

The Environmental Impact of Palm Oil and Other Vegetable Oils**

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INTRODUCTION

The corporate policy of food manufacturers is often to ensure that their products meet customers and consumer's everyday needs for nutrition, hygiene and food safety. However, nowadays many of them are increasingly aware of their social responsibility in ensuring that their manufacturing activities can have serious impacts on the environment and are committed to minimize this by implementing appropriate practices in their corporate policy in order to be recognized as an environmentally responsible company.

One of the ways in which these manufacturers can implement this policy is to carry out environmental life cycle assessments (LCA) on its raw materials and products. This will allow them to improve their knowledge of the environmental performance of their products and their ingredients at every stage in the extended supply chain. The results will enable them to account for environmental issues during the development of and along the supply chain of their products.

WHY AND WHAT IS LIFE CYCLE ASSESSMENT?

Beyond manufacturers' own commitment, there is increasing pressure from stakeholders along the total supply chain to better understand the environment and

environmental impacts. This ranges from the consumers who want to make an informed choice about the food they buy, through to retailers and food companies who might seek to gain competitive advantage by offering greener products, and up to governments who are seeking ways to reduce greenhouse gas (GHG) emissions. The more recent developments in biofuels, a subsequent rise in biomass demand and potential competition between food and fuel accelerated this development significantly.

LCA is a technique for evaluating the environmental performance of

products. This includes assessing impacts associated with obtaining raw materials and ingredients, converting these to finished products, distribution, consumer use and eventual disposal. LCA can be used to identify where impacts occur in the supply chain and where the major improvements can be made (not always the same).

The principles underlying LCA are fairly straightforward. They state that if, at each stage of a product's life cycle, you know the input in raw materials (e.g. as agricultural input, water, energy) and what comes out in terms of product (and pollution to air, water and land) then it is possible to quantify a range of environmental impacts caused by that product. Essential is the definition of the scope and exact boundaries of the system (*Figure 1*).

LCA techniques are generally used to assess the following environmental impact categories:

Energy Consumption

This measures energy consumption from 'primary' sources at each stage in the product life cycle. This tends to correlate closely with other

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** Reproduced, with permission and slight revision, from the paper presented at the SCI (Society of Chemical Industry) Conference on 'Palm Oil—the Sustainable 21st Century Oil - Food, Fuel & Chemicals' at London, 23-24 March 2009.

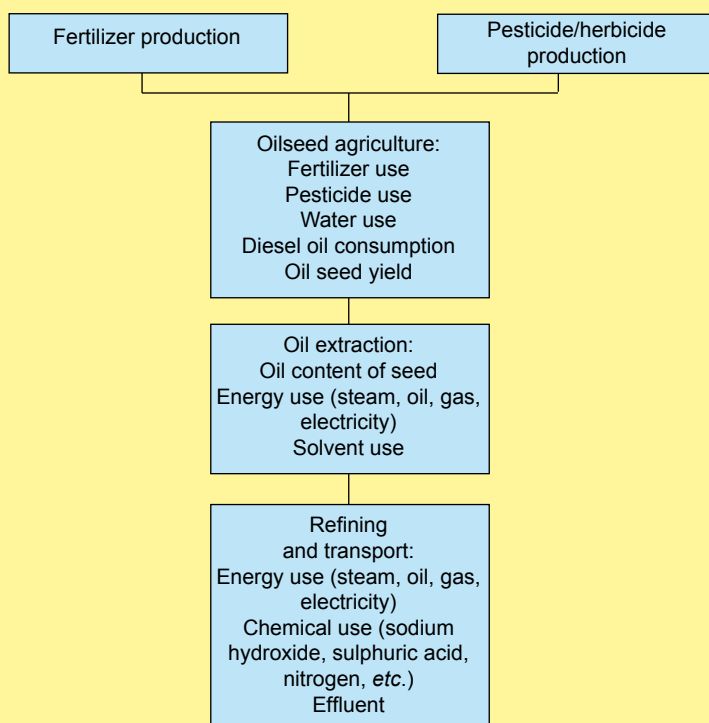


Figure 1. Simplified process flow sheet, system boundary and elements included in the life cycle of vegetable oils.

environmental impacts such as consumption of fossil fuel resources, global warming and acidification;

Acidification potential

Modification potential was caused by emissions to the atmosphere of acidifying gases such as ammonia and oxides of nitrogen and sulphur. These can result in acid rain, which damages ecosystems; therefore also correlates well with energy consumption as SO_x and NO_x emissions from burning fossil fuels contribute to this category.

