

“Comparative study on the sustainability of vegetable oils”

Comparing the contributions of palm oil in Indonesia, soybean oil in Brazil and rapeseed oil in Germany until 2030/2040 to UN SDGs

21 July 2025



Agenda

9:00 – 9:05	Introductions
9:05 – 9:10	Wolter Elbersen: Methods and introduction to oil palm + scenarios
9:10 – 9:15	Sjaak Conijn: Introduction to soybean and rapeseed + scenarios
9:15 – 9:20	Suria: Comparison land use efficiency
9:20 – 9:30	Wolter Elbersen: Comparison GHG performance
9:30 – 9:45	Maja Slingerland: Comparison on biodiversity and socio-economic performance + concluding remarks

3 crops same approach

- For oil palm, focus on Indonesia
- For soybean, focus on Brazil
- For rapeseed, focus on Germany

Define production chain for the different growing systems:

Oil palm: 4 systems: peat vs mineral soil and smallholder vs industrial

Soybean: conventional vs minimum/no tillage

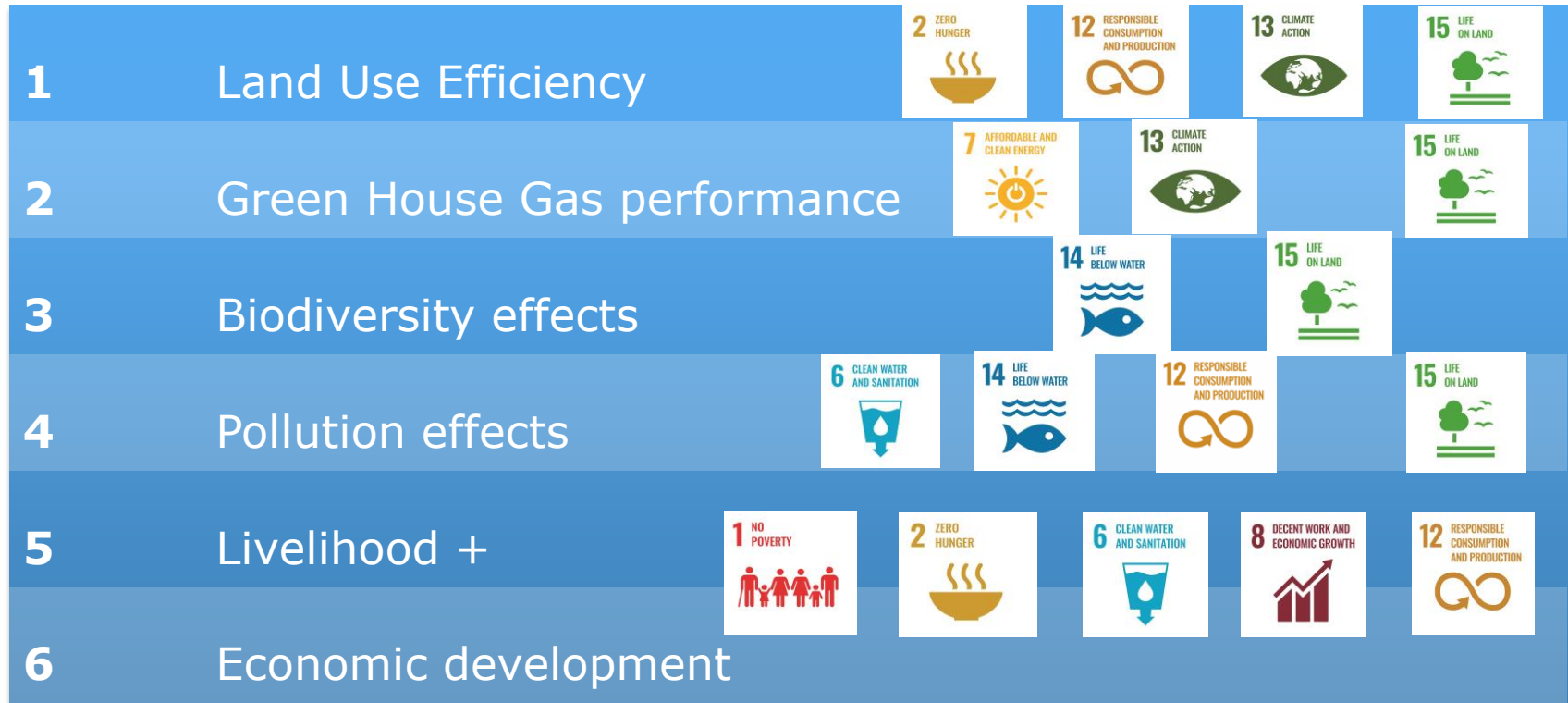
Rapeseed: One system (winter rapeseed)

