Integration of social LCA with sustainability LCA: a case study on virgin olive oil production

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1. Context and scope

Olive oil is increasingly consumed worldwide as a result of its organoleptic properties. Its consumption increased from 2.7 x 10^3 tons per year between 2000 and 2007 to 2.9 x 103 tons between 2008 and 2012 (COI 2012a). The production of olive oil in the European Union has decreased from more than 78 % of the world's olive oil production between 2000 and 2007 to approximately 73 % between 2008 and 2012 (COI 2012b). The olive oil sector represents a strategic sector in European Union countries that faces emerging competition with the arrival of new producers from other countries. The major competitors include Argentina, the USA, Chile and Australia (Salomone and Ioppolo 2012; COI 2012b). These new producers use intensive and highly mechanized methods that increase yields and reduce operational costs.

On the other hand, olive oil production sector faces environmental issues such as water scarcity, fertilizers and chemicals use or fossil fuels consumption. Another crucial issue concerns waste management. Eighty percent of the mass of olives is composed of olive pulp and stones. Thus, the extraction process gives four times more waste than oil. The composition of the waste products depends on extraction technologies including press, 2-phase or 3-phase systems (Cinar and Alma 2008). They contain phytotoxic chemical compounds and, in particular, wastewater (Roig et al. 2006). As a consequence, environmental life cycle assessment (ELCA) has been applied to olive oil for more than ten years in order to identify environmental hotspots and to propose recommendations to limit environmental impact (Salomone et al. 2010).

Finally, the future of LCA methodology is now oriented to life cycle sustainability assessment (LCSA) (Guinée et al. 2011). This new methodology is based on the integration of ELCA, life cycle costing (LCC) and social LCA (S-LCA). One of the difficulties of such integration is the amount and the heterogeneity of impacts indicators. The present study proposes to inform the discussion by applying social LCA to virgin olive oil production in a life cycle sustainability assessment.

2. Main text

Material and methods

The integration of social LCA into a LCSA was carried out following the four steps method according to the UNEP/SETAC guide (2009). Among the solutions to deal with the three aspects of sustainability, the integrated method was chosen. It relies particularly on the use of only one inventory for economic, social and environmental aspects. This choice was made in order to facilitate the link between the three spheres of sustainability. LCSA was performed using the sum of the three methods (ELCA, LCC and SLCA) without weighting, to avoid compensation between positive or negative impacts on the three sustainability pillars (Klöpffer 2008).

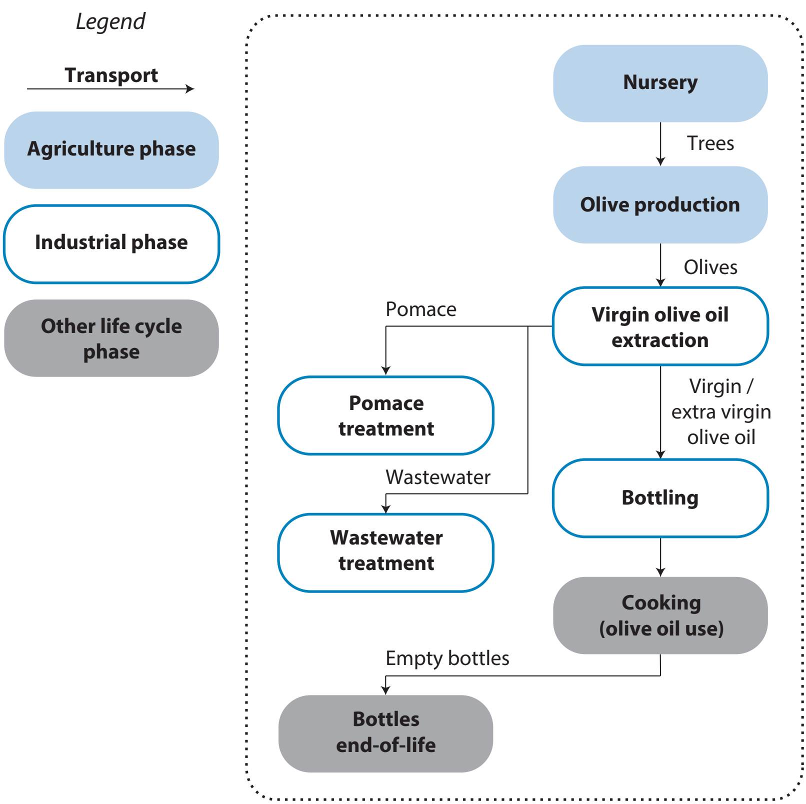

Figure 1: System under study

Goal and scope definition

The objective of the study is to evaluate impact on sustainability of the system of virgin olive oil production. The functional unit of the system is to produce 1 L of virgin olive oil.