Eutrophication potential

Eutrophication potential was caused by excessive use/loss of nutrient emissions to rivers and lakes during agricultural production. These can cause the formation of algal blooms, which deplete oxygen levels, harming fish

and other aquatic life. Therefore, eutrophication potential is dependent upon the quantities of fertilizer required to produce the oils;

Global Warming Potential

This was caused by GHG such as carbon dioxide, methane and nitrous oxide, leading to climate change; therefore tends to correlate closely with energy consumption, as carbon dioxide emissions from burning fossil fuels are a key contributor to global warming. In agricultural systems, nitrous oxide emissions from fertilizer production and use may also be important.

Photochemical smog potential

Photochemical smog potential was caused by the emissions of 'volatile organic compounds' (VOC) that react with NO_x and sunlight to

form ground-level ozone. This may trigger asthma and lead to other human health problems. VOC emissions from hexane use during extraction of some plant oils are major contributors to this category.

Land Use

This shows the area of land required to grow a crop/produce a product.

LCA'S OF VEGETABLE OILS

First LCA results of our total product supply chain study demonstrated a significantly larger impact up front in the chain (the raw material supply) than in processing and manufacturing. As a result the focus shifted from manufacturing to a better understanding of the environmental impacts of agriculture in the growing and production of refined vegetable oils. These as the key raw materials or ingredients for a large number of our products and derived from crops including palm, coconut, rapeseed, soyabean, sunflower and olive oil.

AGRICULTURAL PROCESSES

Developing a model of crop production presents some significant challenges to the LCA practitioner. This mainly due to the high level of complexity of agricultural systems, the high degree of variation in agricultural practice and crop yields from place to place. The model allows to account for climate and soil conditions on the fate of fertilizers in terms of atmospheric emissions of ammonia, nitric oxide and nitrous oxide, on run-off and leaching of nitrates to streams and rivers.

The variability in agricultural practice is due in part to varying degrees of technology and mechanization in different areas but also to fundamental differences in external factors such as soil quality, indigenous pests and prevailing climate, which all influence farm practices and affect crop yields. However, this variability means that it is very difficult to collect generic data on a particular crop because there is no 'average farm' – that is, one that uses an average amount of fertilizer and pesticides, with an average degree of mechanization to deliver an average crop yield. Indeed, variation can be such that differences between the same crop grown in different locations may be greater than between entirely different crops in the same region. Instead, we chose to collect location-specific data for particular production systems in a given area. We accept that impacts will differ from year to year and for other systems and locations, but we know that the results are representative of the areas where Unilever obtains the bulk of its oils. We collected data from Malaysia (for palm fruit and coconut production), Germany (rapeseed), Brazil (soyabeans), France (sunflower) and Spain (olives).

Oil Extraction

After the crop is harvested the next significant step is the extraction of the oil. This usually involves a pre-milling step followed either by an expelling or a solvent extraction process; or a combination of both. The solvent extraction process – with hexane – is commonly used for soyabeans and a combination of both processes for rapeseed and sunflower oil extraction. Expelling after cracking only is applied for

palm kernel and coconut oil and expelling only for palm and olive oil. The oil rich cake (after expelling) or residual oil-containing meal (after hexane extraction) is a common, by-product (except for soy where the high value protein meal is the primary product) and is usually used for animal feed.

Different approaches are used for the allocation of 'previous' impacts to processes producing more than one product. For the allocation between oil and meal – products with very different physical properties and use, it was decided to allocate based on the economic value of the products.

