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

TASK 4.1

Life Cycle Impact Assessment (LCIA)
Polemarchi Region of Crete

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1. Life Cycle Impact Assessment

Life Cycle Impact Assessment is the most important stage of LCA, as it gives the opportunity to better understand the LCI results and how the system under examination can affect the environment and the public health. With the LCIA, one can identify the stages of the system that cause the main negative environmental impacts and take actions to improve the overall performance of the system.

The calculation of environmental impacts is based on the following three steps:

1. Classification and characterization
2. Normalization
3. Evaluation or weighting

In **Step 1**, all substances are sorted into classes according to the effect they have on the environment. For example, substances that contribute to the greenhouse effect or that contribute to ozone layer depletion are divided into two classes. Some substances are included in more than one class. For example, NOx is found to be toxic, acidifying and causing eutrophication. The most common classes are: greenhouse effect/climate change, acidification, eutrophication, ozone layer depletion, carcinogens, respiratory organics, carcinogens, etc. However, the classes used each time by the SimaPro model depend on the substances emitted into the environment by the processes of the system under examination.

The substances are then aggregated within each class to produce an effect score. It is not sufficient just to add up the quantities of substances involved without applying weightings. Some substances may have a more intense effect than others. This problem is dealt with by applying weighting factors to the different substances. This step is referred to as the characterization step. The highest score is usually scaled to 100%.

However, the interpretation of these scores is not so easy. It may be easier to understand the effect scores than to just evaluating emissions of substances to the environment, but sometimes problems may occur. For example, if all the scores for one method, product or process are higher than those for another, it is easy enough to conclude which is the more environmentally friendly. But if one has a higher score for acidification, while the other has a higher score for the greenhouse effect it becomes difficult to justify such a conclusion.

Interpretation depends on two factors:

1. The relative size of the effect compared to the size of the other effects. In this example it is important to see whether the score of 100% of one class refers to a very high or an extremely low effect level. This is called normalization (Step 2).
2. The relative importance attached to the various environmental effects. This is called evaluation (Step 3).

In order to gain a better understanding of the relative size of an effect, a normalization step is required. In **Step 2,** each effect calculated for the life cycle of a product or process is benchmarked against the known total effect for this class. For example, the Eco-indicator method normalizes with effects caused by the average European during a year. Normalization enables one to see the relative contribution from the process to each already existing effect.

Normalization considerably improves the understanding of the results. However, no final judgment can be made as not all effects are considered to be of equal importance. **Step 3** is the final step of LCIA and concerns the evaluation or weighting of the results. In the evaluation phase the normalized effect scores are multiplied by a weighting factor representing the relative importance of the effect. As usually, all these steps are presents in graphs, the length of the columns actually represents the seriousness of the effects. This makes it possible to add the columns to calculate a final result.

For the LCIA of the ECOIL Project, two methodologies are used for the calculation of the environmental scores: EcoIndicator 99 and CML Baseline 2000.

2. The Eco-Indicator 99 Methodology

The Eco-indicator 99 scores are based on an impact assessment methodology that transforms the data of the inventory table into damage scores which can be aggregated, depending on the needs and the choice of the user, to damage scores per each of 3 comprehensive damage categories, or even to one single score.

Over 200 predefined eco-indicator 99 scores for commonly used materials and processes are available in the method as well as normalization and default weighting data.The effects in the characterisation steps previously explained are categorized into 3 damage categories (endpoints). These categories are:

- **Damage to Human Health**
- **Damage to Ecosystem Quality**
- **Damage to Resources**

Damages to human health are expressed in Disability Adjusted Life Years or DALY's. Damage models were developed for *respiratory and carcinogenic effects*, the effects of *climate change, ozone layer depletion and ionizing radiation*.

In these models four steps are used:

1. Fate analysis, linking an emission (expressed as mass) to a temporary change in concentration.
2. Exposure analysis

   Linking this temporary concentration change to a dose.
3. Effect analysis

   Linking the dose to a number of health effects, such as occurrence and type of cancers.
4. Damage analysis

   Links health effects to DALYs, using estimates of the number of Years Lived Disabled (YLD) and Years of Life Lost (YLL).

Damage to ecosystem quality are expressed as percentage of species disappeared in a certain area, due to the environmental load (Potentially Disappeared fraction or PDF). The PDF is then multiplied by the area size and the time period to obtain the damage.

The damage category Ecosystem Quality is unfortunately not as homogeneous as the definition of Human Health. It consists of **Ecotoxicity, Acidification and Eutrophication, Land use and land transformation**.

Ecotoxicity is expressed as the percentage of all species present in the environment living under toxic stress (Potentially Affected Fraction or PAF). As this is not an observable damage, a rather crude conversion factor is used to translate toxic stress into real observable damage, i.e. convert PAF into PDF.

Acidification and Eutrophication are treated as one single impact category. Damage to target species (vascular plants) in natural areas is modelled. Unfortunately the model was only available for the Netherlands, and it is not suitable to model phosphates.

Land use and land transformation is based on empirical data of occurrence of vascular plants as a function of land use types and area size. Both local damage on occupied or transformed area and regional damage on ecosystems are taken into account.

Damages to Resources, minerals and fossil fuels, are expressed as surplus energy for the future mining of resources. For minerals, geostatistical models are used that relate availability of a resource to its concentration. For fossil fuels surplus energy is based on the future use of oil shale and tar sands.

Human Health and Ecosystem Quality are considered to be of almost equal importance, while Resources are considered to be half as important.

3. CML 2 Baseline 2000

The CML 2 baseline method elaborates the problem-oriented (midpoint) approach. The CML Guide provides a list of impact assessment categories grouped into:

A: Obligatory impact categories (Category indicators used in most LCAs)

B: Additional impact categories (operational indicators exist, but are not often included in LCA studies)

C: Other impact categories (no operational indicators available, therefore impossible to include quantitatively in LCA)

In case several methods are available for obligatory impact categories; a baseline indicator is selected, based on the principle of best available practice. These baseline indicators are category indicators at "mid-point level" (problem oriented approach)". Baseline indicators are recommended for simplified studies. The guide provides guidelines for inclusion of other methods and impact category indicators in case of detailed studies and extended studies. Only baseline indicators are available in the CML method in SimaPro.

The impact categories considered in the method model are:

- Abiotic depletion
- Global warming (GWP100)
- Ozone layer depletion
- Human toxicity
- Fresh water aquatic ecotoxicity
- Marine aquatic ecotoxicity
- Terrestrial ecotoxicity
- Photochemical oxidation
- Acidification
- Eutrophication
- Energy use
- Solid waste
- Land use

- Abiotic resource depletion

After extensive research of the University of Leiden, that developed this methodology for impact assessment, for each impact category certain characterization factors have been selected. For example, for climate change the factor used is the global warming potential for a 100-year time horizon for each greenhouse gas emission to the air, measured in kg CO_2 equivalent/kg emission. Similarly, for ozone depletion the indicator used for emissions in the air is the kg of CFC-11 equivalent. For each impact category, indicators have been selected for the measurement of the impacts.

4. Impact Assessment with Eco-Indicator(H)

4.1. Impact Assessment for the process “Voukolies production of olive oil”

For the production of olive oil in the Polemarchy Region in Crete, the impact assessment was first based on the Eco-Indicator 99 method. In the following sections, the steps of LCIA are described in detail.

In this section, the two main processes are compared:

- Olive agriculture, which includes the following stages: plantation of olive trees, irrigation, soil management, production and application of fertiliser, herbicides and pesticides, pruning and olive collection. These stages are further categorized in smaller process as it is shown in Figure 1.
- Olive oil processing, which includes all stages for the final production of olive oil after the olive is collected and transported to the mill. These stages include olive oil grinding, purification, olive oil extraction, management of waste produced, water use for oil production, transportations to units, and storage of olive oil.

The steps of LCIA with the Eco-indicator 99 method is characterization, damage assessment, normalization, weighting. Single score is also available with the SimaPro model.

