Sensitivity analysis

The net result is very sensitive to the preceding vegetation. For the oil palm example, a minimum emission reduction efficiency of 35% can only be reached in a 2nd production cycle, or when oil palm replaced vegetation of less than 40 t C/ha. Investment in CH_4 capture at the mill can improve the situation. Where peat soils are used, the effects of drainage on emissions usually means the target efficiency can not be met. A third factor with considerable influence is the use of N fertilizer in relation to yield. Increase in N use efficiency can lower costs as well as help reaching the fossil fuel substitution efficiency.

Figure 3. pictures of oil palm, coconut, jatropha and sugarcane as 4 biofuel feedstock sources

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Biofuel Emission Reduction Estimator Scheme (BERES)

Land use history, current production system and technical emission factors

Trees in Multi-Use Landscape in Southeast Asia (TUL-SEA)
A negotiation support toolbox for Integrated Natural Resource Management

Biofuel use can decrease or increase net CO_2 emissions?

Biofuels appeared to be such a nice way of reducing the climate change challenge: it reduces political dependence on fossil fuel supply, can be done with minimal change to existing engines and modes of transport, and provides new sources of income for rural economies. Calculations of the area needed to make a dent into current fossil fuel use quickly showed that it cannot be a substantial contribution to energy issues without requiring large areas and interfering with markets for food crops. If biofuel production extends beyond current agriculture, it will often increase emissions of carbondioxide. The net effect will be often a lower estimate of emission reduction than expected, but if high C-stock land is cleared, biofuel use can also increase net emissions. The debate on such emission enhancement has focussed on oil palm in the humid tropics of SE Asia, where forest and peatland conversion currently lead to large emissions – with or without a specific role for oil palm expansion. The public debate, however, has linked the two issues. The EU provided guidance to countries on minimum standards that should be used when biofuels are included in national renewable energy plans. Until 2017, a minimum emission reduction of 35% has to be achieved for any fuel included in the scheme, shifting to 50% by 2017 and 60% beyond. Default estimates are given for major current or potential sources of biofuel. A procedure was established to calculate emission reduction factors, using a lifecycle approach. Specific market flows of biofuels can apply for exception from the 'default' for the commodity. These procedures create the need for exporting countries and entities to understand the steps in calculation and to do the research needed to get reliable data.

Carbondioxide (CO_2) and other greenhouse gas emissions due to the production of biofuel can be attributed to three phases of the production process:

A. the initial conversion of preceding vegetation into a biofuel feedstock plantation, usually based on 'land clearing',
B. the balance of emission and absorption during the growth cycle of the plants, depending on growth rate, green manure and organic waste management and fertilizer practices, and
C. transport to the refinery followed by processing and further transport to the end users.

Emission estimates require data on all three steps:

$$E = \textit{total emissions from the use of the fuel} =$$

$$e_l + e_{ec} + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr} - e_{ee}$$

A
e_l =annualised emissions from carbon stock changes caused by land-use change;

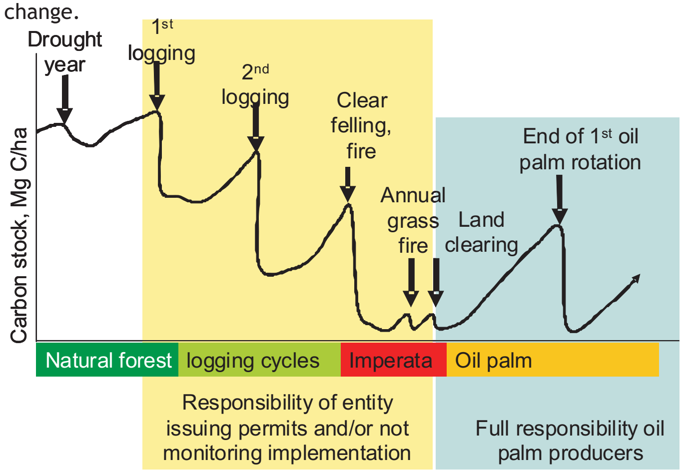
B
e_{ec} =emissions from the extraction or cultivation of raw materials;
e_{sca} =emission saving from soil carbon accumulation via improved agricultural management;

C
e_p =emissions from processing;
e_{td} =emissions from transport and distribution;
e_u =emissions from the fuel in use;
e_{ccs} =emission saving from carbon capture and geological storage;
e_{ccr} =emission saving from carbon capture and replacement; and
e_{ee} =emission saving from excess electricity from cogeneration.

We focus here on steps A and B, relating directly to land use; examples relate to palm oil.

A. Land cover change: Carbon debts and Carbon gains

Land cover change often involves multiple steps between 'natural forest' and 'biofuel feedstock plantation'. The first challenge is to reconstruct what happened by analysis of remote sensing imagery (time-series) combined with interviews with local witnesses. The second step is to negotiate the 'attribution' of this change to multiple actors and agents (e.g. legal, government sanctioned and illegal logging, natural and human-induced fire). See RASA for details on the methods for reconstructing land cover change.



Responsibility of entity issuing permits and/or not monitoring implementation

Full responsibility oil palm producers

Figure 1. Trajectories of land uses and the dynamics of C-stock; attribution is often contested more than what happened to aboveground vegetation.

