LIFE04 ENV/GR/110

LIFE PROJECT NAME

Life Cycle Assessment (LCA) as a Decision Support Tool (DCT) for the ecoproduction of olive oil

Data Project	
Project location	Greece, Spain, Cyprus
Project start date:	01/11/2004
Project end date:	31/10/2006
Total Project duration (in months)	24 months
Total budget	€ 839.575
EC contribution:	€ 419.787
(%) of total costs	50
(%) of elibible costs	50
Data Beneficiary	
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The LIFE project entitled “Life Cycle Assessment (LCA) as a Decision Support Tool (DCT) for the ecoproduction of olive oil - ECOIL” started on 01/11/2004 and ended on 31/10/2006 (duration: 24 months). The beneficiary of the project was the Technical University of Crete – Greece, while the University of Cyprus, the LEIA Foundation of Spain and the Agricultural Cooperative of Polemarchi of Crete – Greece were the partners of the project. The ECOIL project focused on the development of a life cycle assessment during the production of olive oil in three different regions in three Mediterranean countries (Greece, Spain and Cyprus). It was completed successfully and its outcome is in fully accordance to all the individual and overall objectives - targets set.

1. Overall objective of the project

The overall objective of the project was to design and implement a Life Cycle Inventory (LCI) and a Life Cycle Assessment (LCA) during the full cycle of olive oil (OO) production in three different Mediterranean countries, Greece (Voukolies region – Crete), Cyprus (Lytrhodontas region - Nicosia) and Spain (Navarra region - Aragon). By implementing the LCI and LCA in the above regions certain information/coefficients, characteristic to each situation (e.g. olive trees cultivation practices, OO production process, OO mills waste management systems) were provided and the effects to the environment and public health were determined. The results allowed comparisons and identification of those stages of the OO production cycle that can be optimised/redesigned. In addition, the novel LCA system could be used as an integrated decision support tool for all actors involved in the production of OO in order to apply practices of high efficiency, effectiveness and environmental – ecological performance (ecoproduction).

2. Technical activities for the implementation of the project

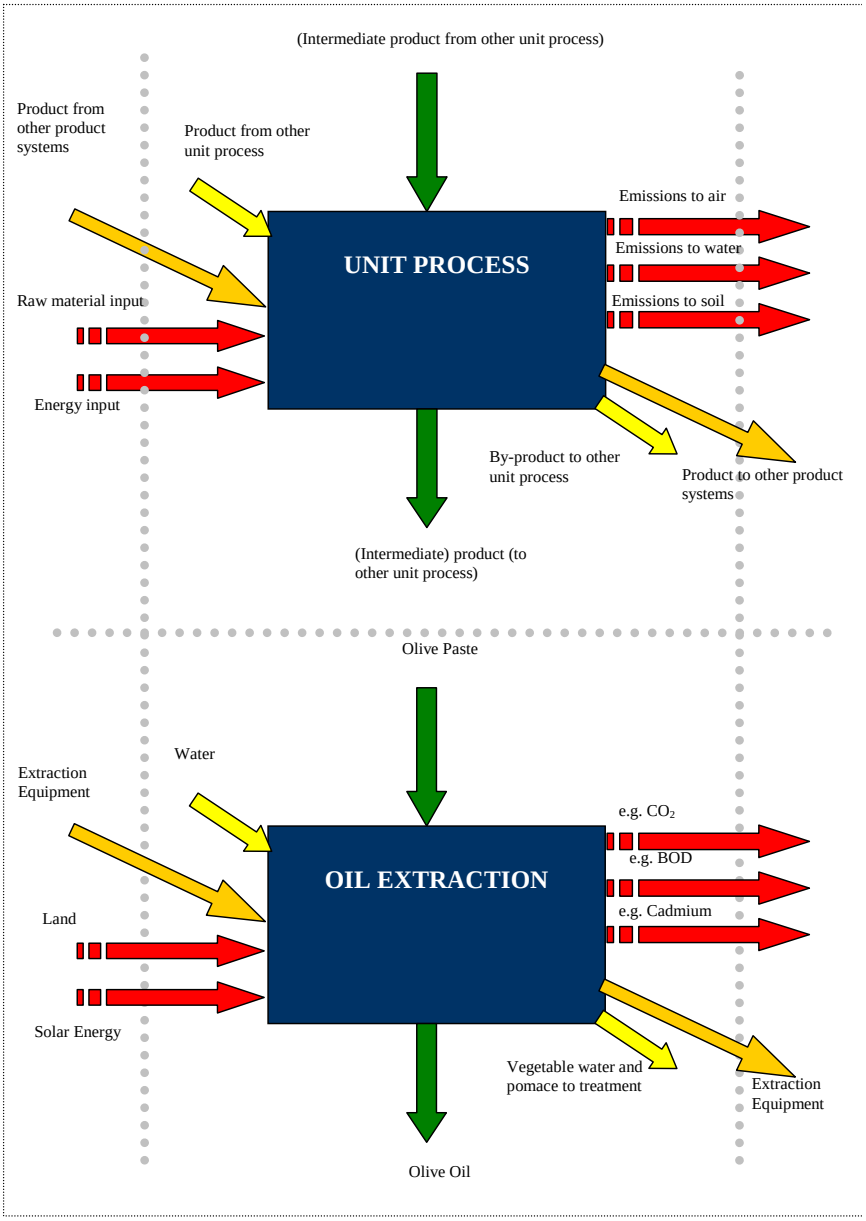
The project was implemented through the development of four technical tasks plus one Task for dissemination/training activities and one Task for its management. The activities of the project have been carried out according to those foreseen in the proposal and all the targets were achieved in quantitative and qualitative terms.