Current (2020) and 2 scenarios to 2040:

BAU (Business as usual) and (very) Ambitious

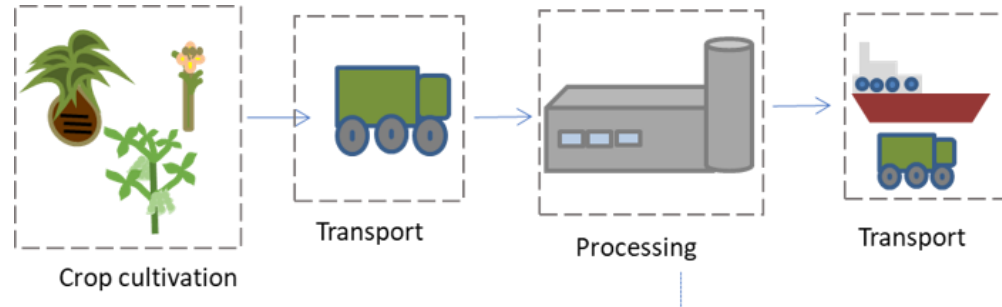


Linking SDGs to impacts categories



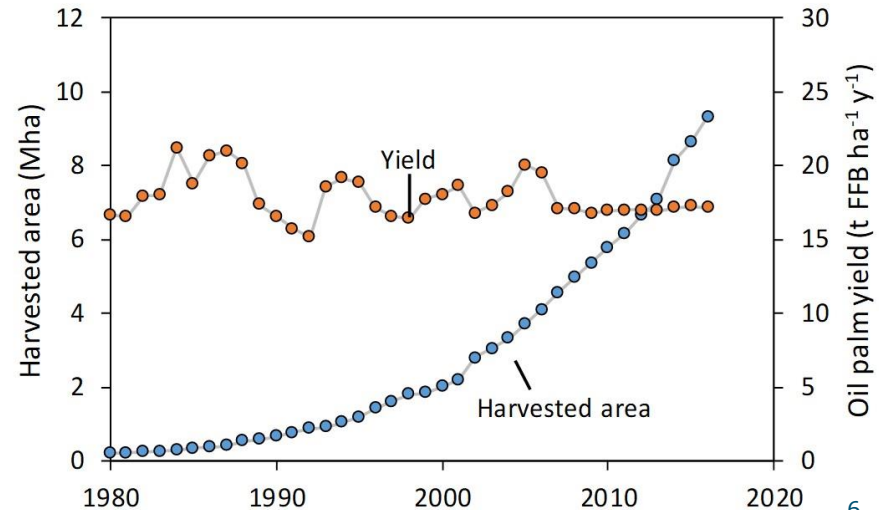
Methods

- Comparing Crude oil up to delivery to Rotterdam and Jakarta: CPO, CSO, CRO. Excluding refinery of oil
- Allocation of impacts to oil, and co- and by-products on basis of economic allocation vs all impacts allocated only to the oil
- Comparisons made for Current (2020) to BAU (extrapolation to 2040) and Very Ambitious (2040)



Oil Palm perennial crop

- 3 to 4 years immature; replanting after 25 to 30 years
- High oil yields but yield/ha stagnant
- Large expansion in last 20 years (replacing rubber, rice, etc and forest)
- Main product CPO