B1. Time-averaged C stock of the production system

The average over a production cycle of the sum of 5 C pools (aboveground biomass, understorey vegetation, surface necromass, soil organic matter and roots) is called 'time-averaged C stock'. When the preceding vegetation has a higher time-averaged C stock, the plantation starts with a 'Carbon Debt' with a 'pay back time' or annualized draw on the biofuel C accounting. If it is lower, the el term can reflect a net emission saving for the first production cycle. Methods for measurement of the pools where described in RACSA methodology and technical manuals.

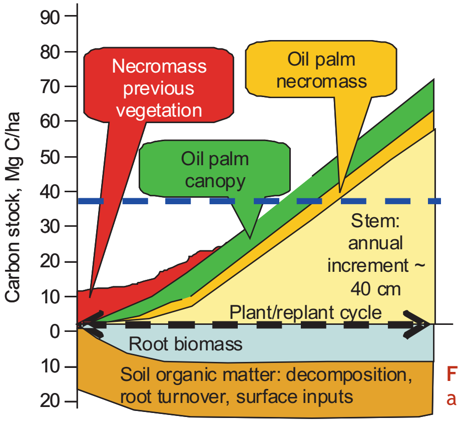


Figure 2. Components of C-stock in oil palm plantation and its time-averaged over a planting cycle (schematic)

B2. Changes in soil C content?

Plantation management includes use of cover crops, recycling of dead leaves and litter, recycling of organic wastes from the factory. Rather than having to trace all these flows, we focus on the end result. Appropriate sampling scheme for soil C can compare actual to what would be expected under forest soil conditions ('C/Cref' ratio). Sampling depths is an issue. For peat soils a separate calculation scheme is needed, as the whole profile can change.

B3. Greenhouse gas emissions linked to fertilizer use

IPCC National Greenhouse Gas inventory guidelines suggest that 1% of N fertilizer is lost as N_2O from agricultural systems. Other literature suggests this can be 4%. In the absence of site-specific measurements, both assumptions can be compared for impact on the end result.

C. Technical coefficients

Emission factors for transport and mill are based on fossil fuel use and technical design of mill and processing steps before the product reaches the end-user.

Integrated scheme

Current 'default' value refers to knowledge at inception stage and will be modified by the full-scale assessment:

Phase	Parameter	Default	Based on:
A	Accounting period for plantation (yr)	25	Policy decision, ideally linked to typical production cycle
A	Attributable time-averaged C stock before the plantation crop was planted [t C/ha]	60	Pre-condition (can range from 250 to 0 t C/ha
B	Time-averaged C stock of the plantation crop [tC/ha]	40	Pilot-phase field assessments; value depending on management style
B	N-fraction of fertilizer-N lost as N_2O	0.04	Literature value to be updated by actual emission studies; 0.01 is current IPCC default, 0.04 is based on Crutzen et al. (2008)
B	Peatland CO_2 loss per cm drain depth, Mg CO_2/(ha.yr)	0.8	Literature value to be updated by new findings
B	Mineral soil CO_2 loss (depending on EFB and POME recycling to maintain C_{org} levels…)	0	Assumption linked to soil C studies
B	Peatland?	0	Pre-condition
B	Peatland drain depth, cm	50	Management choice
C	N fertilizer use (kg N/ha, averaged over lifecycle)	150	Management choice
C	FFB yield Mg per ha/yr (averaged over life cycle)	21.12	Depending on management style
C	CPO extraction rate (OER), % CPO per FFB	20.5	Technical coefficient
C	Kernel extraction rate (pKER), % Ker per FFB	5.2	Technical coefficient
C	PKO kernel oil per kernel extracted	0.5	Technical coefficient
C	**C concentration of CPO**	0.6	Technical coefficient
C	**C concentration of Kernel oil**	0.6	technical coefficient
C	Mill emissions of CH_4 expressed as CO_2eq/t C extracted	0.6	Mill dependent
C	CO_2eq emissions processing and transport , t CO_2eq/t C	0.2	Depends on distance to port
C	Biodiesel production per t CPO	0.87719	Technical coefficient
C	Biodiesel / fossil fuel diesel equivalence ratio	1	Technical coefficient
Instants			
	CO_2/C	3.66667	
	N_2O/N	1.57143	
	GWP of N_2O relative to CO_2	296	
Intermediate steps			
	Annual oil harvest, t C/(ha.year)	2.92723	
	Annual CO_2e emissions due to production [t CO_2eq/(ha.year)]	2.79086	
Results			
	Payback time [years]	13.1	
	Net C sequestration during first production cycle (I): tCO_2eq/(ha.year)	2.67	
	Net C sequestration during second production cycle (II): tCO_2eq/(ha.year)	5.60	
	Fossil fuel emissions substituted by biodiesel, 1st production cycle (I): tCO_2eq /t biodiesel	0.62	
	Fossil fuel emissions substituted by biodiesel, 2nd (or subsequent) production cycle (II): tCO_2eq /t	1.31	
	Fossil fuel substitution efficiency CO_2eq/CO_2eq, 1st cycle (I)	0.17	Well below the target
	Fossil fuel substitution efficiency CO_2eq/CO_2eq, 2nd cycle (II)	0.36	This meets the 35% target