2.1. Task 1: Recording and assessment of existing situation (1.11.2004 – 28.2.2005)

- All the existing Greek, Spanish, Cypriot, European Union and international legislative framework and standards related to the implementation of LCA in production processes, eco-efficient agricultural practices, operation of industries in an environmental friendly way and environmental management systems (ISO, EMAS) were recorded and assessed.
- The current situation concerning the olive oil production cycle in the three areas under examination (Greece, Spain and Cyprus) was described and recorded in detail. In particular, information about the following were collected, examined and assessed: olive tree varieties, olive oil cultivation practices (irrigation demands, applications of pesticides and herbicides, type of pesticides and herbicides), quantities of olive oil produced, olive milling processes for the production of oil (three or two phase olive mill systems) and olive mill waste management practices.
- A significant number of cases concerning the development and application of successful systems and methods related to eco-efficient practices and LCA studies were recorded, examined, analysed and assessed. These success stories refer to several production processes at national, European and international level, in order to obtain a complete and representative picture on the subject of the project.

2.2. Task 2: Development of the LCA methodology (1.12.2004 – 31.7.2005)

The life cycle assessment principles and guidelines (LCA system) were described and analysed, in detail (requirements, assumptions, restrictions, conditions of application, inputs, outputs, etc.). Also, the exact material flows were determined. In addition, the measurement units for the aforementioned coefficients were set and justified. Moreover, the exact boundaries of the LCA system, which is one of the cores of the LCA methodology, were defined. The appropriate framework of the LCA tool was developed. This tool performs the necessary calculations to extract site specific coefficients and also includes all primary coefficients that will be the basis for further calculations. Moreover, the plan for the collection of the necessary data from the three areas under study was set.



Flow Data Required

2.3. Task 3: Implementation of the LCI in the areas under examination (1.8.2005 – 30.6.2006)

The overall target of Task 3 was the implementation of the LCI, based on the methodology and software developed during task 2:

- In the Municipality Department of Polemarchi and in general in the Municipality of Voukolies in Crete Island. Practices followed in Voukolies region are practices found in the majority of Cretan and Greek regions areas where olive oil production is as a vital economic activity.
- in the area of Lythrodontas in the District of Nicosia in Cyprus. One of Cyprus' main agricultural products is olive oil and the district of Nicosia is the area with the largest number of trees
- in the Navarra region in Aragon in Spain. Spain is the biggest olive oil producing country worldwide

Pruning by petrol ran chainsaw

Pesticide application

The implementation of the methodology in each region produced certain site-specific LCI coefficients via the software tool developed under task 2 and based on site-specific conditions. For each unit process, within the system boundary defined, quantified data on inputs and outputs were collected. Inputs are material or energy that enters a unit process, whereas outputs are material or energy that leaves a unit process. The main results that were obtained through the implementation of the LCI in the three areas under study are presented below, synoptically.

