Towards a Sustainability Model for Olive Sector in Palestine

Conference Paper · October 2019

3 authors:


Ahmed Mohammed Abu Hanieh
Birzeit University


Mohammad Karaeen
Birzeit University


Afif Hasan
Birzeit University

Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 00 (2019) 000–000

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

17th Global Conference on Sustainable Manufacturing

Towards a Sustainability Model for Olive Sector in Palestine

Ahmed Abu Hanieh[a], Mohammad Karaeen[a], Afif Hasan[a]*

[a] *Birzeit University, Al Marj street 1, Birzeit, P.O.Box 14, Palestine*

Abstract

This paper aim is to present a sustainability model for the olive sector in Palestine. Based on a Life Cycle Analysis, the entire sector processes are accomplished in three main stages: cultivation, oil extraction, and oil treatment. The main inputs for these three stages are energy, water, labor, and machines with different percentages for each stage. The value creation index can be defined as the ratio between the revenues and the costs. Value creation index is calculated for each stage of the olive sector and the results showed that the total value creation for the sector is greater than two.

Peer review under the responsibility of the scientific committee of the Global Conference on Sustainable Manufacturing

Keywords: Olive tree; Olive oil; Sustainability; Oil industry; Value Creation; Cultivation; Extraction; Treatment.

1. Introduction

1.1. Olive sector and Palestinian economy

Olive tree is an ancient plant that was introduced to the Mediterranean basin about 6,000 years ago. Olive tree is one of the oldest known cultivated trees in the world and it reaches between 8-15 m height. The olive leaves are oblong silvery green, measuring 40–100 mm long and 10–30 mm wide. The trunk is typically gnarled and twisted. The fruit is a small 10–25 mm long, thinner-fleshed and smaller in wild plants than in orchard cultivars. Olive is harvested in the green to purple stage during autumn season [1], [2]. Olive groves cover 940 million m^2 of Palestinian land and contribute to the economy through linkages with the food industry and other industries such as traditional soap making and crafts. According to data published in 2011 [3], there are 8.9 million olive trees in Palestine. The olive subsector comprises 15 per cent of the total agricultural income, mitigating the impact of unemployment and poverty on the Palestinian society by providing 3 to 4 million seasonal work days per year and by supporting 100,000 Palestinian

* Corresponding author. Tel.: +970-2-298-2115; fax: +970-2-298-2984.
E-mail address: ahanieh@birzeit.edu

2351-9789 © 2019 The Authors, Published by Elsevier B.V.
Peer review under the responsibility of the scientific committee of the Global Conference on Sustainable Manufacturing

families.

Olive fruits and oil production are in decline as oil production dropped from an average of 23 million kg per year during the period 2000–2004 to 14 million kg per year during the period 2007–2010. As a result, 50% of domestic demand in 2009 was met by imported olive oil [4]. Palestine exports an average of 4 million kg of olive oil per year. With imports from the Palestinian market accounting for about two thirds of Israel's olive oil imports, the Israeli market remains the largest market for Palestinian olive oil. The Palestinian exports to the Israeli market show marked instability, owing to political conditions and recurring crises [5]. In 2009 and 2010, the Israeli market registered a significant decline in its imports of the Palestinian olive products, reaching 23,000 kg only in comparison to 890,000 kg in 2007 and 2008.

1.2 Literature review

Sustainability of any product or service would be based on balancing economic, environmental and social aspects. It should entail the life cycle of the olive supply chain. Improving the product sustainability can be achieved by maximizing the economic and social values while reducing the environmental impact and cost. Olive oil supply chain can be described as follows: planting and harvesting or cultivation, olive oil production, oil treatment and packaging, product transport - distribution, and consumption, in addition to the waste management. Reference [6] investigated LCA for olive production in Spain and found that optimizing fertilizers used in the olive oil production is a priority to optimizing olive growing. Using LCA with boundaries as "cradle to farm gate" for Southern Italy in [7] stressed the importance of innovation in planting and improving the olive sector and reducing its environmental impact.