Not only oil – also co-products and residues, intercropping and livestock integration

FFB	193	\$/ton FW
CPO	1194	\$/ton DW
PKO	1561	\$/ton DW
PKM	100	\$/ton DW
Shell	100	\$/ton DW
MF	50	\$/ton DW
EFB	20	\$/ton DW
POME	25	\$/ton DW
Trunk	15	\$/ton DW
Intercropping	100	\$/ha/yr
Cattle grazing	50	\$/ha/yr



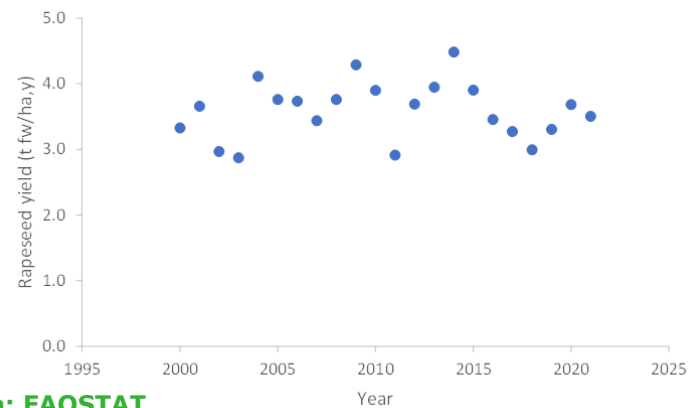
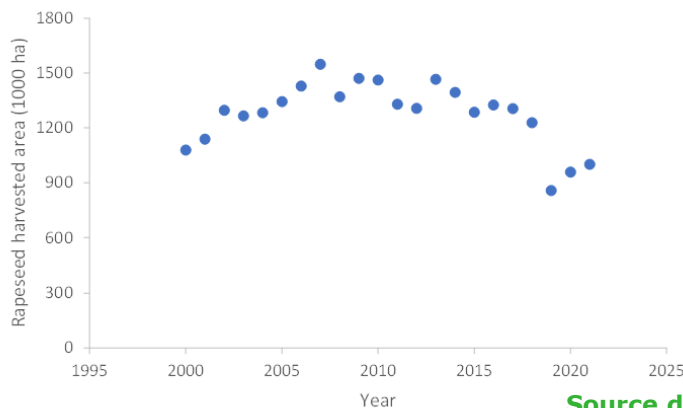
Oil Palm scenarios 2040: BAU vs very ambitious

	Current	BAU	Very Ambitious
	2020	2040	2040
Yield improvement		--	25%
Peatland			
Improved drainage <-50 cm		0%	20%
Palm on peat phased out		0%	80%
Intercropping (first 4 years)			
Industrial	0%	0%	40%
Smallholder	10%	20%	60%
Cattle grazing (mature stand)	3%	3%	30%
POME methane emissions capped	6%	24%	90%
Shell sold	50%	50%	90%
Mesocarp fibre sold for other applications	1%	1%	40%
EFB sold for other applications (fibre, methane, pellets)	2%	2%	40%
POME methane sold for energy	3%	12%	45%
Trunk sold for applications (wood, gula, starch)	1%	1%	40%

Rapeseed in Germany

Current cultivation practices (~ 2020)

- Annual crop (ca. 6-9 months), arable rotation, sown in autumn (winter variety) or sown in spring (spring variety)
- This study: one cultivation system (winter rapeseed)
- Production of meal (animal feed) and vegetable oil (40%)
- Straw can be harvested too, but reliable data are missing
- Whole cultivation is highly mechanical



Rapeseed scenarios

Main assumptions for

Current (~2020) ➔ BAU(2040) or Very ambitious (2040):