	Stage / Parameter	Crude Oil			fresh water			fossil CO2 to air			NOx to air		
	Country	Greece	Cyprus	Spain	Greece	Cyprus	Spain	Greece	Cyprus	Spain	Greece	Cyprus	Spain
Agricultural Stage	Olive tree Planting												
	Irrigation	12,10%	11,30%		94,20%	46,20%	100,00%	4,38%	15,80%			35,70%	
	Soil Management		15,10%						20,60%	6,92%		31,40%	10,53%
	applied fertilisers	35,90%	32,30%	38,38%	5,32%	25,80%		27,30%	26,70%	50,83%	30,70%	16,60%	36,60%
	applied pesticides	4,02%	18,50%	7,65%		26,60%			7,20%	8,86%	3,68%	2,70%	12,10%
	applied herbicides			10,02%									
	pruning	15,20%	10,00%					56,70%	23.3%		55,90%	11,50%	12,73%
	Olive Collection	7,28%		4,07%						2,86%	3,03%	0,90%	2,73%
Processing	olive tranportation	5,61%		18,10%				1,95%		12,53%	3,03%		12,40%
	olive oil extraction	14,90%	12,00%	18,49%	0,02%	1,40%		5,38%	5,90%	14,94%		0,90%	12,40%
Total	Agricultural	79,50%	87,60%	60,12%	99,70%	98,60%	100,00%	92,70%	93,90%	69,47%	95,60%	99,10%	74,69%
	Processing	20,50%	12,40%	36,59%	0,03%	1,40%	0,00%	7,33%	6,10%	27,47%	4,37%	0,90%	24,80%
	Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

	Stage / Parameter	SO2 to air			COD to water			BOD to water		
	Country	Greece	Cyprus	Spain	Greece	Cyprus	Spain	Greece	Cyprus	Spain
Agricultural Stage	Olive tree Planting									
	Irrigation	8,57%	4,30%		1,19%			3,99%		
	Soil Management		2,90%				10,19%			10,38%
	applied fertilisers	57,10%	61,70%	58,03%	5,86%	13,50%	40,75%	12,00%	23,50%	40,77%
	applied pesticides		9,60%	22,90%		7,60%	9,53%		13,20%	8,70%
	applied Herbicides									
	pruning	21,50%	9,60%	3,84%						
	Olive Collection	10,50%					4,10%			4,15%
Processing	olive tranportation			3,45%	0,87%		18,49%	1,82%		18,75%
	olive oil extraction		11,30%	7,10%	90,60%	78,90%	13,96%	80,60%	63,10%	13,94%
Total	Agricultural	88,80%	88,30%	84,77%	85,08%	21,10%	64,57%	17,50%	36,90%	64,00%
	Processing	11,20%	11,70%	10,55%	9,17%	78,90%	32,45%	82,50%	63,10%	32,69%
	Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

	Stage / Parameter	Lead to soil			Zinc to Soil		
	Country	Greece	Cyprus	Spain	Greece	Cyprus	Spain
Agricultural Stage	Olive tree Planting						
	Irrigation						
	Soil Management		0,70%			19,40%	
	applied fertilisers	0,08%		38,07%	0,85%	1,10%	39,80%
	applied pesticides	0,10%		4,42%	4,32%	2,20%	1,13%
	applied Herbicites				0,56%		
	prunning		45,20%	1,00%		47,80%	1,04%
	Olive Collection						
Processing	olive tranportation	0,06%			0,65%		
	olive oil extraction	99,80%	53,80%	56,10%	93,60%	29,10%	57,65%
Total	Agricultural	0,19%	46,20%	43,49%	5,73%	70,80%	41,97%
	Processing	99,80%	53,80%	56,10%	94,30%	29,20%	57,65%
	Total	100%	100%	100%	100%	100%	100%

2.4. Task 4: Evaluation of results, impact assessment and systems optimisation (1.12.2005 – 31.10.2006)

The environmental impacts of the LCI results that were obtained through Task 3 were assessed. An impact index was assigned to each pollutant so that an overall hazard index for each case study will be calculated. Direct comparisons were made both horizontally (overall hazard potential of each case study) as well as vertically (among similar pollutants for all case studies) and the weak points in regard to the environmental burden for each case study were identified. Synoptically:

Greece

- The agricultural stage of olive oil production is the stage which pollutes more and has more effect in most impact categories.
- In the agricultural stage, the main environmental impacts are related with the burning of the pruning waste, the use of fertilisers and pesticides.
- The most important impacts of the agricultural stage are the emissions of carcinogens to the atmosphere resulting to human toxicity, photochemical oxidation, as well as eutrophication.
- In the olive oil processing stage, the impacts are related with the disposal of liquid waste.
- The environmental impacts of the disposal of liquid waste are toxicity in all level (fresh water, marine, terrestrial and human), as well as eutrophication.
- As it was shown from the LCIA with both methods, in order to optimize the production of olive oil and minimizing the environmental impacts measures should be taken so as to: i. reduce the use of fertilisers, ii. reduce the use of pesticides, iii. find alternative method to deal with pruning waste iv. apply appropriate treatment to liquid waste so as to protect the natural environment from the adverse effects of its disposal

Cyprus

The agricultural stage of the production system is more significant in regards to raw material consumption and air pollution, when compared to the processing stage. However, the processing stage is of primary importance when it comes to toxicity effects, mainly due to the particular management practice of liquid wastes from olive mills (disposal to evaporation ponds).