According to [8], life cycle analysis of olive oil chain shows that the most eco-compatible production chain is the one that uses continuous two-phase transformation and employs the pomace treatment to produce fuel, while the least eco-compatible system is the system using three-phase continuous production, that composts of the pomace and spreads the oil mill waste water on the soil [9]. A comparison between organic and conventional farms in Italy is shown in [10]. This reference discusses the high impact of farming practices in both types. It indicates that in the organic production a huge amount of fuel is consumed due to the use of old machinery. LCA is also used by [11] to analyze the reduction of carbon emissions by using pomace as a source of heat. This study shows a significant greenhouse gas emission savings in the four studied combustion scenarios. The complete LCA of olive oil production is discussed in [12]. It presents all stages of olive oil production from cultivation to oil extraction and pomace treatment. Emissions and pollutants from oil production are discussed in [13], taking the case of Cyprus (Greece) to show the environmental effects of this process. This paper classifies fertilization and oil extraction as the first priority of the process affecting the environment followed by soil management and tree planting while the transportation is considered as the last priority for its low environmental impact.

The integrated environmental and economic assessment is also discussed in [14]. This study shows the complete process of olive oil production starting from planting and fertilizer production to oil production but not distribution and consumption. It shows that the mechanization of cultivation and harvesting processes reduced the costs significantly. Reference [15] compared conventional and organic olive planting systems using LCA assessment and life cycle costing with system boundary as (cradle-to-farm gate) and showed that conventional cultivation methods have more environmental impacts than the organic methods. References [12] and [13] discuss the overall process of olive oil production or cradle-to-grave LCA. Whereas [12] and [16] focus on the cultivation phase and environmental impact. Other references like [16] show the influence of irrigation on olive productivity. The references [8] and [17] show that using the conventional scenarios of cultivation and harvest have higher load and impact on environment than organic ones. Reference [18] used LCA qualified environmental effect of olive oil production in Greece, and pointed out that the cultivation stage and the oil production stage have the major effect on the environment during the supply chain. In order to develop strategies for improving the oil supply chain for Sicily province [8] used LCA approach to explore the processes of major potential environmental impact in the olive oil supply chain. Employing LCA, reference [19] investigated olive oil production in Jordan and found that soil management has the highest impact on the environment and concluded that low mechanization and waste management are the key to lowering the impact on the environment.

The olive oil extraction process is discussed in several references where [13] shows the influence of oil by-products treatment on the groundwater contamination. The oil extraction process using continuous two-phase transformation is shown in [14]. Using olive wastewater as a fertilizer and using pomace as a fuel or source of energy is discussed in

[8]. In reviewing agro-industrial waste, reference [20] concentrated on carried out research for extraction of various compounds of olive liquid and solid waste and its potential in other industries. Reference [21] employed fuzzy approach analysis for olive oil production optimization, and concluded that a “combination of the traditional cultivation system and innovative extraction system seems to be the optimal solution.”

2. Development of Sustainability Model

2.1 Olive supply chain

The olive supply chain life cycle in this model extends to the consumption stage, but it does not include the disposal stage. Fig. 1 shows the flow chart of the production chain process of olive oil and its applications. The process consists of three main stages; the first stage is the cultivation stage, represented by planting trees and harvesting olive fruits; the second stage is the oil extraction from the olive fruits and the third stage is the stage of treatment and packaging of olive oil. The model, expressed here, takes into account the running costs only without including the initial costs such as the initial price of machines, price of lands and the period necessary for the tree to start giving fruits. This assumption is based on the fact that the olive sector is an ancient and a long-standing sector in Palestine.

The main inputs for these three stages are: energy, water, labor and machines with different amounts and percentages. Transportation is required between these stages to transfer products from one stage to the next one. Transportation is also needed to transport fertilizers from animal farms (sheep, goat or cows) to the olive fields. Fertilizers’ influence is included in the transportation expenses because only organic fertilizers taken from manure of animals like sheep, goats and cows are applied to olive trees. The main output of the cultivation process is the olive fruit. Ten percent of the olive fruits are used as hand-made pickled olives in the Palestinian kitchen, whereas 90% are transported to the olive presses for oil extraction. The other output of the cultivation stage is olive wood. Part of this wood is used to produce wooden crafts and souvenirs, especially in Jerusalem and Bethlehem, while most of the wood is burned in fire stoves for heating and cooking. One kg of this wood costs around 0.2 US Dollars [4].