System boundaries include the following phases: transport of phytosanitary products, olive production (including nursery) and transport to mills, virgin olive oil extraction, waste (water and pomace) management, transport of empty new bottles, bottling, distribution and disposal of used bottles. All phases are organized into three groups: agricultural, industrial and others (figure 1).

All flows and impacts are allocated to the virgin olive oil. When recycling or incineration leads to energy recovery, no avoided emissions are calculated. In terms of life cycle cost evaluation, externalities from environmental cost remediation do not count. Only direct costs are included. The LCSA here applied is attributional. Social inventory data only come from the enterprises of the sector. No social data from database are included.

Life Cycle Inventory

Environmental and economic data were taken from Busset et al. (2012). Two kinds of environmental and economic data were collected during the inventory: direct data from professional or experts and indirect data from calculation or from database. Direct data were gathered through visits and interviews with 10 olive mill directors for extraction, bottling and waste treatment processes (Busset et al., 2012). For olive production phase, data from 11 olive cultivators were given by expert from the "Centre Technique de l'Olivier" (CTO), an association involving all the professionals of the French olive sector (Busset et al., 2012). The CTO also provided statistics about olive oil sector production.

Social direct data correspond to social indicators included in the UNEP/SETAC guidelines (2009). The most relevant with regard to the sector were selected.Table 1 present the main inventory data for the three aspects.

Table 1: Inventory data for olive production and olive oil extraction (average)

Direct data	Unit	Olive production	Olive oil extraction
Diesel	kg/year	0.052	0.00020
Electricity	kWh/year	0.015	0.39
Water	m3/year	0.59	0.0022
Gasoline	kg/year	0.0032	-
Fertilizers	kg/year	1.0	-
Pesticides	kg/year	0.0099	-
Number of fatal accidents per year	#/year	0	0
Preventive measures	no unit	yes	yes
Emergency protocols exist regarding accidents & injuries	no unit	yes	yes
Preventive measures and emergency protocols exist regarding pesticide & chemical exposure	no unit	yes	no
Appropriate protective gear is required in all applicable situations	no unit	yes	yes
Number of full-time jobs	#	1	2
Quality of information/signs on product health and safety	no unit	enough	enough
Sector efforts in technology development (level of automation)	#	0	0
Relevance of the considered sector for the local economy	%	100	100
Number of consumer complaints to the company	%	100	50
Certifications	no unit	none	none

Because of the qualitative or semi-quantitative nature of some social data, social inventory cannot be expressed by functional unit. Furthermore, qualitative data needs to be transformed in order to become semi-quantitative or quantitative. The factors or scale used for data transformation were inspired by the work of Foolmann and Ramjeeawon (2013) and Hsu et al. (2013) (Table 2).

Table 2: Transformation of qualitative social indicators from inventory into semi-quantitative indicators

Indicator	Value for midpoint category
Number of fatal accidents per year	1 if number of accidents is 0, -1 if it is >=1
Preventive measures	-0 if no, 1 if yes
Emergency protocols exist regarding accidents & injuries.	-0 if no, 1 if yes
Preventive measures and emergency protocols exist regarding pesticide & chemical exposure	-0 if no, 1 if yes
Appropriate protective gear is required in all applicable situations	-0 if no, 1 if yes
Number of full-time jobs	1 if >0, 0 else
Sector efforts in technology development (level of automation)	0 if no, 1 if yes
Relevance of the considered sector for the local economy	1 if taxes paid, 0 else
Number of consumer complaints to the company	1 if = 0 et -1 if >=1
Quality of information/signs on product health and safety	0 if not enough, 0,5 if enough, 1 if more than enough
Percentage of workforce hired locally	0 between 0 % and 20 %, 1 between 20 % and 40 %, 2 between 40 % and 60 %, 3 between 60 % and 80 %, 4 between 80 % and 100 %
Employees with higher education	0 between 0 % and 20 %, 1 between 20 % and 40 %, 2 between 40 % and 60 %, 3 between 60 % and 80 %, 4 between 80 % and 100 %
Employees with basic education	0 between 0 % and 20 %, 1 between 20 % and 40 %, 2 between 40 % and 60 %, 3 between 60 % and 80 %, 4 between 80 % and 100 %
Certifications	0 if none, 1 else.

Life Cycle Impact Assessment

Environmental impact calculations are made using ILCD 2011 and ReCiPe 2008 methods for eighteen chosen midpoint impact categories: Climate Change (IPCC GWP 100a), Human toxicity, cancer (UseTox), Human toxicity, non-cancer (UseTox), Photochemical Oxidant Formation, ReCiPMidH, Acidification, Eutrophication, terrestrial, FreshWater eutrophication, ReCiPMidH, Marine eutrophication, ReCiPMidH, Ecotoxicity (UseTox), Abiotic depletion (CML 2001), Resource depletion, Water, Ozone Layer Depletion, Ionizing radiation, human health, Particulate matter/respiratory inorganic, Ionizing radiation, ecosystems, Agricultural land occupation, Urban land occupation and Natural land transformation.