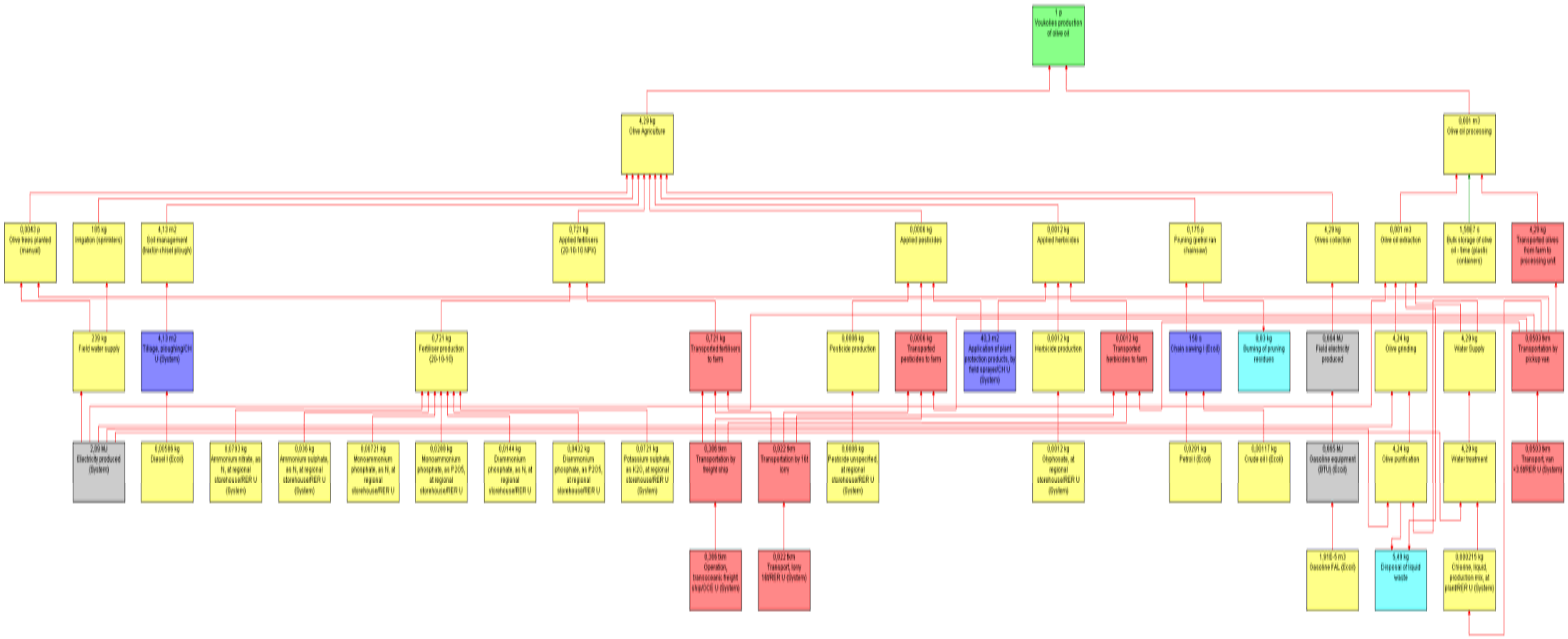

Figure 1: Final SimaPro Model for Polemarchy Region

4.1.1 Characterization

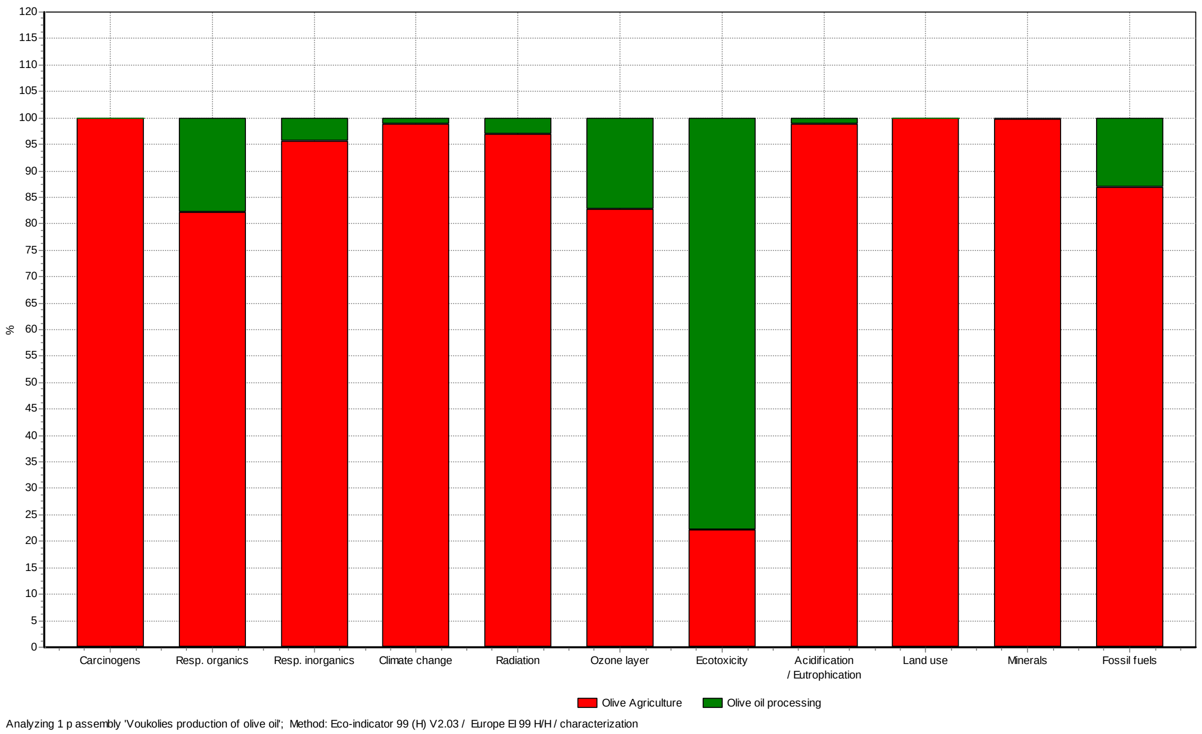

Figure 2: Results of characterization of the two processes

As it is clear from figure 2, although it is one the first step of LCIA, the olive oil agriculture stage is contributing in almost all impact category indicators. The severity of the contribution in each will be apparent in the following steps of LCIA. The only impact category where olive oil processing seems to have more serious effects to the environment is ecotoxicity.

In Table 1, the aggregated data per impact category are shown.

Table 1: Characterization

Impact category	Unit	Total	Olive Agriculture	Olive oil processing
Carcinogens	DALY	0,000253	0,000253	2,51E-07
Resp. organics	DALY	2,02E-07	1,66E-07	3,59E-08
Resp. inorganics	DALY	2,67E-06	2,55E-06	1,17E-07
Climate change	DALY	2,63E-06	2,60E-06	3,10E-08
Radiation	DALY	1,36E-09	1,32E-09	4,17E-11
Ozone layer	DALY	1,08E-10	8,96E-11	1,88E-11
Ecotoxicity	PAF*m2yr	13	2,89	10,1

Acidification/ Eutrophication	PDF*m2yr	0,266	0,263	0,00297
Land use	PDF*m2yr	9,7	9,7	6,32E-06
Minerals	MJ surplus	0,0013	0,0013	2,85E-06
Fossil fuels	MJ surplus	2,05	1,78	0,271

4.1.2 Damage Assessment

Damage Assessment provides similar results to the characterization step. The main difference concerns ecotoxicity is converted from PAF into PDF.

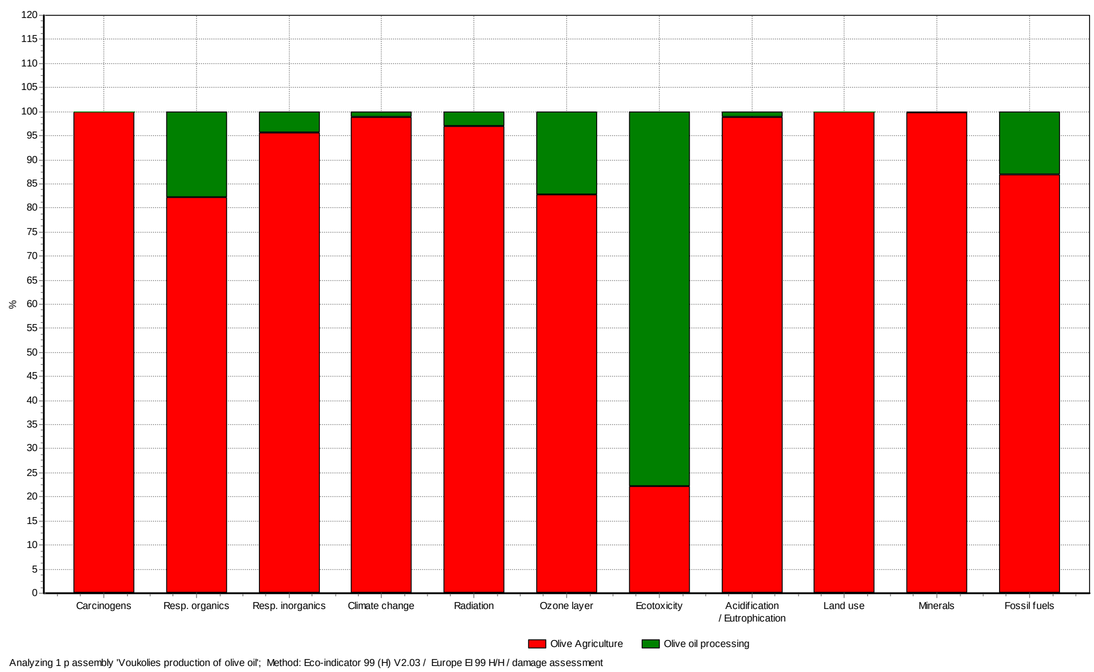

Figure 3: Damage analysis with Eco-Indicator 99

Table 2: Damage Assesment

Impact category	Unit	Total	Olive Agriculture	Olive oil processing
Carcinogens	DALY	0,000253	0,000253	2,51E-07
Resp. organics	DALY	2,02E-07	1,66E-07	3,59E-08
Resp. inorganics	DALY	2,67E-06	2,55E-06	1,17E-07
Climate change	DALY	2,63E-06	2,60E-06	3,10E-08
Radiation	DALY	1,36E-09	1,32E-09	4,17E-11
Ozone layer	DALY	1,08E-10	8,96E-11	1,88E-11
Ecotoxicity	PDF*m2yr	1,3	0,289	1,01
Acidification/	PDF*m2yr	0,266	0,263	0,00297

Eutrophication				
Land use	PDF*m2yr	9,7	9,7	6,32E-06
Minerals	MJ surplus	0,0013	0,0013	2,85E-06
Fossil fuels	MJ surplus	2,05	1,78	0,271

4.1.3 Normalization

Normalization step is very important as it allows us to better understand the relative importance of a specific effect. As it can be seen from Figure 4, the most severe environmental impact is the emissions of carcinogens to the atmosphere during olive oil agriculture stage. Carcinogens are probably a by-product of the burning of pruned olive tree branches. Green waste might not be so innocent, as a part of the pesticide used still remains in the branch when the latter is burnt. The second most important impact seems to be land use, which is not unexpected, as in all agricultural processes is inevitable.