The oil extraction stage produces extracted olive oil, pomace and wastewater. The mill wastewater is usually sprayed over the dirt and non-asphalted roads especially near stone quarries and dusty roads, in order to prevent or reduce the amount of dust on these roads, hence replacing and saving clean water. The pomace is dried and used as a source of energy for heating and other process heat applications. The third output of this process is the extracted olive oil. Forty percent of this untreated (extracted) oil is filled in 16-liter vessels and is used directly for household consumption and cooking as olive oil is a core ingredient in the Palestinian kitchen. It is also used in making soap and many pharmaceutical industries, while the rest 60% is transported for further treatment and packaging [4]. The third stage is the treatment and packaging stage. In this stage the extracted oil is treated further by filtering and reducing its acidity. The resulting extra virgin olive oil is filled in proper bottles for commercial use and exportation.

2.2 Sustainability model and value creation

The life cycle of olive can be modelled for sustainability using triangular modelling technique. The triangular model shows the inputs and outputs of each process and their economic, environmental and social impacts. Each side of the triangle is represented by the factors that affect each of the three sustainability parameters (environment, economy and society). When the arrow crossing the side points outwards this means a positive contribution to the parameter and when it points towards the centre of the triangle this means a negative contribution. This leads to the fact that the triangular model gives a compromise between the outputs (revenues) and inputs (costs) which give an indication of sustainability. The value creation of these systems can be estimated as the ratio between the outputs (revenues) and the inputs (costs). The Value Creation Index (VCI) can be calculated by equation 1 [22]:

$$Value\ Creation\ Index = \frac{Summation\ of\ values\ of\ outputs}{Total\ value\ of\ all\ inputs} \tag{1}$$

The Value Creation Index represents the benefit factor of the sector or the process where having a VCI more than one means that the process or sector is effective economically, environmentally and socially and since it includes such costs and revenues it will also imply increasing benefits. Reference [23] defined the value creation as the clear, simple statement of the benefits, both tangible and intangible, that the company will provide.

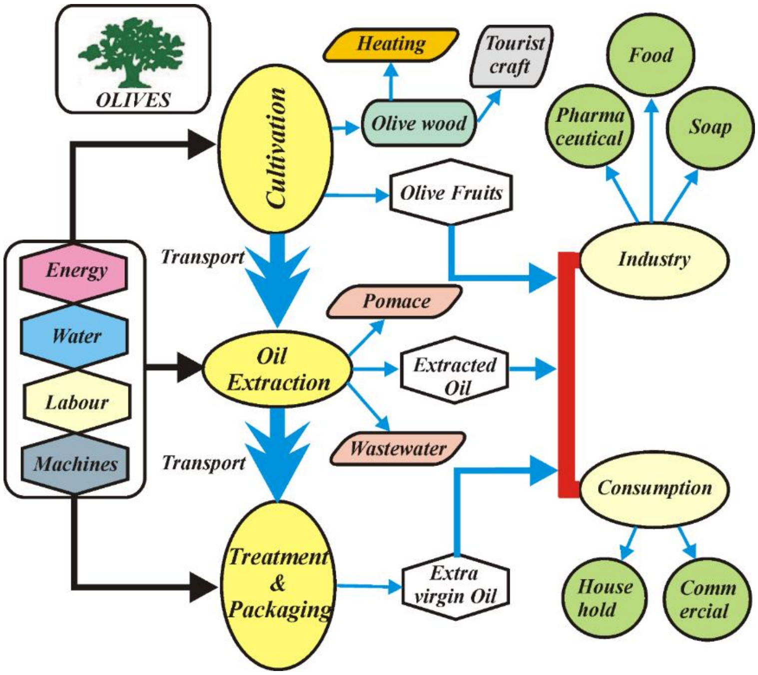

Fig. 1: Flow chart for the life cycle of olives

Table 1: Parameters of the olive sector sustainability model in Palestine (All values are in US Dollar per kilogram olive oil)

Stage	Inputs (Costs)	Outputs (Revenues)	Notes
Cultivation	Energy: 0 Water: 0.143 Labor: 2.385 Machines: 0.122	Olive fruits: 5.6 Olive wood: 0.5	Each kg of olive oil needs 4 kg of olive fruits
Oil Extraction	Olive fruits: 5.6 Energy: 0.0162 Water: 0.0162 Labor: 0.0325 Machines: 0.06	Extracted oil : 6.5 Pomace : 0.0185 Wastewater : -0.06	The wastewater is negative because it has negative effect on the outputs.
Treatment and packaging	Extracted oil: 6.5 Energy: 0.114 Water: 0 Labor: 0.342 Machines: 0.342	Extra virgin olive oil: 7.7	Extra virgin oil is the final output ready for commercial use.