Based on the results of the study, individual processes of the overall system were classified in priority categories according to the effect a potential optimisation could have in the environmental improvement of the olive oil production system:

- Tree planting, olive collection and transportation of olives to the processing unit do not raise any concern as their contribution to all environmental impacts and damage categories was extremely low. Thus, their optimisation is not considered an effective way of optimising the system.
- Irrigation, apart from the fact that, itself is a major consumer of fresh water in the system, most of environmental impacts arise as a result of the emissions from mechanical extraction of water from wells. Similarly, soil management consumes fossil fuels and causes heavy emissions of pollutants during tractor operation, causing moderate resource depletion and global warming impact problems, respectively.
- The use of fertilisers and pesticides, the particular residue management and the liquid waste management techniques are the major contributors to most of the environmental impacts and damage categories considered. Preventive management measures should therefore focus on these processes since their optimisation could potentially prove particularly effective in the environmental optimisation of the overall system of olive oil production.

Spain

- The agricultural phase is the main pollutant stage when producing olive oil
- In the agricultural phase, main environmental impacts come from production and transportation of agricultural inputs: fertilizers, pesticides (mainly copper oxychloride) and herbicides. On field application has a smaller environmental impact when using LCA:
- In the industrial phase, pomace processing (transport) has a high environmental impact. It must be taken into account an environmental allocation of 7% when interpreting results.
- In the overall life cycle, it has been shown that environmental impact comes from “occult” or non-visible processes that cannot be uncover without using Life Cycle

Assessment.

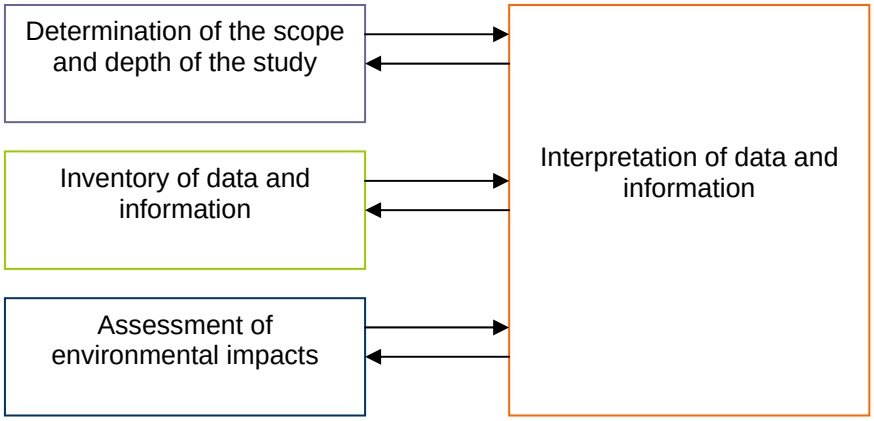
According to the results that were obtained through the assessment of the LCI results, guidelines for the improvement of the entire O.O production cycle in order to achieve the eco-production of O.O, were developed. The guidelines for the olive cultivation stage refer to:

- Selection of the plantation site
- Planting setout
- Preparing the site for plantation
- Planting of new trees
- Pruning (regulated pruning, pruning for fruiting, renovating Pruning)
- Irrigation
- Fertilization:
    - Types of nitrogen fertilizers and nitrogen application
    - Types of potassium fertilizers and Potassium application
    - Boron fertilizers and application
- Deficiencies of nutrient elements: Boron deficiency Potassium deficiency, Calcium and Magnesium deficiencies
- Organic fertilizers application
- Weed control – soil management – herbicides application:
    - Types of herbicides
    - Herbicides application
    - Weed control in new orchards
    - Weed control in established orchards
- Types of Pesticides and pesticides application (according to the insects of olive trees)
- Biodiversity and landscape conservation
- Fruit harvesting

The guidelines for the olive oil production stage refer to:

- Optimum consumption of water during olive oil production
- Optimum consumption of energy during olive oil production
- Water saving during oil refining stages:
- Odour emissions
- Wastewater management
- Solid waste management at olive oil production and oil refining stages
- General guidelines of good practice

Additionally, policy recommendations (short, medium and long term proposals, other policy initiatives) concerning the olive farming stage were developed as well as policy recommendations related to the olive oil production stage (use of clean technologies, modifications of production stages, adaptation of the principles of the integrated product policy, application of market – based instruments, potential funding opportunities etc.).
Finally, a framework of specifications for the implementation of the LCA methodology and software were prepared, a tool that is very useful for the adaptation of the know-how of the ECOIL project in other applications (assessment of the environmental performance of various processes and not only olive oil production).