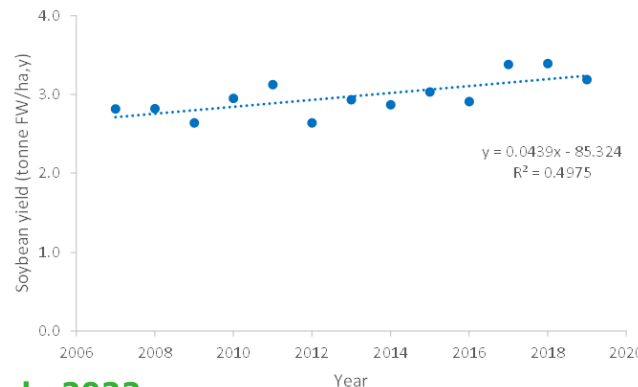
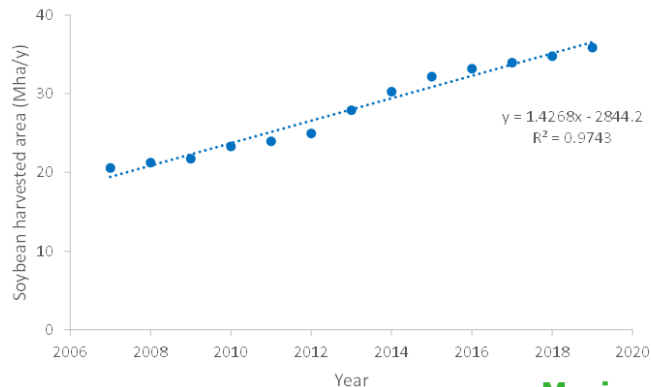
- No area increase
- Yield increase (from 3.6 to 4.9 ton/ha,yr)
- No increase in straw use
- Higher NPK fertiliser use (e.g. from 176 to 197 kg N/ha,yr)
- Reduction in pesticide use (from 1.9 to 0.4 kg/ha,yr)

➤ Rapeseed in Germany: no issues with peat or deforestation (<20 years)

Soybean in Brazil

Current cultivation practices (~ 2020)

- Annual crop (ca. 4 months), no rotation, partly double cropped (maize)
- Production of meal (animal feed) and vegetable oil (19%)
- This study: two systems: minimum/no tillage and conventional
- Leaves are shed (no by-product) + demand for mulch (min. till)
- Cultivation is highly mechanical and partly on former forest land



Marin et al., 2022



Soybean scenarios

Main assumptions for

Current (~2020) → BAU(2040) or Very ambitious (2040):

- Area increase (from 36 to 66 or 43 Mha in 2040)
- Yield increase (from 3.2 to 3.7 or 4.4 ton/ha,yr in 2040)
- More double cropping (100%, where possible), less fallow land (→ 0%)
- Very ambitious scenario: zero deforestation and zero fertiliser N application (from 6.1 kg N/ha,yr); less pesticide use (-50%)

➤ Soybean in Brazil: no issues with peat

Land use efficiency of crude oil production

➤ **Definition:**

Amount of produced vegetable oil per hectare of land *occupied/used in a year* (365 days)

➤ **Reduction of land use efficiency:**

- Land needed for seeds and nursery (generally very small)
- Land used during non-productive years in total plantation duration (i.e. juvenile phase)
- Land left fallow in the agricultural system (*soybean* in Brazil)

➤ **Increase of land use efficiency:**

- Increased productivity
- Land shared with other crops within one year (e.g. *soybean*+maize) or within plantation period (e.g. *oil palm*+livestock)
- Selling co-products and residues (i.e. soybean cake, oil palm trunks) if economic allocation is used

Results land use efficiency

	Current (2020)			Business as usual 2040			Very ambitious 2040		
	Oil palm	Soybean	Rapeseed	Oil palm	Soybean	Rapeseed	Oil palm	Soybean	Rapeseed
Crude oil yield	----- ton oil per ha per year-----								
- 100% allocated to oil	3.2	0.6	1.4	3.2	0.8	1.4	4.0	1.3	1.9
- economic allocation	3.8	1.6	1.8	3.8	1.9	1.8	4.8	3.1	2.6

Currently (2020)

Palm oil has the highest land use efficiency: 3.8 ton oil / ha (= 2.4 x soybean oil and 2.1 x rapeseed oil)

In v. ambitious scenario 2040

Palm oil has the highest land use efficiency: 4.8 ton oil / ha (= 1.5 x soybean oil and 1.8 rapeseed)

Note: The crude oil yield presented here is the amount of oil that is allocated to one ha. If co-products and residue are also produced and sold this will reduce the allocated land to crude oil.