Transport cost is calculated as 0.1 USD per kg olive oil; this transport cost includes the transportation of olive fruit, olive oil and natural fertilizers.

It is necessary to have an idea about the different parameters of the olive sector in Palestine to be able to build triangular models and calculate the value creation for each stage of the sector. These parameters are listed in Table 1, showing the value of each parameter divided into inputs and outputs for each stage. These values are extracted from the official report of the Palestinian Ministry of Agriculture [4]. All parameters are calculated in US Dollar per kilogram olive oil. There is no fertilizers effect on environment here because olive sector in Palestine uses only organic fertilizers, taken from animal farms and there is no record of using chemical fertilizers in this sector.

Fig. 2 depicts the Triangular model for the cultivation (planting and harvest) stage; it shows that this process has a positive contribution to the society through labour and to economy through olive fruits and olive wood value, while it has a negative influence on the environment because it consumes energy and water. Machines have a positive economic and social contribution but they have a negative impact on the environment due to their air pollution. All calculations of the value creation are based on the unit function of one kilogram of olive oil. The value creation index for the cultivation stage is calculated using equations 2 through 4 and values of parameters summarized in Table 1.

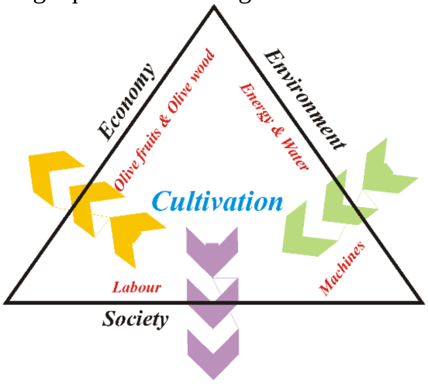

Fig. 2: Triangular model for cultivation process

In order to calculate the value creation of the cultivation stage, it is necessary to include the costs and revenues of this stage as shown in the equations 2, 3 and 4:

$$Cost_{cult} = E_{cult} + W_{cult} + L_{cult} + M_{cult} \quad (2)$$

$$Revenue_{cult} = Wood + Olive\ fruit \quad (3)$$

$$VCI_{cult} = \frac{Revenue_{cult}}{Cost_{cult}} \quad (4)$$

Where, E_{cult} = Energy needed for cultivation per kg olive oil, W_{cults} = Water needed for cultivation per kg olive oil, L_{cult} = Labour needed for cultivation per kg olive oil, M_{cult} = Machine operation needed for cultivation per kg olive oil, $Cost_{cult}$ = Costs of cultivation process per kg olive oil, $Revenue_{cult}$ = Revenues of cultivation process per kg olive oil, VCI_{cult} = Value Creation Index for cultivation process. Depending on data taken from Table 3, VCI for this stage is calculated to be 2.3 which implies a 2.3 multiplication effect of this stage. The cultivation process is done by human labor, where labor costs here reach 90% of the cultivation costs. Using machinery in cultivation processes could improve the value of this stage. Fig. 3 depicts the Triangular model for the oil extraction stage showing that this process has a positive contribution to the society by providing food and paid-work opportunities. Similarly has positive value creation to the economy through production of oil and pomace. However this stage has a negative impact on the environment because it consumes energy, water and machines and produces wastewater with polluting potential if discharged to the environment without treatment.

