journal of Food Engineering. 2009;**90**(1):1e10

[3] Schimmenti E, Migliore G, Di Franco C, Borsellino V. Is there sustainable entrepreneurship in the wine industry? Exploring Sicilian wineries participating in the SOStain program. UNI EN ISO 9001:2015. Quality Management Systems. 2016

[4] ISO. ISO 14044—Environmental Management–Life Cycle Assessment–Requirements and Guidelines. Ginevra, Switzerland: International Organization for Standardization; 2006

[5] ISO. ISO 14044—Environmental Management—Life Cycle Assessment—Principles and Framework. In: International Organization for Standardization. Switzerland: Ginevra; 2006

[6] Amienyo D, Camilleri C, Azapagic A. Environmental impacts of consumption of Australian red wine in the UK. Journal of Cleaner Production. 2014;**72**:110-119

[7] Notarnicola B, Hayashi K, Curran M, Huisingh D. Progress in working towards a more sustainable Agri-food industry. Journal of Cleaner Production. 2012;**28**:1-8

[8] De Gennaro B, Notarnicola B, Rosella L, Tassielli G. Innovative olive-growing models: An environmental and economic assessment. Journal of Cleaner Production. 2011;**28**:70-80

[9] Greadel T, Allenby B. An introduction to life cycle assessment. In: Industrial Ecology. 2nd ed. Upper Saddle River, New Jersey, USA: Pierce Education; 2003

[10] Gunady MGA, Biswas W, Solah VA, James AP. Evaluating the global warming potential of the fresh produce supply chain for strawberries, romaine/cos lettuces (*Lactuca sativa*), and button mushrooms (*Agaricus bisporus*) in Western Australia using life cycle assessment (LCA). Journal of Cleaner Production. 2012;**28**:1-8

[11] Berners-Lee M, Howard DC, Moss J, Kaivanto KWA, Scott WA. Greenhouse gas footprint for small businesses-the use of input-output data. Science of the Total Environment. 2011;**409**:883-891