Greenhouse gas emissions

➤ For each sub-system we have calculated GHG emissions:

❑ *Crop cultivation, includes*

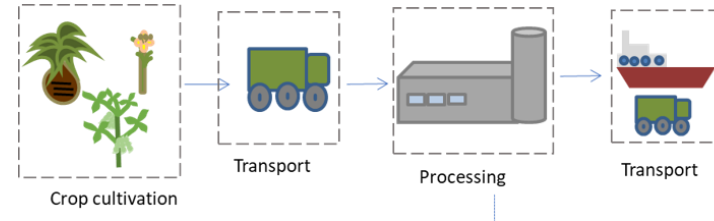
- Deforestation discounted over 20 years (IPCC)
- Peat oxidation (40 to 80 ton CO₂ eq/ha)
- Field operations (planting, harvesting, fertilization, etc.)

❑ *Transport to mill*

❑ *Crude oil extraction, including handling waste streams (POME CH₄ emission)*

❑ *Transport to Rotterdam or Jakarta*

➤ GHG emissions include CO₂, N₂O (273) and CH₄ (26.5)



Results GHG emissions

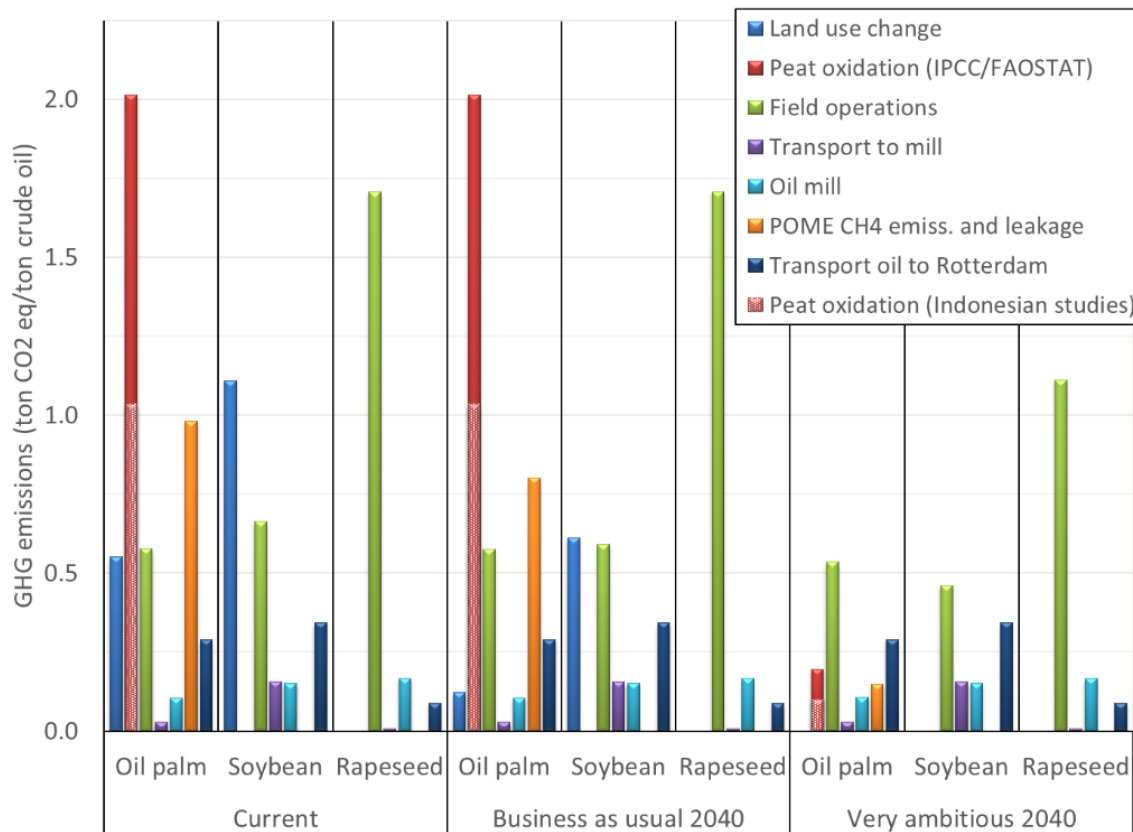
	Current (2020)			Business as usual 2040			Very ambitious 2040		
	Oil palm	Soybean	Rapeseed	Oil palm	Soybean	Rapeseed	Oil palm	Soybean	Rapeseed
GHG emissions	----- ton CO ₂ -eq/ton crude oil -----								
Delivery to Rotterdam									
- 100% allocated to oil	4.2 / 5.3	5.4	2.6	3.4 / 4.6	4.0	2.6	1.4 / 1.5	2.2	1.8
- economic allocation	3.6 / 4.5	2.4	2.0	3.0 / 3.9	1.9	2.0	1.2 / 1.3	1.1	1.4
Delivery to Jakarta									
- 100% allocated to oil	3.0 / 5.1	5.5	2.9	2.3 / 4.4	4.1	2.9	1.3 / 1.3	2.3	2.1
- economic allocation	3.3 / 4.3	2.5	2.2	2.7 / 3.7	1.9	2.2	1.0 / 1.1	1.1	1.6