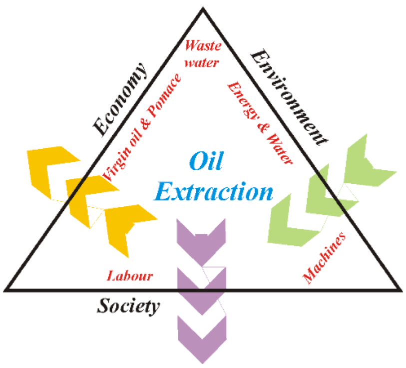

Fig. 3: Triangular model for oil extraction process

The (VCI) for oil extraction stage is calculated using equations 5 through 7, taking all inputs and outputs shown in Fig. 3 and explained below.

$$Cost_{ext} = E_{ext} + W_{ext} + L_{ext} + M_{ext} + Olive\ fruit \quad (5)$$

$$Revenue_{ext} = Extracted\ oil + Pomace + Wastewater \quad (6)$$

$$VCI_{ext} = \frac{Revenue_{ext}}{Cost_{ext}} \quad (7)$$

Where, E_{ext} = Energy needed for oil extraction per kg olive oil, W_{ext} = Water needed for oil extraction per kg olive oil, L_{ext} = Labor needed for oil extraction per kg olive oil, M_{ext} = Machine operation needed for oil extraction per kg olive oil, $Cost_{ext}$ = Costs of oil extraction process per kg olive oil, $Revenue_{ext}$ = Revenues of oil extraction process per kg olive oil, VCI_{ext} = Value Creation Index for oil extraction process, The pomace produced by the extraction process is sold at a price of 0.02 US Dollars per kg. The cost of getting rid of the olive wastewater is considered as a negative value in the calculations. VCI for the oil extraction stage amounts to 1.13 and this implies a slight benefit of this stage due to the negative and environmental cost of the waste streams during the stage.

Fig. 4 represents the Triangular model for the oil treatment and packaging stage; it shows that this process has a positive contribution to the society and economy, while it has a negative influence on the environment because it consumes energy, water and machines, and discharges the waste streams into the environment.

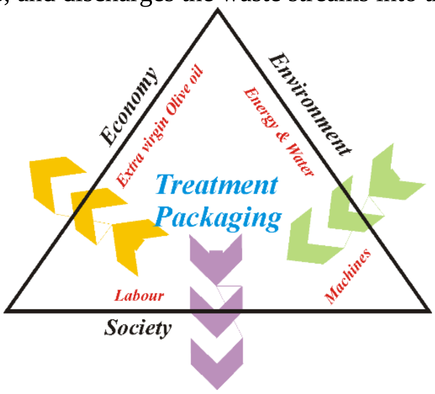

Fig. 4: Triangular model for treatment and packaging process

The (VCI) for treatment and packaging stage is calculated using equations 8 through 10 and all inputs and outputs shown in Fig. 4 and explained below with their values, given in Table 3,

$$Cost_{treat} = E_{treat} + W_{treat} + L_{treat} + M_{treat} + Extracted\ oil \quad (8)$$

$$Revenue_{treat} = Extra\ virgin\ Olive\ oil \quad (9)$$

$$VCI_{treat} = \frac{Revenue_{treat}}{Cost_{treat}} \quad (10)$$

Where, E_{treat} = Energy needed for oil treatment and packaging per kg olive oil, W_{treat} = Water needed for oil treatment and packaging per kg olive oil, L_{treat} = Labor needed for oil treatment and packaging per kg olive oil M_{treat} = Machine operation needed for oil treatment and packaging per kg olive oil, $Cost_{treat}$ = Costs of oil treatment and packaging process per kg olive oil, $Revenue_{treat}$ = Revenues of oil treatment and packaging process per kg olive oil, VCI_{treat} = Value Creation Index for oil treatment and packaging process, The VCI for the treatment stage amounts to be 1.05, indicating little benefit in this stage., The overall value creation index ($VCI_{overall}$) of the whole process can be estimated by calculating the ratio between the total outputs ($Revenue_{total}$) and the total inputs ($Cost_{total}$) as shown in equations 11 through 13:

$$Cost_{total} = Cost_{cult} + Cost_{ext} + Cost_{treat} + Transport - Olive\ fruit - Extracted\ oil \quad (11)$$

$$Revenue_{total} = 0.1 \times Olive\ fruit + 0.9 \times (0.4 \times Extracted\ oil + 0.6 \times Extra\ virgin\ Olive\ oil) + Wood + Pomace + Wastewater \quad (12)$$