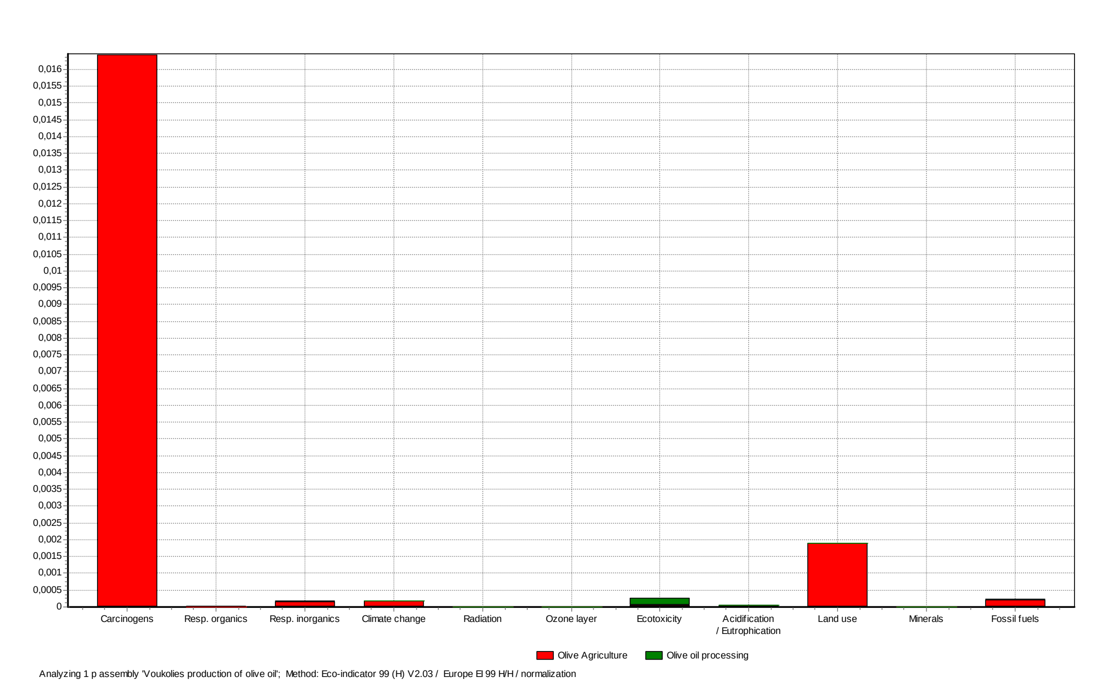

Figure 4: Normalization with Eco-indicator 99

Table 3: Normalization table

Impact category	Unit	Total	Olive Agriculture	Olive oil processing
Carcinogens		0,0165	0,0164	1,64E-05
Resp. organics		1,31E-05	1,08E-05	2,34E-06
Resp. inorganics		1,74E-04	1,66E-04	7,63E-06
Climate change		1,71E-04	1,69E-04	2,02E-06
Radiation		8,84E-08	8,56E-08	2,71E-09
Ozone layer		7,06E-09	5,83E-09	1,23E-09
Ecotoxicity		0,000254	0,0000564	0,000198
Acidification/ Eutrophication		5,18E-05	0,0000512	5,79E-07
Land use		0,00189	0,00189	1,23E-09
Minerals		1,55E-07	1,55E-07	3,40E-10
Fossil fuels		0,000244	0,000212	0,0000323

4.1.4 Weighting

After weighting, where the normalized effect scores are multiplied by a weighting factor representing the relative importance of the effect, carcinogens and land use still remain the most important environmental impacts from olive oil agriculture.

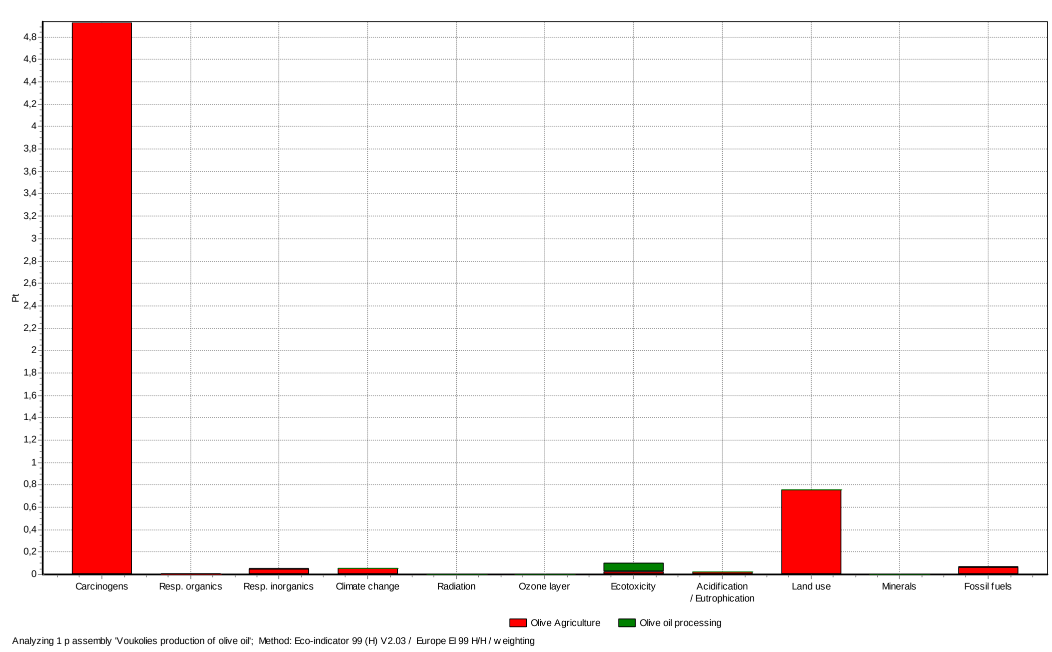

Figure 5: Weighting results

Table 4: Weighting

Impact category	Unit	Total	Olive Agriculture	Olive oil processing
Total	Pt	6	5,9	9,76E-02
Carcinogens	Pt	4,94E+00	4,93E+00	4,91E-03
Resp. organics	Pt	3,94E-03	3,23E-03	7,02E-04
Resp. inorganics	Pt	5,22E-02	4,99E-02	2,29E-03
Climate change	Pt	5,14E-02	5,08E-02	6,06E-04
Radiation	Pt	2,65E-05	2,57E-05	8,14E-07
Ozone layer	Pt	2,12E-06	0,00000175	3,68E-07
Ecotoxicity	Pt	0,102	0,0226	0,0791
Acidification/ Eutrophication	Pt	0,0207	0,0205	2,31E-04
Land use	Pt	0,756	0,756	4,93E-07
Minerals	Pt	4,65E-05	0,0000464	1,02E-07
Fossil fuels	Pt	0,0733	0,0636	0,00968

4.1.5 Single Score

The single score diagram for the two stages of olive oil production is shown in the following figure.