Economic midpoint category is unique and corresponds to life cycle cost for 1 functional unit.

Social midpoint categories corresponding to selected indicators (or impacts sub-categories) are taken from UNEP/SETAC (2009) guidelines for SLCA: Health and Safety at work, Technology development, Health & Safety of consumer, Local employment, Promoting social responsibility.

Results & discussion

Impacts of olive production are higher than virgin olive oil extraction in twenty-one out of the twenty-four midpoint categories. Only one environmental impact is mainly caused during extraction phase: agricultural ionizing radiation on human health, due to the French electricity production mix. The most impacting processes are fertilization and phytosanitary treatment (pest control and disease control). Pest control has the most important impact (97 %) for ecotoxicity due to the use of pesticides and particularly dimethoate. Harvest contributes to 41 % of total cost of olive production, even whether it does not contribute significantly to environmental categories. This is mainly due to the high workforce costs in France.

Social impacts are higher in two out five categories and equals in the three others categories. Furthermore, the deviation is less than 15 %. That means that social impacts are similar between the two main phases of the life cycle of olive oil production. Absolute social results are not interpretable here (figure 2 below).

From this case study, some limits appear. First, social impacts only concern gate-to-gate boundaries because the lack of data on the other phases of the life cycle. Then, the interpretation of social impacts must be clearly explained because the highest impact corresponds to the best social solution. A hotspots identification of social impacts do not appear relevant because, for it is not possible to express results per functional unit. Furthermore, for instance, the enterprise indicators such as number of employees can not be compared because the need of workforce is different from a company to another, depending on its size, its strategy, etc. Even if in theory, social LCA seems to be applicable, in practice, results are not enough precise and complete to be usable. This conclusion is in line with the recent review by Macombe et al. (2013).

Conclusion

A life cycle sustainability assessment of virgin olive oil production was carried out. It emerged that production of olives was the most impacting phase for the most environment, social and economic midpoint categories, in accordance to previous LCA studies on olive oil. The integration of social LCA with environmental LCA and LCC appears possible but difficult due to the singularity and the availability of social data. Main results were the difficult choice of social indicators and the lack of social data (problem of confidentiality and lack of more complete social database). The study also showed that it was easy to make a single inventory with economic and environmental data but not with social data.

Further investigation could also complete the integration in order to reduce the number of indicators. Indeed, as a tool for decision makers who are not able to deal with more than few indicators, a multicriteria analysis is needed. This study finally raised the major and emergent issue of the integration of social sciences and engineering.

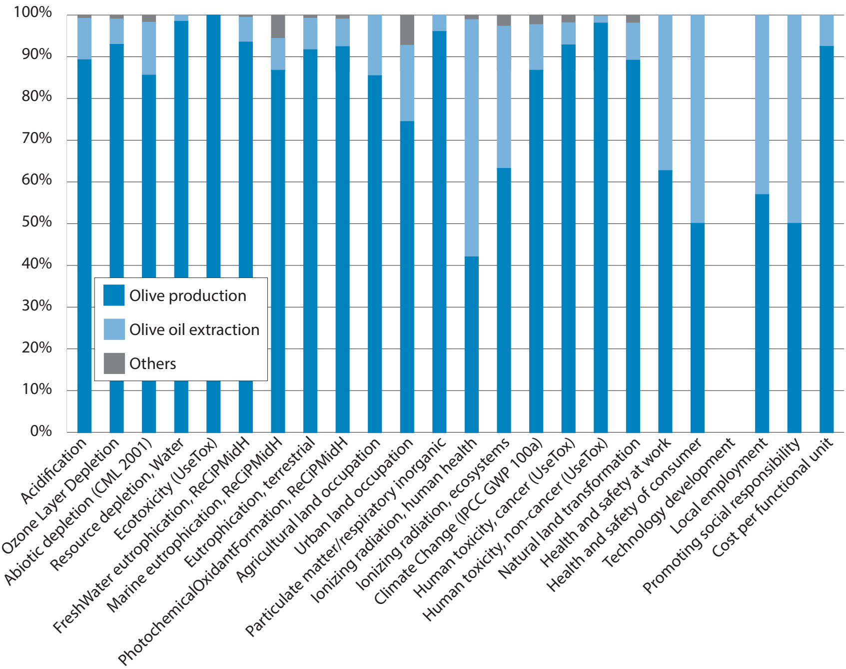

Figure 2: Comparison of impacts between olive production phase and virgin olive oil extraction

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