These specifications comprise the experiences and know-how gained during the implementation of the LCA for the production of olive oil in Greece, Spain and Cyprus and describe in detail the stages of the methodology that must be followed. These stages are:

- Definition of the goal and scope
- Definition of the baseline unit
- Determination of the system boundaries
- Determination of the system processes
- Determination of the assumptions and limitations of the system
- Model preparation
- Development of LCI
- Insertion of data into the LCA software
- Life Cycle Impact Assessment
- Interpretation phase
- Type and format of the reports

3. Environmental benefits

The completeness of the project resulted in significant long-term environmental benefits. More specifically, the recommendations that were developed, based on the results that were obtained by the application of the LCA methodology, include the introducing of sustainable technologies in the sector of the O.O. production, such as: use of clean technologies and best available techniques in the production process, promotion of eco-production and eco-cultivation practices, adaptation of the principles of the integrated product policy, etc. This can be achieved by applying modifications in the individual production stages or/and by redesigning the entire cycle of O.O. production e.g. the switch to the use of non-chemical (biological) means during olive tree cultivations, fact that will assure the production of product of a high quality, since the quality of the product depends strongly on the quality of the raw material (olive crops), the minimization of energy requirements, the effective management of the waste/wastewater generated (appropriate treatment of wastewater, utilization of the organic solid waste for the production of compost that could be used for agricultural purposes etc.) and the switch to the application of two-phase centrifugal olive mills instead of the three-phase centrifugal mills (the two-phase olive mills have eliminated liquid wastes and water consumption while the three-phase olive mills produce both a solid and a liquid waste).

Furthermore, the outcome of the project focuses on the environmental problems that are observed in the sector of O.O. production and it suggests practical solutions to cope with them. These solutions could lead to reduction in the quantity of waste that is generated in the mills (resulting to lower cost for its management), energy savings, reduction in the operational and maintenance costs, etc. Additionally, the project provides solutions to the problems that are observed in the olive tree farming (resulting to control of the use of agro-chemicals, protection of the biodiversity, control of the use of water for irrigation purposes,

increase of the productivity etc.). Also, the project may have a spin-off effect in other industrial sectors, since the same approach could be implemented to a variety of other production processes such as fruit and vegetables canning, juice production, seed oil production, corn oil production, dairy industries, etc.

4. Economic benefits

The main long-term economic benefits of the project are:

- The improvement of the environmental performance of the O.O. mills and the harmonization with the provisions of the EU and national legislation should lead to avoidance of imputing of fines and penalties by the competent authorities for inappropriate olive mill waste/wastewater management
- The modernization of the existing processes and systems for the production of olive oil will lead to reduction in operational and maintenance costs
- The production of high quality olive oil should lead to an increase in the quantity of product that is forwarded to the market, and consequently to an increase of the income for the owners of the mills
- The application of good agricultural practices regarding olive trees cultivations (irrigation, use of biocides) will lead to reduction in the relative cost for the farmers as well as in the protection of the environment and the public health.
- The appropriate management of the waste/wastewater generated in the mills will result to the prevention/minimization of natural recipients pollution, fact that lead to avoidance of cost for polluted sites restoration
- The technology that was developed through the project could be applied both in the entire sector of O.O production and in other industrial sector, fact that support the industrial development in regional level
- The redesign and/or the application of modifications in the industrial units will lead to the creation of new jobs (engineers and technicians, environmentalists, chemicals)

5. Other benefits

The ECOIL project is characterised by a high level of reproducibility and economic feasibility. Also, it is relevant to environmental significant issues and policy areas since it deals with a sector with significant environmental impact and the methodology that was developed and applied is based on the principles and the priorities of the EU environmental legislative framework and policy, such as: Prevention of the industrial pollution, minimization of industrial pollution, Recover/Reuse/Recycling, Integrated Pollution Prevention and Control (IPPC), Integrated Product Policy (IPP), etc. Additionally, the outcome of the project is in complete accordance with the targets set by the European Environmental Technologies Action Plan – ETAP that focuses on the development and promotion to the market of new environmental technologies.

Finally, the project results in significant social benefits and it is characterised by high potential of replicability, demonstration, transferability and innovation at local, regional, national and international level.