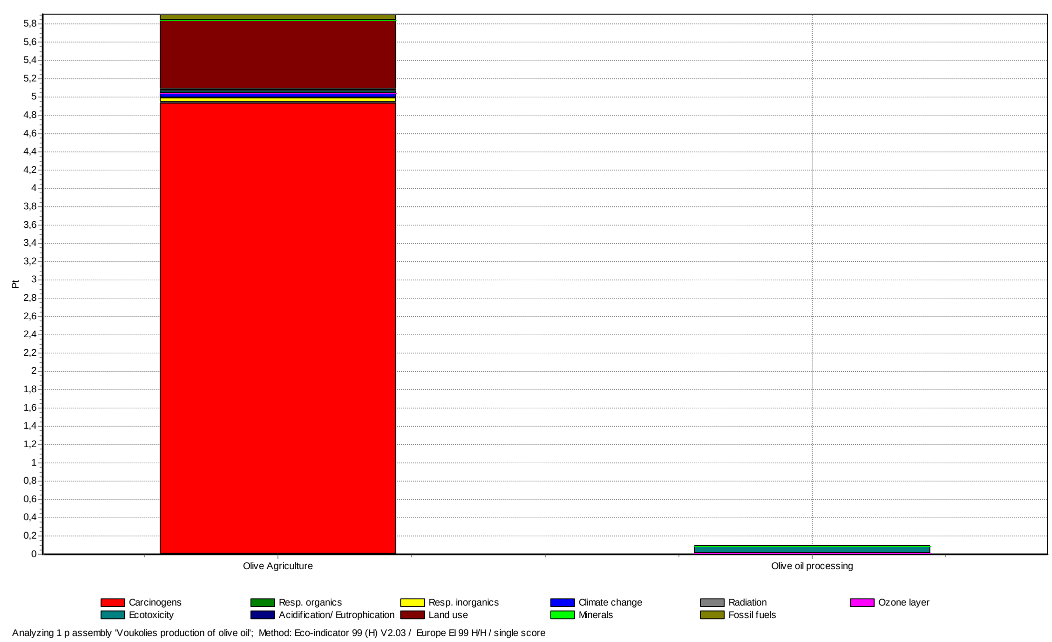

Figure 6: Single Score per Process

4.2 Impact Assessment for the process “Olive Agriculture”

In this section, the stage of olive agriculture is examined in more detail using the Eco-indicator 99 method. All steps of LCIA are followed in this stage as well. Using LCIA gives the possibility to identify the processes with the highest negative impact into the environment and the public health.

4.2.1 Characterization

Characterization in this stage does not provide a clear picture on the most important environmental effects. However, it allows the user to understand the environmental impacts of each process at least in qualitative terms. For example, it is obvious that the use of fertilizers contributes to eutrophication due to the N and P nutrients that end up in neighboring water recipients. Fertilizers seem to have impact in the majority of the categories through either their production or application. Pruning seems also to have adverse environmental impacts and this is mainly due to the burning of pruning waste. However, from this early stage it is difficult to highlight the process with the highest relative impact.

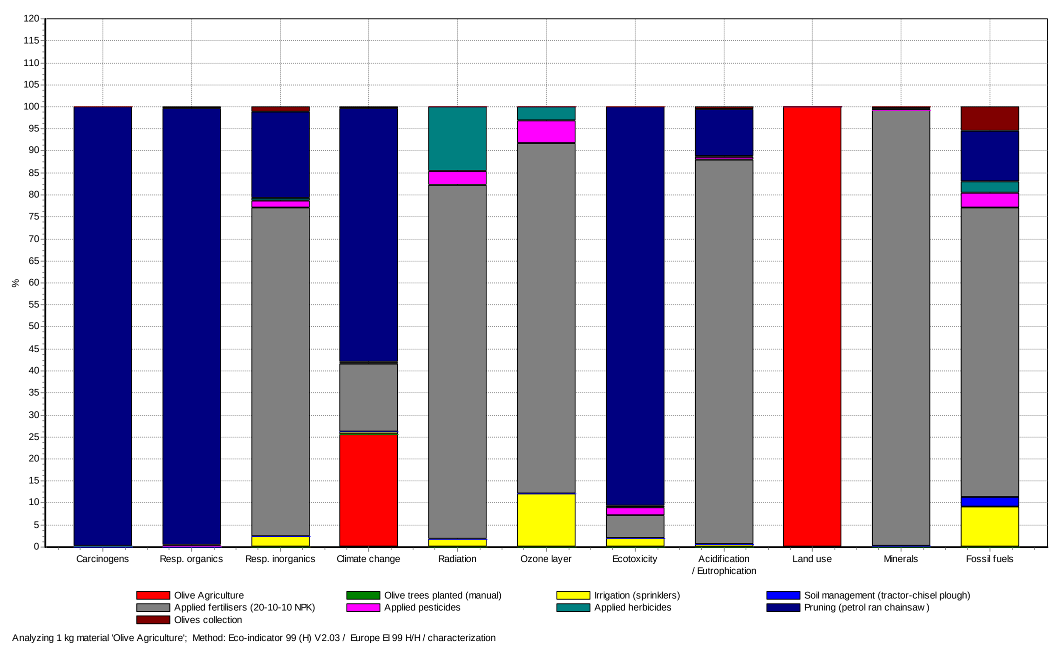

Figure 7: Characterization of all processes of olive oil agriculture

4.2.2 Normalization & Weighting

With the normalization steps, things become clearer. It becomes obvious that the burning of pruning residues leads to the emission of carcinogen substances into the air due to the dangerous substances of pesticides that still remain in the branches that are incinerated.

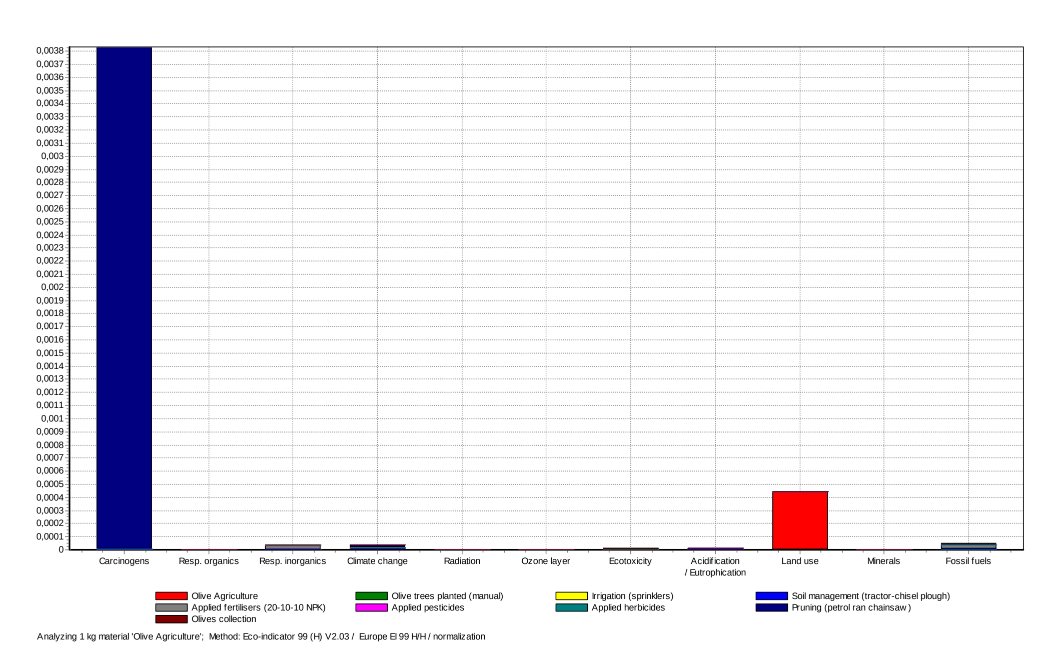

Figure 8: Normalization

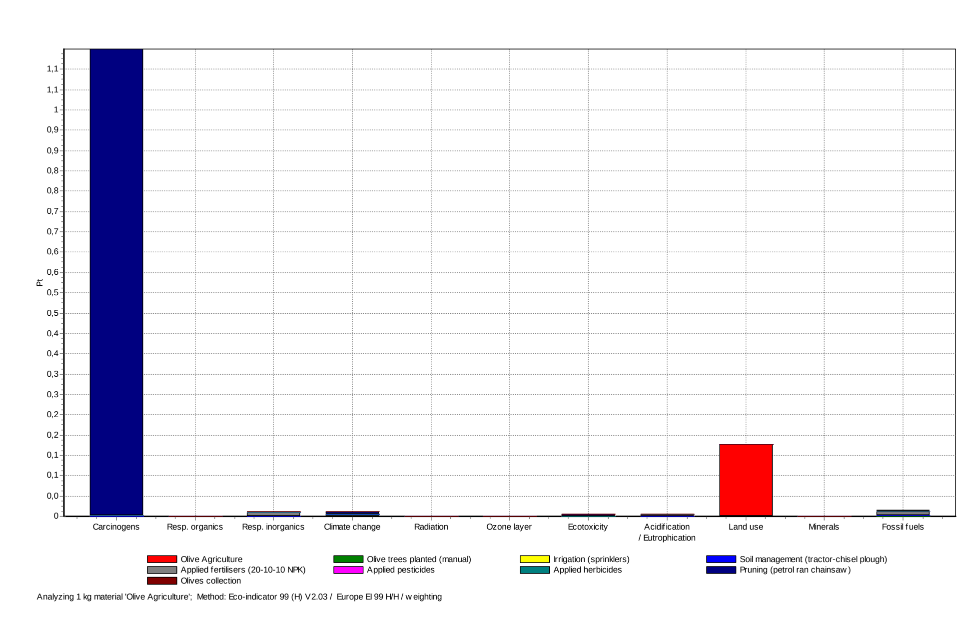

Figure 9: Weighting

4.2.3 Single Score

By examining the single score for each process, it seems that the burning of green waste causes serious problems mainly to public health. As this is a common practice in agricultural areas, this study shows that sometimes this can be proven to be extremely harmful and can have adverse effects to human beings. The olive oil agriculture stage has many impacts into the environment; however through normalization and evaluation their relative contribution and importance is not apparent as the results are weighted against the effect of these impacts in wider scale. However, this does not mean that the use of fertilizers can be continued without prudence, as it is proven that the extensive use of fertilizers can seriously damage the ecosystems.