$$VCI_{overall} = \frac{Revenue_{total}}{Cost_{total}} \quad (13)$$

Note that the transportation cost (*Transport*) is added to the total cost, it is worth mentioning that this transportation costs about 0.1 US Dollar per kg olive oil. This transport parameter involves the transportation of olive fruits from olive fields to olive presses, transport of extracted olive oil to commercial points or treatment factories and transportation of natural fertilizers from animal farms to olive fields. The olive fruit and extracted oil are subtracted from the costs. Olive fruits are output of the cultivation stage and also input for the extraction stage. Similarly, extracted oil is an output of the extraction stage and also an input for the treatment stage. They were calculated in the costs of intermediate stages of cultivation and extraction. In the Revenues, the olive fruit is multiplied by 0.1 because only 10% of the olive fruits are pickled to be used in household food while 90% is transformed into olive oil. 40% of the extracted olive oil is used directly without treatment and 60% of this oil is transported to be treated and packaged for commercial and industrial use as an extra virgin olive oil. The total costs were calculated to be equal to 3.67 US Dollars per kg olive oil while the overall revenues equal to 7.52 US Dollars per kg olive oil. This leads to an overall value creation index for the olive process equals to 2.05. Table 2 shows the detailed quantitative presentation of the costs, revenues and VCIs for each stage of the olive sector. It can be easily seen that the VCI for the cultivation process is the highest followed by the extraction stage while the VCI for the treatment process is the least of all. This means that the multiplication benefit is highly influenced by the cultivation stage.

Table 2: Detailed VCI calculation results for the three stages of olive oil sector

Stage	Costs	Revenues	VCI
Cultivation	2.65	6.10	2.31
Extraction	5.72	6.46	1.12
Treatment	7.29	7.70	1.05
Overall	3.67	7.51	2.05

Note in Table 2 that the columns of costs and revenues for the three stages cannot be summed to get the overall costs and revenues because some values are repeated in the calculation of each stage. For example olive fruits are included in the cultivation process as a revenue while the same value is included in the extraction as a cost. Another example is the extracted olive oil which is taken as a revenue in the extraction stage and as a cost in the treatment stage.

Conclusions

The foregoing sustainability study of the olive sector in Palestine has a high importance for the Palestinian economy. The designed model for olive sector divides the overall process into three stages; cultivation, oil extraction and oil treatment. The three stages have positive contribution to the society and economy while having negative impact on the environment. The main inputs of the three stages are the energy, water, labor and machines, but they have different values and percentages according to each stage.

The calculation of the value creation index for each stage shows that all stages are feasible, leading to the feasibility of the whole process. This value creation index calculation for the sector is considered the main contribution of the paper. The study of VCI sensitivity related to the different activities is a unique and new study and it can be used as a basis for future modification of the olive oil income.

One of the main drawbacks in the current situation is that the cost of labor in the process is extremely high; thus replacing this labor work by automated machinery especially in harvest process can reduce the costs and improve the value creation significantly. Although this replacement of human workers with machines can be seen to have a negative social impact but on the other hand it can be a motivation for these workers to turn from unskilled workers to skilled ones by training them on using these machines and encouraging them to plant wider areas which increases the size of the sector that will need more labor and more machines. This expectation about man-machine relationship is based on the fact that the modern industrial automation didn't influence the labor employment in industry, on the contrary, it turned workers to skilled ones. The study is considered the first step of a long research that in the future will take into account the applications of olive oil and olive fruits for industrial and commercial purposes, such as food, soap and pharmaceutical industries. On the other hand, LCA was not discussed here in details because it requires a complete similar effort, this also will be tackled in future research work.