Oil Refining and Transport

Refining is based on GMP-refining in a typical European refinery in the NL. The processes applied are physical refining for palm oil, palm kernel and coconut oil, while alkali-refining is assumed for the other oils. Transport includes transferring of the oil from the place of origin to the NL (road in Europe, ship overseas).

Results

The results from the environmental profiling including crop production, oil extraction and refining can be seen in *Figure 2*.

Across the impact categories of energy consumption, acidification, eutrophication and global warming there is consistency in the general ranking of the different oils. Sunflower and olive oils, followed by rapeseed oil tend to have high environmental burdens while those of coconut and palm oil tend to be low. Palm kernel and soyabean somewhere between these extremes.

As shown in *Table 1*, the largest burdens are associated with crop production (mostly due to the production and use of synthetic fertilizers), followed – in decreasing order - by crude extraction, transport and refining. Most of the variation between the different oils in these impact categories occurs in the agricultural stage and relies upon a combination of factors, as follows:

- sunflower oil tends to have high environmental impacts because of the relative low yields per hectare compared to other crops. This means that there are more fertilizers and pesticides required per tonne of oil produced, even though the amount applied per hectare does not seem larger in comparison to other crops;
- rapeseed oil shows a high environmental impact in spite of a higher yield. This because of the highest agricultural input requirements (fertilizer and pesticides) of all the oil crops;
- olive oil has higher environmental impacts than other perennial plantation crops because it requires significantly more fertilizers and pesticides and more intensive mechanization;
- coconut oil has very low impacts because very low levels of pesticides are used and most farm operations are carried out by hand so very little fuel is consumed;
- palm oil also performs well, primarily because of the very high yields per hectare that are obtained from palm plantations; and

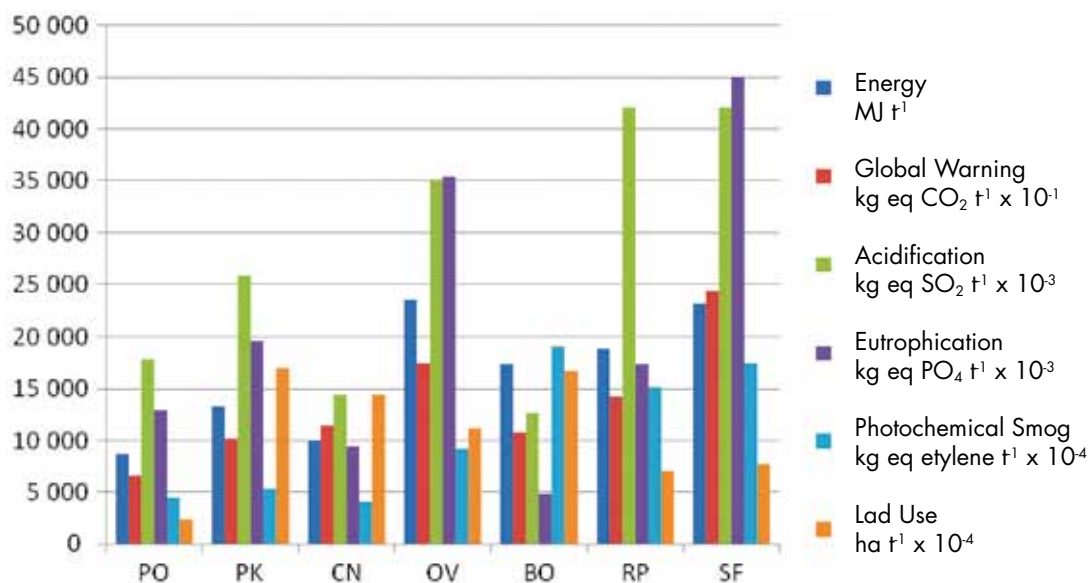


Figure 2. Environmental profile of plant oils.