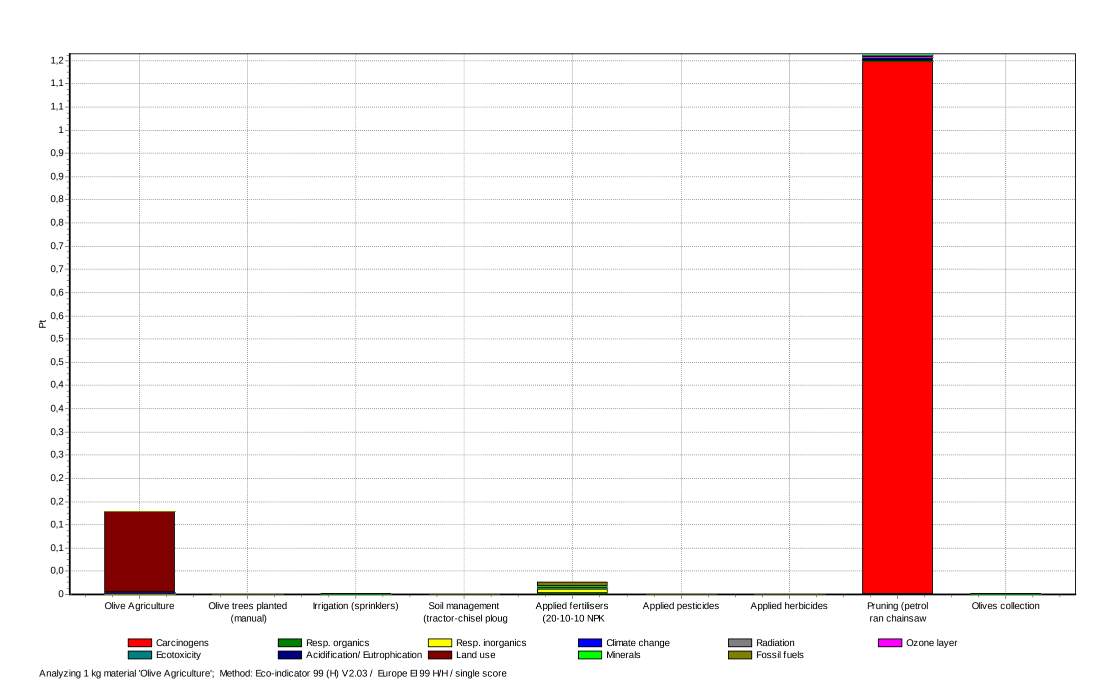

Figure 10: Single score per process

4.3 Impact Assessment for the process "Olive Oil Processing"

In this section, the stage of the production of olive oil is examined in more detail using the Eco-indicator 99 method. All steps of LCIA are followed in this stage as well. Using LCIA gives the possibility to identify the processes with the highest negative impact into the environment and the public health.

4.3.1 Characterization

As it can be seen from the characterization step, the process 'olive oil extraction' has a predominant environmental impact through all impact categories. Olive oil extraction includes the disposal of waste that is generated through the processes followed for the production of olive oil. As the liquid waste is not at all treated, and its polluting load is extremely high, it has serious negative environmental impacts. However, the relative importance of these impacts becomes clear only in the next steps of the model.

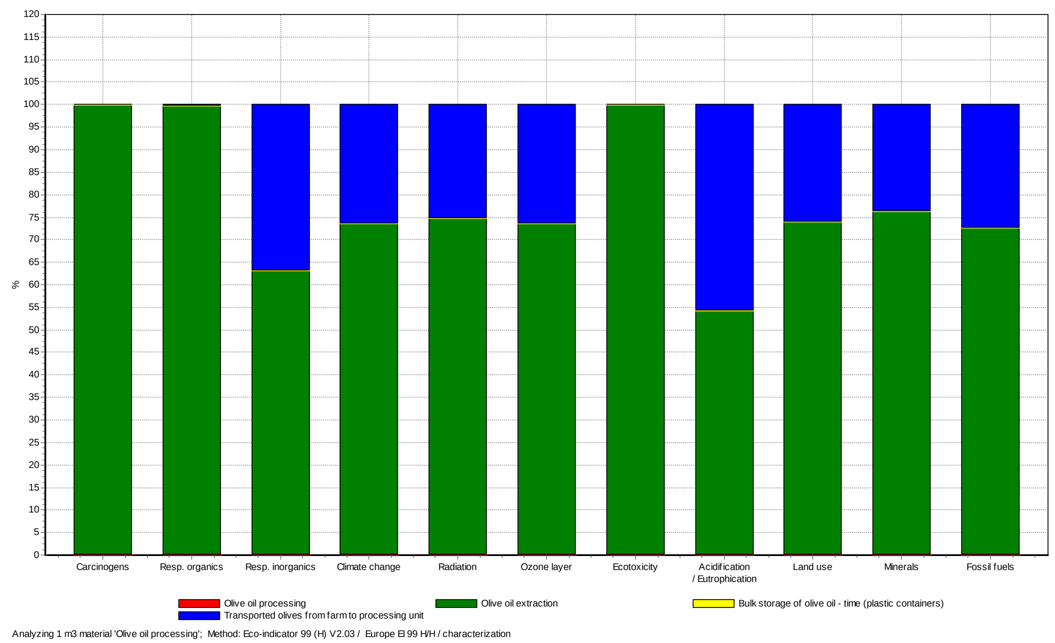

Figure 11: Characterization of olive oil processing

4.3.2 Normalization & Weighting

Through normalization and weighting it becomes apparent that olive oil processing's most important impact is the exotoxicity damage. The disposal of liquid waste into the environment is translated into toxic stress for the species living in the neirghboring habitats. The disposal of liquid waste should be dealt with care as it is within the main environmental problems that are related to the production of olive oil.