- Currently (2020) GHG emissions: oil palm > soybean > rapeseed
- BAU (2040) GHG emissions: oil palm > rapeseed > soybean
- Very ambitious scenario (2040) GHG emissions: rapeseed > oil palm > soybean
- Very ambitious assumptions:
 - Oil Palm: no deforestation, phasing out palm on peat, capping methane from POME, residue valorization, yield increase.
 - Soybean: no deforestation, yield increase and more double cropping.
 - Rapeseed: yield increase.

GHG emissions for palm, soybean and rapeseed oil, economic allocation (to Rotterdam)

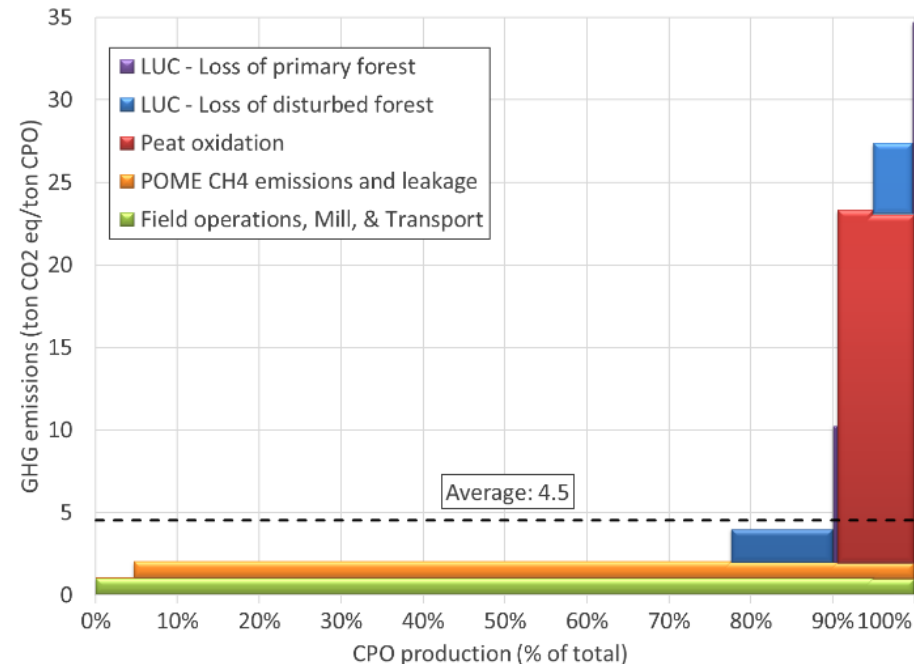
Largest impacts:

- Peat oxidation
- Deforestation (LUC)
- Field operations
- Methane (POME)
- *No improvements assumed for transport or fertilizer production*

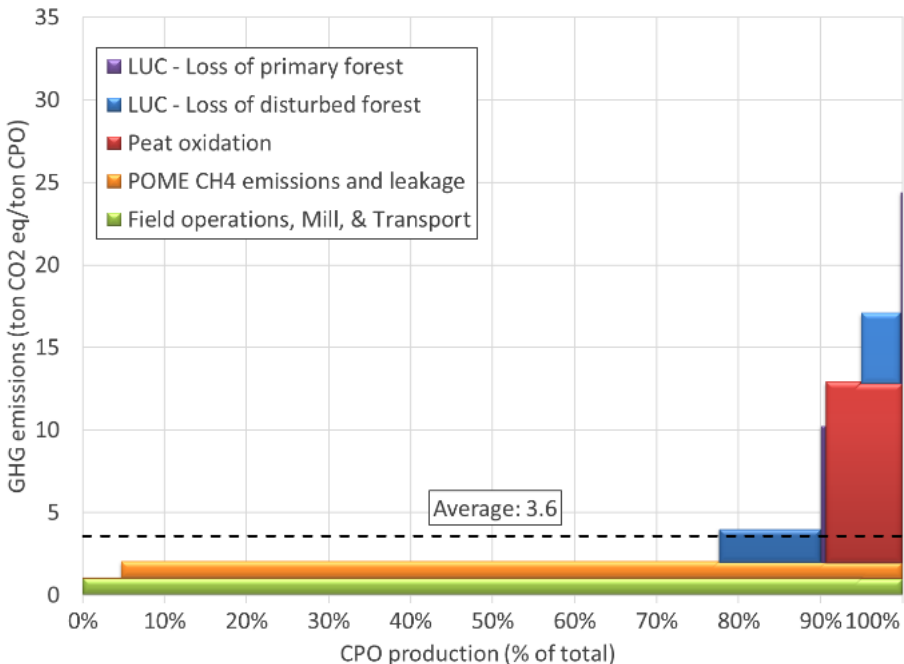


Current (2020) GHG emissions for CPO production

Assuming 80 tons CO₂-eq/ton crude oil



Assuming 40 tons CO₂-eq/ton crude oil

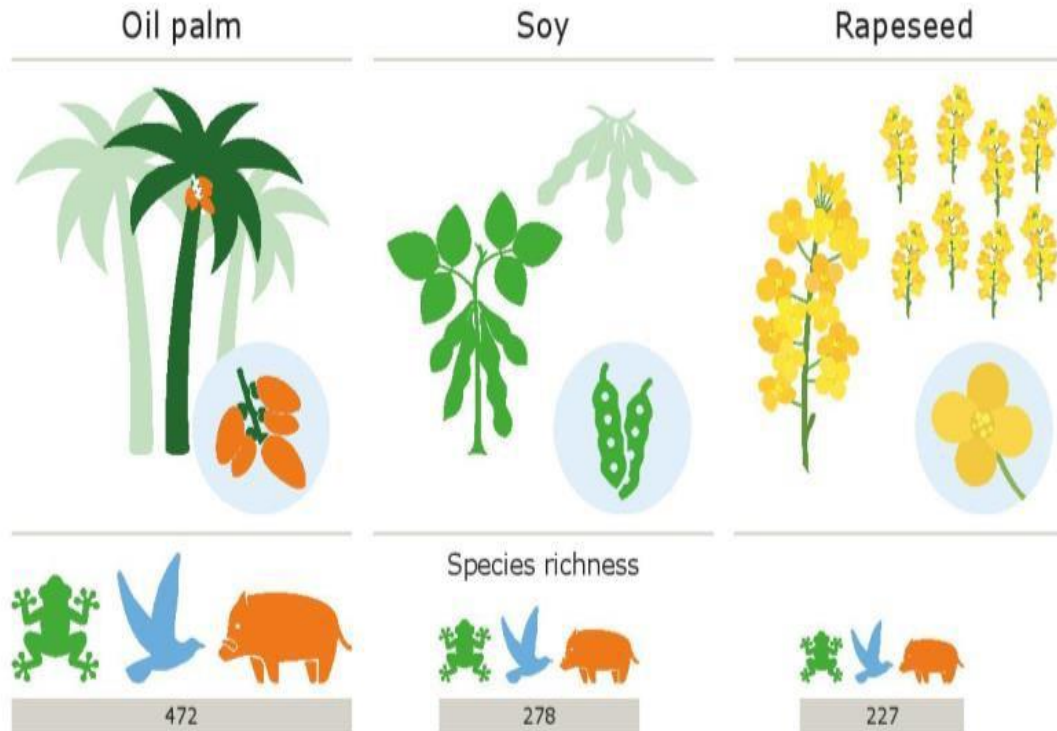


Recent biodiversity loss due to deforestation

Forest type	Indonesia oil palm	Brazil soybean
	2001-2020 (ha)	2002-2019 (ha)
Primary	154,044	1,344,000
Secondary	2,750,668	3,430,000
TOTAL	2,904,712	4,774,000

- **Primary forest** has a higher biodiversity value than **secondary** (e.g. logged-over) forest
- Recent **total** deforestation: *Soybean* > *Oil palm* > (*Rapeseed*)
- Recent loss of **biodiversity rich** primary forest: *Soybean* > *Oil palm* > (*Rapeseed*)

Biodiversity impact: species diversity in fields



Species diversity in fields:

oil palm > soybean > rapeseed

Contribution to Food Security

- Fats are energy dense (9 calory/g), contain essential fatty acids and fat-soluble vitamins which are indispensable for diets
- In 2020 soybean oil (25.2) contributed more to global food security than palm oil (20) and rapeseed oil (9.4 million ton)
- Palm oil is cheapest and therefore contributes most to dietary fat requirements of poor people worldwide



Contribution to employment

Current

Palm oil has highest contribution to smallholder employment (number and % of smallholders & labour per t of oil). Rapeseed oil has lowest contribution.