- soyabean benefits from leguminoses being N-fixing (being self-sufficient in N) compared to the other annual crops but shows the lowest yield per hectare (a protein not an oil crop).

for extraction and perform therefore well in this category.

One factor that does not vary much from oil to oil is the impact due to transport. In absolute terms this is of the same order of magnitude whether the crop is produced in Europe (near the GMP-refinery assumed in the Netherlands) or much further away in Brazil or Malaysia. The impacts are a combination of type of transport and distance. Distribution by ship is much more efficient than distribution by road and the impacts from shipping remain near

the same level as those from road haulage.

EVALUATION OF THE LCA SYSTEM AND INTERPRETATION

Strengths and Weaknesses of the System

The strength of this model is that it provides a valuable tool for quantifying potential impacts using a limited number of impact themes. It can be used for assessing a production or product application process against a bench-mark or comparing a number of potential

The results for the photochemical smog category do not follow the same trend. Unlike the others the major contribution to photochemical smog occurs due to the hexane solvent (a VOC) used in the process. Palm and olive oil do not and palm kernel and coconut usually also do not depend on hexane

TABLE 1. CONTRIBUTION OF THE TWO MAJOR LIFE CYCLE PHASES AGRICULTURE AND PROCESSING (including expelling/extraction and refining) TO THE INDIVIDUAL IMPACT CATEGORIES IN %

Plant oil	Energy consumption		Global warming potential		Acidification potential		Eutrophication potential		Photochemical smog potential	
	Agric	Proc	Agric	Proc	Agric	Proc	Agric	Proc	Agric	Proc
Palm oil	41	22	62	7	77	1	97	-	34	6
Palm kernel oil	41	34	62	18	82	3	97	1	44	3
Coconut oil	27	41	68	15	68	5	95	1	14	20
Olive oil	69	9	79	4	93	1	98	-	62	4
Soyabean oil	40	30	48	22	50	12	82	5	21	60
Rapeseed oil	55	33	70	21	93	5	97	2	24	67
Sunflower oil	56	30	78	14	87	5	98	1	25	61

Note: 1. Agric: Agriculture; Proc: Processing.
2. Shortfalls account for transport.

options against each other. It can also be useful to ensure continuous improvements in environmental performance. For example, the potential effects of a number of different agricultural practices can be assessed in terms of the impact for the total agricultural stage, for the effect of improvements in one stage or the resulting effect on the total life cycle impact (e.g. pesticide use and the implications on the refining requirements).

The weakness of an LCA is that it is not suitable for addressing all environmental impacts. When considering total agricultural systems; issues relating to biodiversity, soil quality, and effects of pesticide use are better assessed using other tools. e.g. while burdens associated with pesticide production have been considered in the LCA models, the eco-toxicological impacts resulting from the use have been excluded.

Recent developments have also shown the potential temptation for a cherry picking at the expense of other categories. The example in

Figure 3 (IFEU, 2003) shows the environmental impact of rapeseed based biodiesel vs. fossil diesel. While some benefits can be achieved in GHG emissions, it also results in rather detrimental consequences in acidification, eutrophication and ozone depletion. Unfortunately, there is no real possibility for a summing up of the different elements!

All in All: The Net Environmental Benefit Remains Unclear' (IFEU)