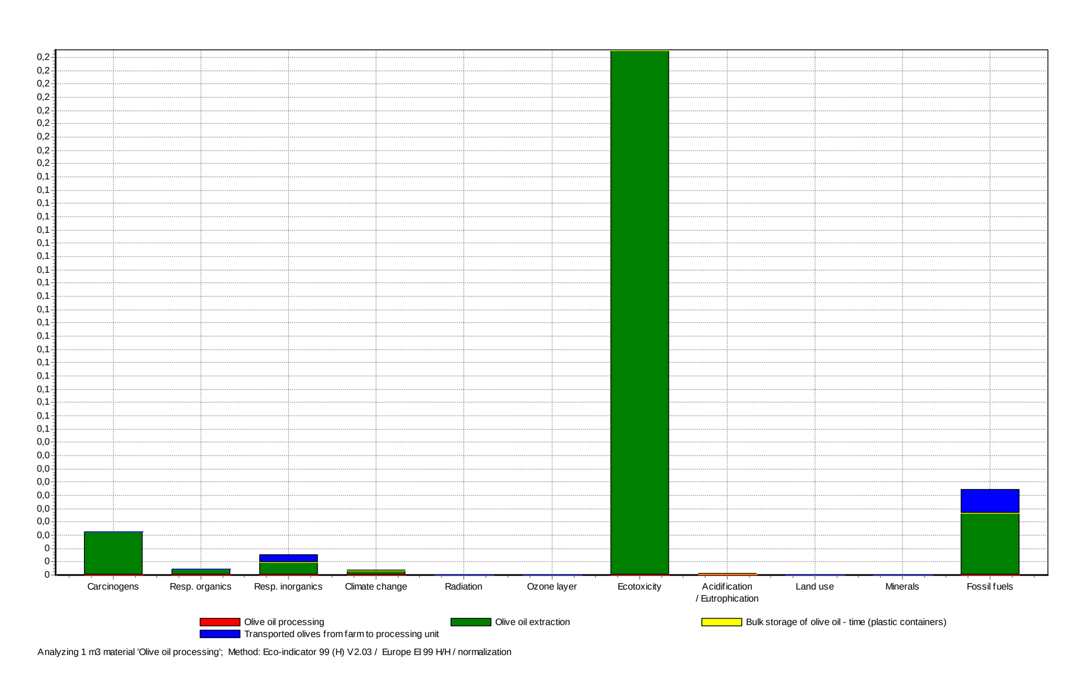

Figure 12: Normalisation of results

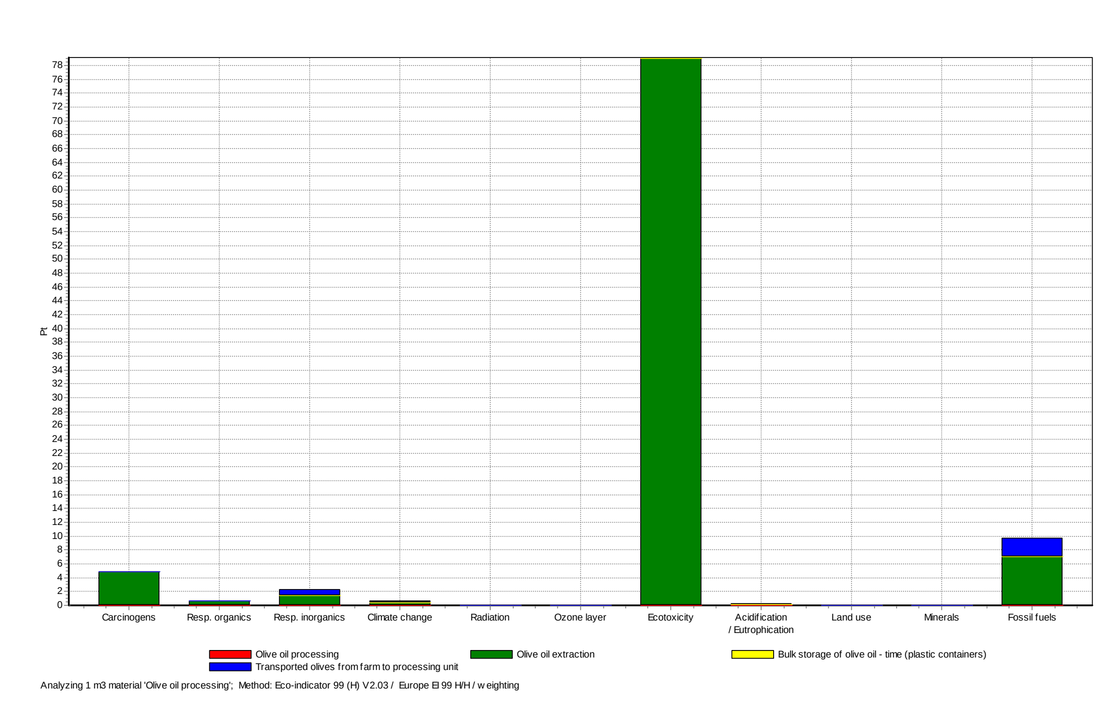

Figure 13: Weighting of results

4.3.3. Single Score

The single score per process proves once again the serious negative impacts that are related with olive oil processing. Apart from the effect it has on ecotoxicity, it also contributes to the emission of carcinogens, the use of fossil fuel (energy needed for the operation of the olive oil mill), and respiratory inorganics.

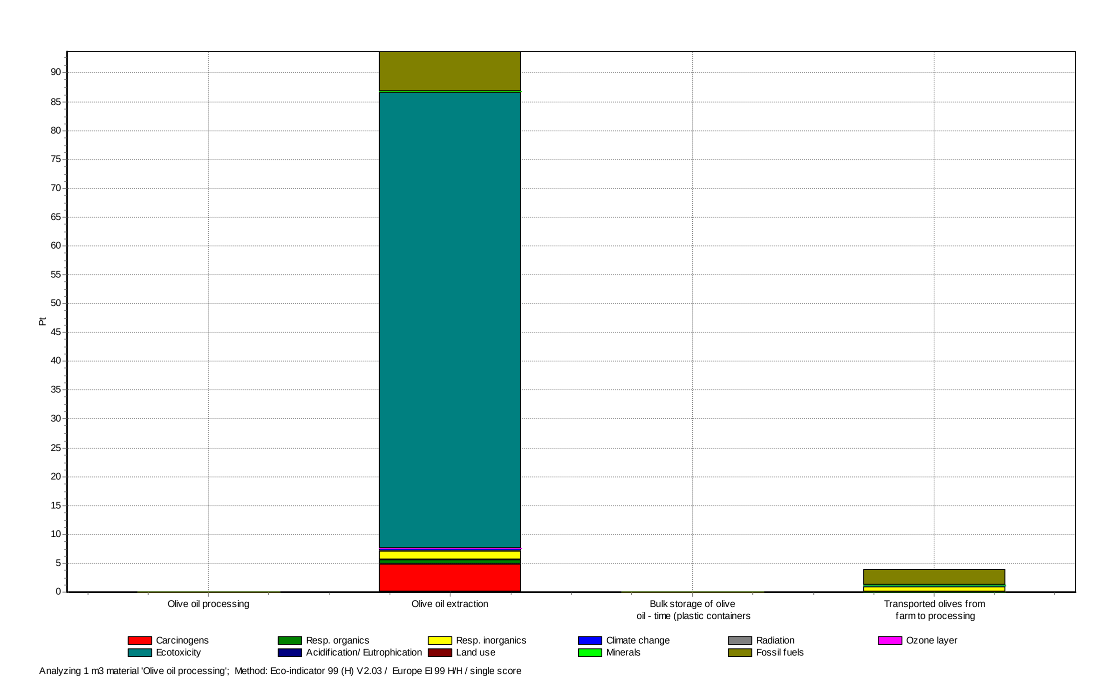

Figure 14: Single score per process

5. Impact Assessment with CML 2 Baseline 2000

A similar assessment like the one used with the Ecoindicator 99 methodology for LCIA has also taken place with the CML Baseline 2000 method. The results are presented in the following sections.

5.1 Impact Assessment for the process "Voukolies production of olive oil"

5.1.1 Characterization

The characterisation step shows as in the case of the Eco-indicator method 99 that the olive agriculture stage has the predominant contribution in all impact categories. However, in this case it is clearer that the olive oil processing stage has impacts into the environment in two categories: terrestrial ecotoxicity and eutrophication.

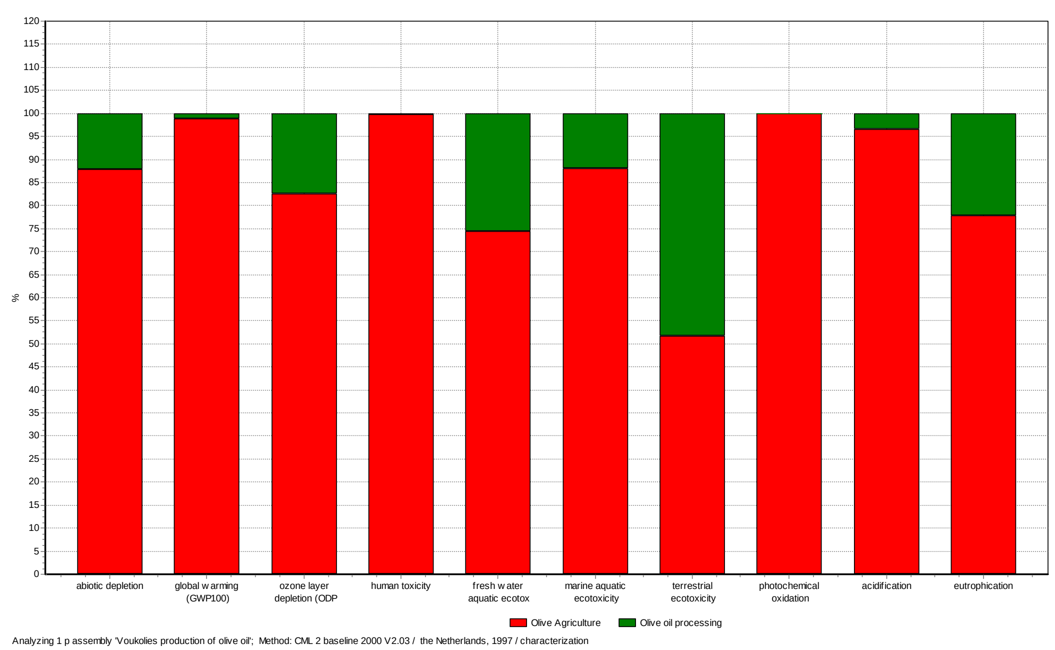

Figure 15: The characterization steps of the results with the CML 2 Baseline 2000 method

Table 5: Characterization table

Impact category	Unit	Total	Olive Agriculture	Olive oil processing
abiotic depletion	kg Sb eq	0,0073	0,00641	8,90E-04
global warming (GWP100)	kg CO2 eq	1,27E+01	1,26E+01	1,48E-01

ozone layer depletion (ODP)	kg CFC-11 eq	1,03E-07	8,51E-08	1,79E-08
human toxicity	kg 1,4-DB eq	3,59E+01	3,58E+01	1,11E-01
fresh water aquatic ecotox.	kg 1,4-DB eq	1,64E+00	1,22E+00	4,21E-01
marine aquatic ecotoxicity	kg 1,4-DB eq	7,74E+02	6,81E+02	9,28E+01
terrestrial ecotoxicity	kg 1,4-DB eq	0,0395	0,0204	0,0191
photochemical oxidation	kg C2H4	0,0595	0,0595	0,0000766
acidification	kg SO2 eq	0,0349	0,0337	1,21E-03
eutrophication	kg PO4--- eq	0,0359	0,0279	7,96E-03

5.1.2 Normalization

As weighting with the CML 2 Baseline 2000 method is not available in SimaPro, the relative size of each environmental impact can be only examined through the normalization step. For normalizing the results in this method, 3 types of normalization factors are suggested. These factors have derived from various studies and are the following:

- Normalization factors for West-Europe (1995)
- Normalization factors for the Netherlands (1997)
- Normalization factors for World Population (1990)

For the ECOIL project, the normalization factors for West-Europe have been used for all case studies. These values can be seen in Figure 16.