References

[1] Rugini, E., Baldoni, L., Muleo, R. and Sebastiani, L., The Olive Tree Genome. Springer. (2016) p. 14.
[2] Kiritsakis, A. and Shahidi, F., Olives and Olive Oil as Functional Foods: Bioactivity, Chemistry and Processing. John Wiley & Sons. (2017) p. 129.
[3] Palestinian Central Bureau of Statistics, National Strategy of Olive Sector in Palestine, Palestine (2014)
[4] Ministry of Agriculture, 2014. National Strategy of Olive Sector in Palestine (2014 - 2019), report, Palestine
[5] Abu Hanieh, A. AbdElall, S. and Hasan, A., Sustainable Development of Stone and Marble Sector in Palestine, Journal of Cleaner Production, Elsevier; 84: (2014)581–588.
[6] Romero-Gámez, M., Castro-Rodríguez, J. and Suárez-Rey, E., Optimization of olive growing practices in Spain from a life cycle assessment perspective. Journal of Cleaner Production Volume 149, (April 2017) pp 25-37.
[7] De Luca, A., Falcone, G., Stillitano, T., Iofrida, N. Strano, A. and Gulisano, G., Evaluation of sustainable innovations in olive growing systems: A Life Cycle Sustainability Assessment case study in southern Italy. Journal of Cleaner Production Volume 171, (January 2018) pp 1187-1202.
[8] Salomone, R., and Ioppolo, G., Environmental impacts of olive oil production: A life cycle assessment case study in the province of Messina. Journal of Cleaner Production, volume 28, (2012) pp 88–100.
[9] Cerutti, A., Editor, Life Cycle Assessment in the Agri-food Sector. 59 Springer (2015).
[10] Neri, E., Rossetti, F., Rugani, B., Niccolucci, V., Pulselli, F. M., Bastianoni, S. and Marchettini, N., Life Cycle Assessment and energy application to the comparison between organic and conventional productions. Paper presented at the 8th International Conference on LCA in the Agri-Food Sector, Saint- Malo, France (October 2012).
[11] El Hanandeh, A., Carbon abatement via treating the solid waste from the Australian olive industry in mobile pyrolysis units: LCA with uncertainty analysis. Waste Management and Research, volume 31, (2013) pp 341–352.
[12] Salomone, R., Applicazione della metodologia Life Cycle Assessment alla produzione di olio di oliva: alcuni risultati preliminari. Paper presented at the Euroconference on University and Enterprise, Rome (September 2002).
[13] Avraamides, M., & Fatta, D., Resource consumption and emissions from olive oil production: a life cycle inventory case study in Cyprus. Journal of Cleaner Production, volume 16, (2008) pp 809–821.
[14] De Gennaro, B., Notarnicola, B., Roselli, L. and Tassielli, G., Innovative olive-growing models: an environmental and economic assessment, Journal of Cleaner Production, volume 28, (June 2012) pp 70-80.
[15] Mohamad, R., Verrastro, V. and Cardone, G., Bteicha, M., Favia, M., Morettic, M. and Romac, R., Optimization of organic and conventional olive agricultural practices from a Life Cycle Assessment and Life Cycle Costing perspectives. Journal of Cleaner Production. Volume 70, (May 2014) pp 78-89.
[16] Notarnicola, B., Salomone, R., Petti, L., Renzulli, P. and Roma, R., Conference on Life Cycle Assessment in the Agri-Food Sector, Bari (September 2000).
[17] Salomone, R., Cappelletti, G. M., Ioppolo, G., Mistretta, M., Nicoletti, G., Notarnicola, B., Olivieri, G., Pattara, C., Russo, C., and Scimia, E., Italian experiences in life cycle assessment of olive oil: a survey and critical review. Paper presented at the VII International Conference on Life Cycle Assessment in the Agri-Food Sector, Bari (September 2010).
[18] Tsarouhasa, P., Achillas, Ch., Aidonisa, D., Folinasa, D. and Maslisc, V., Life Cycle Assessment of olive oil production in Greece. Journal of Cleaner Production. Volume 93, (April 2015) pp 75-83
[19] El Hanandeh, A. and Gharaibeh, M., Environmental efficiency of olive oil production by small and micro-scale farmers in northern Jordan: Life cycle assessment. Agricultural Systems Volume 148, (October 2016) pp 169-177.
[20] Mirabella, N., Castellani,V. and Salam S., Current options for the valorization of food manufacturing waste: a review. Journal of Cleaner Production, volume 65 (November 2013).
[21] Cappellettia, G., Giuseppe, L., Nicolettia, M. and Russoa, C., Innovations in the olive oil sector: A fuzzy multicriteria approach. Journal of Cleaner Production Volume 159, (August 2017.) pp 95-105.
[22] Abdelall, S. Enabling sustainable value creation by engineering capacity building, in Institute Werkzeugmaschinen und Fabrikbetrieb, Ph.D thesis, Technische Universität Berlin: Berlin (2014).
[23] Lanning, M., Delivering Profitable Value, Basic Books. ISBN 0-7382-0162-6 (1998).