COMPARATIVE LIFE CYCLE ASSESSMENT OF FIVE DIFFERENT VEGETABLE OILS

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OBJECTIVES

- To evaluate the environmental impacts of several major vegetable oils (**Fig. 1**), providing decision support for situations where these oils are substitutable.

Fig 1. Vegetable oils under study.

METHODS

Consequential life cycle inventory (CLCI) modelling

- The attributional approach would fail to comply with the purpose of the study, which focuses on predicting the consequences of choosing different oils. CLCI involved applying system expansion rather than allocation, and marginal rather than average suppliers.
- Production of refined vegetable oils is associated with by-products, namely oil meals from the oil mills and free fatty acids (FFA) from the refining process. Both are used as animal feed. Oil meals and FFA will substitute marginal suppliers of feed protein and feed energy in proportion with their protein and energy content.

Scope and assumptions

- The oils were inventoried from cradle to gate, including: 1) oil crop cultivation, 2) oil mill, and 3) refinery. The palm oil system includes an additional step, since the kernels are sent to another oil extraction step. **Fig. 2** shows the process diagram for palm oil and rapeseed oil.
- The functional unit is 1 ton of refined oil.
- Marginal suppliers are summarised in **Table 1**. Feed protein is based on Brazilian soybean, whereas feed energy is based on barley from Ukraine.

Table 1. Marginal suppliers of main raw materials.

Product	Fresh fruit bunches	Soybean	Rapeseed	Sunflower	Peanut	Barley
Supplier	Malaysia/Indonesia	Brazil	EU27	Ukraine	India	Ukraine

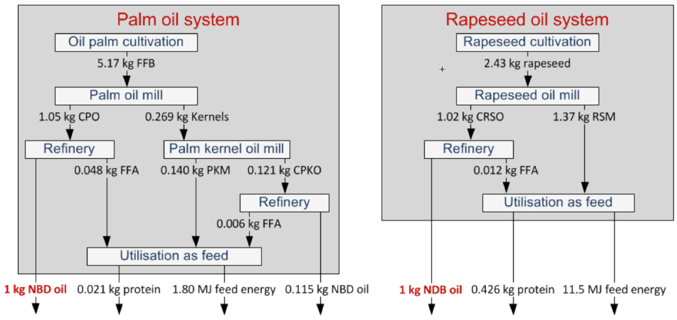

Fig. 2. Process diagrams for palm oil (left) and rapeseed oil (right). NBD: neutralized, bleached, deodorized, FFB: fresh fruit bunches, CPO: crude palm oil, CPKO crude palm kernel oil, FFA: free fatty acids, PO: palm oil, PKO: palm kernel oil, PKM: palm kernel meal, RSM: rapeseed meal, CRSO: crude rapeseed oil.

- For all systems the determining product is the oil, whereas in soybean it is the meal. Thus demanding soybean oil does not lead to soybean oil production, but to the marginal oil production, assumed to be palm oil.
- Indirect land use change (iLUC) is included by means of a deterministic model taking into account land transformation and land intensification (**Fig. 3**) [1].
- Impact assessment is performed at midpoint, including Greenhouse-gas (GHG) emissions, water use, water use adjusted for the Water stress index (WSI) and land occupation.
- Temporary biogenic carbon sequestration in the oil is included as a negative emission of -2.8 kg CO_2/kg oil.

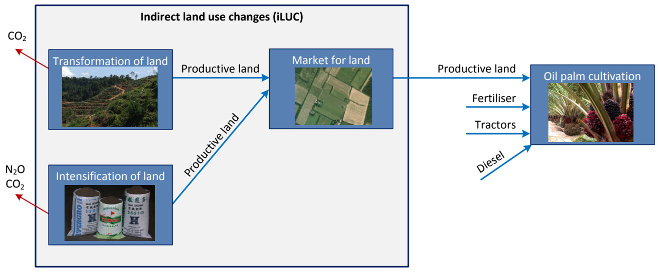

Fig. 3. Conceptual representation of the iLUC model used in the study.

RESULTS

- GHG emissions are lowest for rapeseed oil and the highest for peanut oil. The latter is related to low yield.
- iLUC substantially increases GHG emissions, but the ranking is not changed.
- Rapeseed oil and sunflower oil involve a net saving of freshwater, due to the displacement of animal feed through meal by-product.
- The inclusion of the WSI factor does not change the ranking of oils in terms of water use.
- Land occupation is higher for peanut oil and sunflower oil, due to lower yields.
- The results of palm oil and soybean oil are equal since soybean oil is constrained (the meal is determining). Consequently, demand for soybean oil leads to production of the marginal oil, i.e. palm oil.

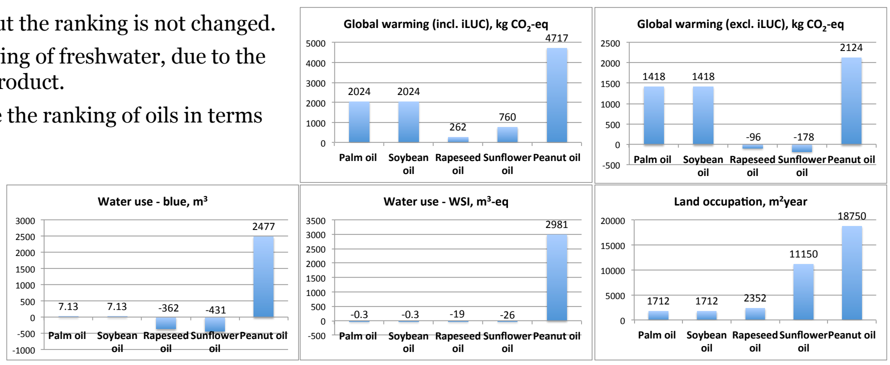

Fig. 4. Results per ton refined oil. Global Warming includes biogenic carbon sequestration in the oil.

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References: [1] Schmidt J H, et al. (2012) A model of indirect land-use change. 8th International Conference on LCA in the Agri-Food Sector, 1-4 Oct 2012, St. Malo, France. [2] Schmidt J H (2014) Life cycle assessment fo five vegetable oils. Journal of Cleaner Production, submitted.