impact category	Netherlands, 1997	West-Europe, 1995	World, mid 1995	World, 1990	
depletion of abiotic resources	1.71E+09[1]	1.06E+10	1.57E+11	1.58E+11	kg (antimony eq).yr^{-1}
effects of land use					
land competition	P.M.	P.M.	P.M.	P.M.	P.M.
climate change	2.51E+11	4.73E+12	3.86E+13	4.45E+13	kg (CO2 eq). yr^{-1}
stratospheric ozone depletion	9.77E+05	8.30E+07	5.15E+08	1.14E+09	kg (CFC–11 eq). yr^{-1}
human toxicity	1.88E+11	7.57E+12	4.98E+13	5.71E+13	kg (1,4-DCB eq). yr^{-1}
ecotoxicity					
fresh water aquatic ecotoxicity	7.54E+09	5.05E+11	2.03E+12	1.98E+12	kg (1,4-DCB eq). yr^{-1}
marine ecotoxicity	4.26E+12	1.14E+14	5.12E+14	9.11E+13	kg (1,4-DCB eq). yr^{-1}
terrestrial ecotoxicity	9.59E+08	4.73E+10	2.68E+11	2.06E+11	kg (1,4-DCB eq). yr^{-1}
photo-oxidant formation	1.82E+08	8.24E+09	4.55E+10	1.07E+11	kg (C_2H_4 eq). yr^{-1}
acidification	6.69E+08	2.74E+10	2.99E+11	3.13E+11	kg (SO_2 eq). yr^{-1}
eutrophication	5.02E+08	1.25E+10	1.29E+11	1.32E+11	kg (PO_4^{3-} eq). yr^{-1}

Figure 16: Set of normalization data

The normalized figure for the two processes is shown in Figure 17. From this figure, it becomes apparent that olive agriculture has serious impact primarily in photochemical oxidation, and secondarily in marine aquatic ecotoxicity. Other important impacts seem to be fresh water aquatic ecotoxicity and human toxicity. On the other hand, olive oil processing seems to have effect on fresh water aquatic toxicity and eutrophication. When analysing separately these two stages, the processes that have the most serious impact will be identified.

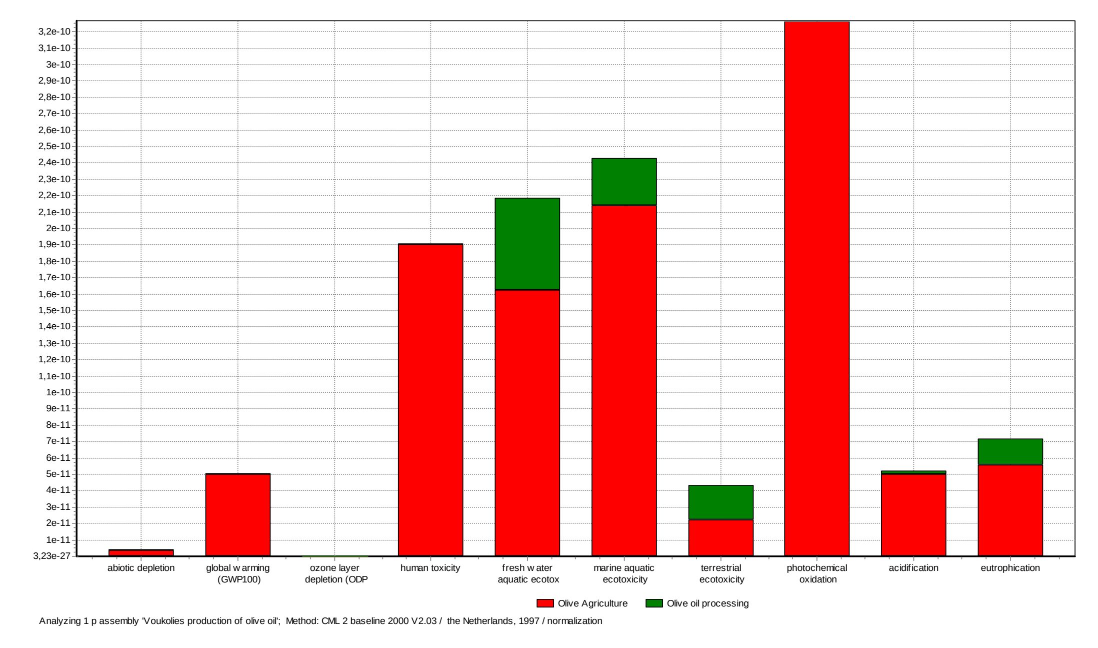

Figure 17: Normalization of results with the CML Baseline 2000 Method

Table 6: Normalization Table

Impact category	Total	Olive Agriculture	Olive oil processing
abiotic depletion	4,27E-12	3,75E-12	5,21E-13
global warming (GWP100)	5,04E-11	4,98E-11	5,85E-13
ozone layer depletion (ODP)	1,05E-13	8,68E-14	1,83E-14
human toxicity	1,91E-10	1,90E-10	5,87E-13
fresh water aquatic ecotox.	2,18E-10	1,62E-10	5,60E-11
marine aquatic ecotoxicity	2,43E-10	2,14E-10	2,91E-11
terrestrial ecotoxicity	4,31E-11	2,23E-11	2,08E-11
photochemical oxidation	3,27E-10	3,26E-10	4,2E-13
acidification	5,21E-11	5,03E-11	1,81E-12
eutrophication	7,14E-11	5,56E-11	1,58E-11

5.2 Impact Assessment for the process “Olive Agriculture”

In this section, the olive agriculture stage of the production of olive oil will be examined separately so as to identify the processes that mostly contribute to environmental degradation.

5.2.1 Characterization

The characterization step for olive agriculture produces Figure 18. The processes that seem to have effect in many impact categories are the application of fertilisers, pruning, as well as the use of pesticides. However, the relative size of the effects of these processes will become clear with the normalization.

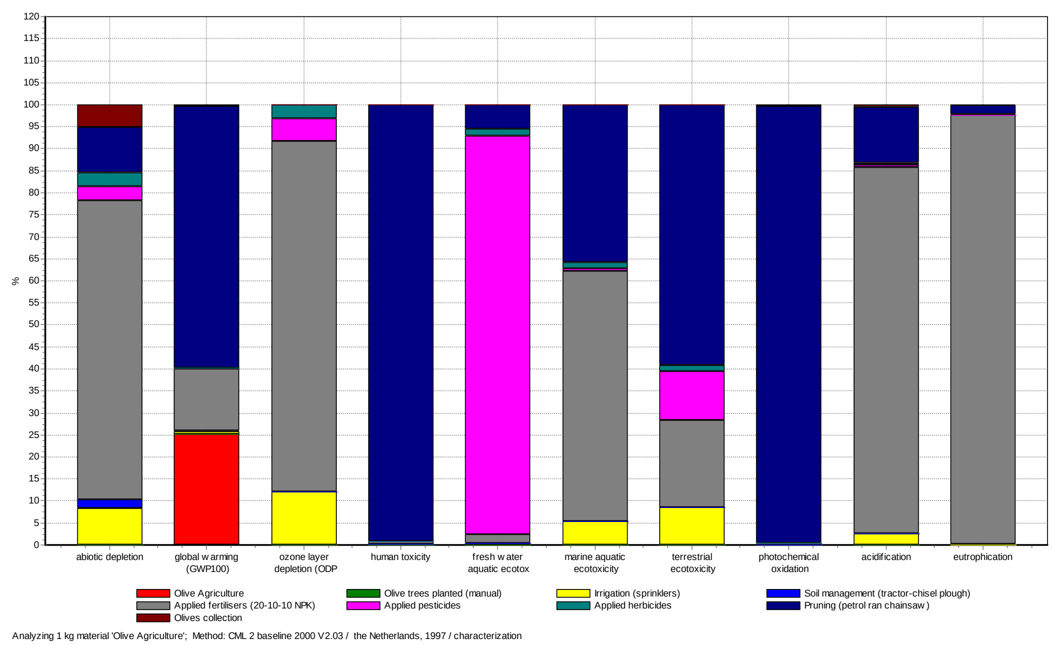

Figure 18: Characterization of olive agriculture stage

5.2.2 Normalization

With the normalization of the results, the following conclusions can be derived:

- Pruning (which includes the burning of green waste) has impact on the following categories: photochemical oxidation, human toxicity, marine aquatic ecotoxicity and global warming. All these effects are mainly connected with the burning of green waste and the air emissions that generate through this practice.

- The use of fertilisers contributes to eutrophication and marine aquatic toxicity. This is mainly due to the fact that the overuse of chemical fertilisers creates a surplus of nutrients in the soil. These nutrients end up in neighbouring recipients causing eutrophication and negatively affecting the aquatic environment.
- The use of pesticides which contain dangerous substances for both the human health and the environment contributes to fresh water aquatic ecotoxicity. The use of pesticides should take place with caution, as their toxic effect cannot be neglected.