Very ambitious scenario

- Palm oil contribution remains the highest while intercropping and livestock integration even further increase employment
- Soybean contribution remains lower than palm oil even though double cropping increases employment (mechanization)

Contribution to livelihood

Current

Palm oil is cheapest of the three oils but oil palm has relatively highest oil production/ha → revenue/ha: oil palm > rapeseed > soybean

Cost of living Indonesia < Brazil < Germany → Contribution of vegetable oil to cost of living: oil palm > soybean > rapeseed

Very ambitious scenario

- Income increase for all, oil palm scores still highest



Contribution to export value & % GDP

Export value (Billion USD, 2020)

- Oils only: oil palm (27.3) > soybean (2.1) > rapeseed (1.77)
- Crops: soybean (48) > oil palm (29.6) > rapeseed (2.63)

Very ambitious scenario

- All crops generate extra export value from extra yield
- Oil palm and soybean also from co-products and residues

Concluding remarks

Current

- Palm oil scores best on land use efficiency
- Palm has lowest score on GHG performance
- Palm has best score for socio-economic performance

BAU – extrapolates current trends and brings limited changes towards 2040

Very ambitious (2040) assumes strong interventions (!) for oil palm and soybean

- Palm will still have best land use efficiency
- Palm will then have much lower and similar GHG emissions as the others

Thank you

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