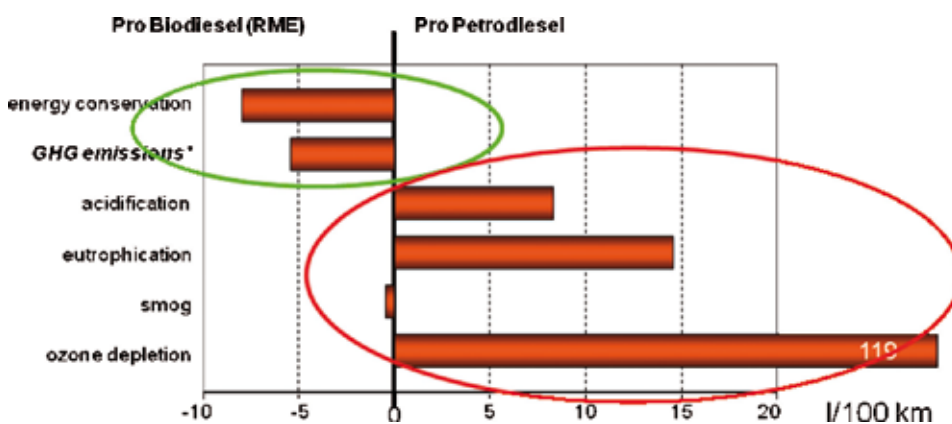
Also the impact of land conversion – a big issue in the huge biomass demand for biofuels – is not reflected in a LCA. This generally just covers land use per function unit what does not give justice to issues associated with wider sustainability aspects. This a weakness that becomes very obvious in context with the carbon footprint discussion for agricultural products and the environmentally justified biofuel developments as demonstrated in Table 2 for the examples palm oil and soyabean. The time period required for the product CO₂ pay back released by

land/wood conversion is too long to make this a feasible proposition.

CONCLUSION

LCA studies can provide important insights into where the major environmental impacts occur. They allow us to identify improvement options or to decide for alternatives to reduce environmental impacts. The results show the large impacts during the agricultural stage when growing oil crops relative to extraction, transport and refining. They also show the environmental strength of the perennial, tropical crops. Extending the typical borders of a LCA however also demonstrates the high sensitivity of significant expansions and land conversions (often applying particularly to plantation/tropical crops).

The results suggest that the most effective way of improving environmental performance is to encourage farmers to use good, sustainable agricultural practices. Product yield and agricultural input requirement indicate furthermore



Note: * Land use change and soil conversion effect not included

Figure 3. LCA profile of rapeseed methyl ester (RME) vs. petrol diesel showing positive and negative environmental effects of rapeseed oil derived biodiesel [there is more than Greenhouse Gas (GHG) only!!].

TABLE 2. LAND CLEARING AND THE BIOFUEL CARBON DEBT

Product	Land type	Carbon debt (t CO ₂ ha)	Debt allocated to biofuel (%)	Annual repayment (t CO ₂ ha ⁻¹ yr ⁻¹)	Time to repay biofuel carbon debt (yr)
Palmoil biodiesel	Tropical rain forest	702	87	7.1	86
	Peatland rain forest	3 452	-	-	423
Soyabean biodiesel	Tropical rain forest	737	39	0.9	319
	Cerrado, wooded	85	-	-	37

Source: Fargione *et al.* (2008).

the large effect of optimal growing conditions (including climate and soil conditions). Good agricultural practices can also bring benefits elsewhere in the life cycle, for example less intensive refining of pesticide-free oils.

Traditional LCA methodology is well defined in the ISO standards but, due to its complexity, modelling agricultural processes is particularly challenging. However, this area is developing with new tools coming to the market, such as PE International's Agrarian LCA model, that take into account some of the wider agricultural elements (such as use of pesticides, land use change/crop rotation, carbon sequestration, nitrogen cycle, *etc.*).

Clear definitions are also still missing for the carbon footprint or life cycle GHG emission information, a growing demand from

stakeholders (like customers and consumers) along the food supply chain and agriculturally derived products. There are initiatives ongoing and on international level, the World Business Council of Sustainable Development and World Resource Institute launched the GHG Protocol Product and Supply Chain Initiative. First guidelines should become available by early 2010.

Selecting alternatives with lower environmental impact might often be constrained by other demands however, in food particularly, to meet consumer expectations for taste and nutrition. To follow a real balanced, sustainable approach, social as well as economical aspects also have to be considered. The experience and results of the LCA's provide a stimulus for manufacturers to look more broadly at the total product issues. This can triggered

them to initiate the Sustainable Agriculture Initiative for their key raw materials with the objective to incorporate and balance all the impacts on the 3 P's (profit-planet-people) to meet their customers and consumers everyday needs for nutrition and hygiene!

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