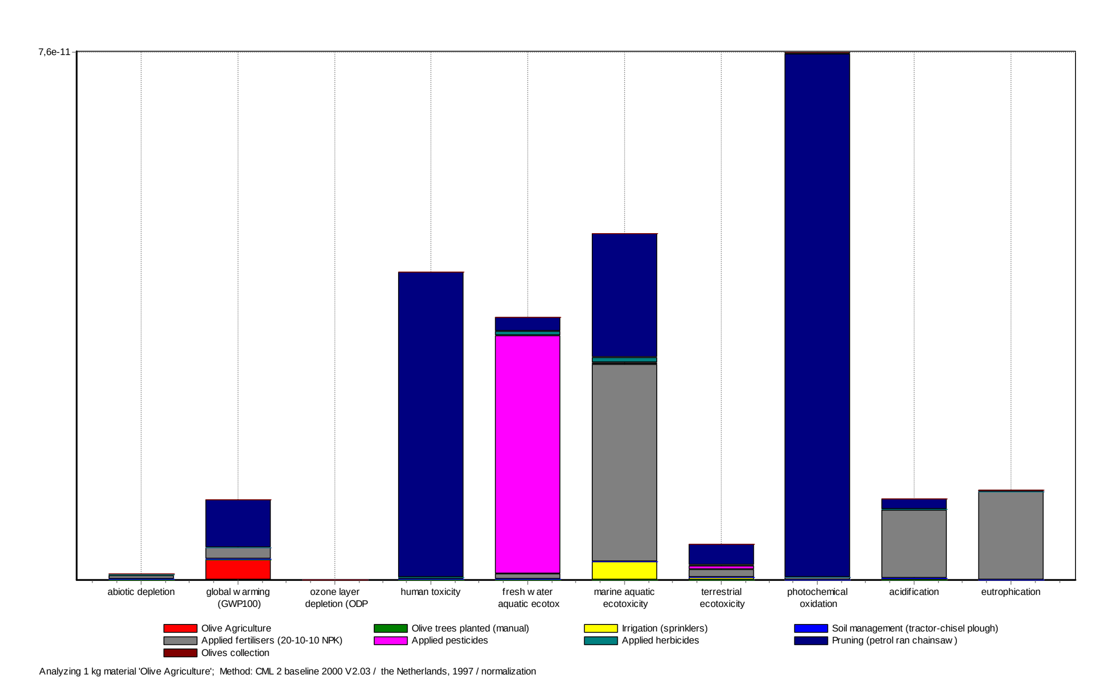

Figure 19: Normalization of results for olive oil agriculture

5.3 Impact Assessment for the process "Olive Oil Processing"

The same methodology has been followed for the olive oil processing stage. With the following step, the processes with the most serious impacts on the environment can be identified.

5.3.1 Characterization

With the characterization step, it becomes clear that olive oil extraction has adverse effects in all impact categories. The transportation to the olive mill has also some effects which are mainly connected to the use of fossil fuels.

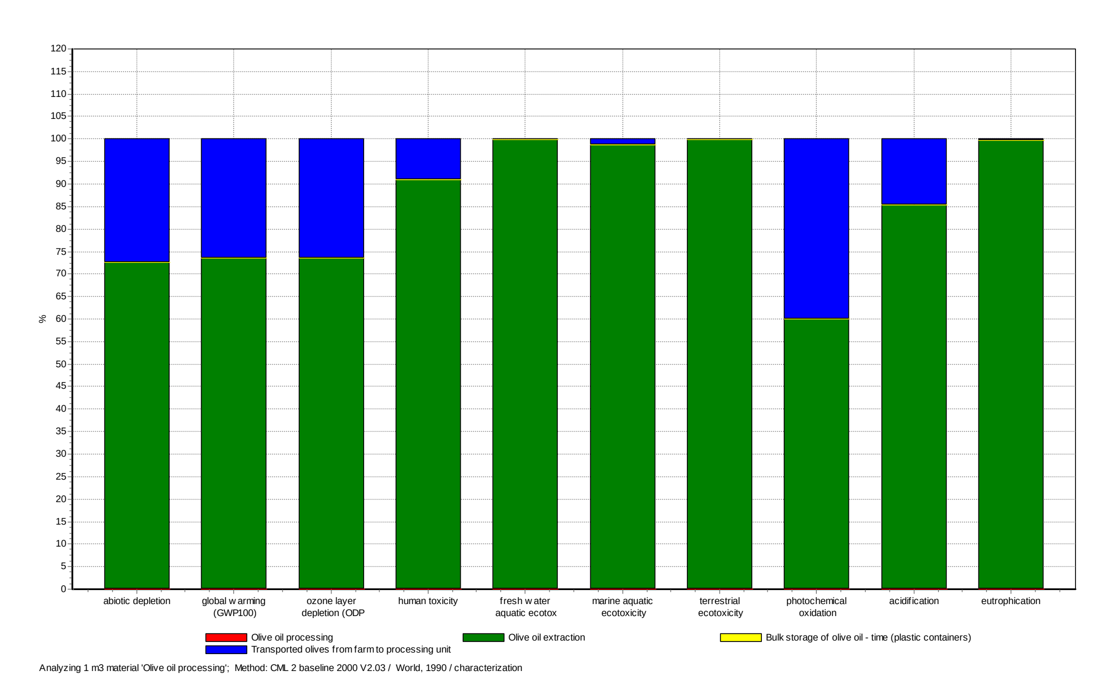

Figure 20: Characterization step for olive oil processing

5.3.2 Normalization

With the normalization, the relative size of each impact becomes clearer. As it was expected olive oil extraction has impact in the following impact categories: fresh water aquatic ecotoxicity, marine aquatic ecotoxicity, terrestrial ecotoxicity and eutrophication. All these effects are related with the disposal of liquid waste to the environment without any prior treatment. The composition of the liquid waste has serious adverse impacts onto the environment and therefore measures should be taken to reduce this impact.

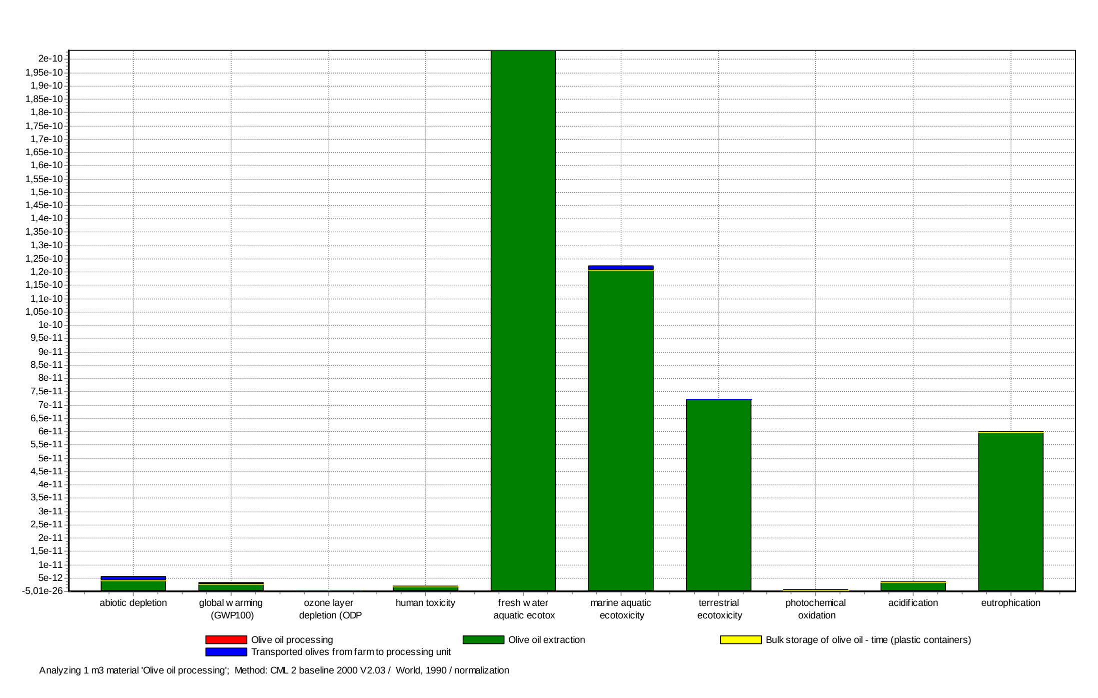

Figure 21: Characterization for olive oil processing

6. Conclusions

By using the Eco-indicator 99 and the CML 2 Baseline 2000 Methods for LCIA the main environmental impacts related with the production of olive oil have been identified. The results of the LCIA are summarized below:

1. The agricultural stage of olive oil production is the stage which pollutes more and has more effect in most impact categories.
2. In the agricultural stage, the main environmental impacts are related with the burning of the pruning waste, the use of fertilisers and pesticides.
3. The most important impacts of the agricultural stage are the emissions of carcinogens to the athospheres resulting to human toxicity, photochemical oxidation, as well as eutrophication.
4. In the olive oil processing stage, the impacts are related with the disposal of liquid waste.
5. The environmental impacts of the disposal of liquid waste are toxicity in all level (fresh water, marine, terrestrial and human), as well as eutrophication.
6. 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:
    - Reduce the use of fertilisers
    - Reduce the use of pesticided
    - Find alternative method to deal with pruning waste
    - Apply appropriate treatment to liquid waste so as to protect the natural environment from the adverse effects of its disposal
7. Similar results have derived from the LCIA in the other two countries which were examined: Spain and Cyprus although with some minor differences. Guidelines adopted to each case were developed to optimise olive oil production.

7. References

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