

Assessing the Sustainable Development of Oil Palm Industry in Thailand

A Life Cycle Assessment Approach

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World Vegetable Oil Production

World Palm Oil Producers(2018)

Indonesia	55.90%
Malaysia	27.90%
Thailand	3.90%
Colombia	2.30%
Nigeria	1.50%
Others	8.50%

Total production
=70.6 million tonnes

Palm oil
39.7%

Soybean oil
27.8%

Rapeseed
14.1%

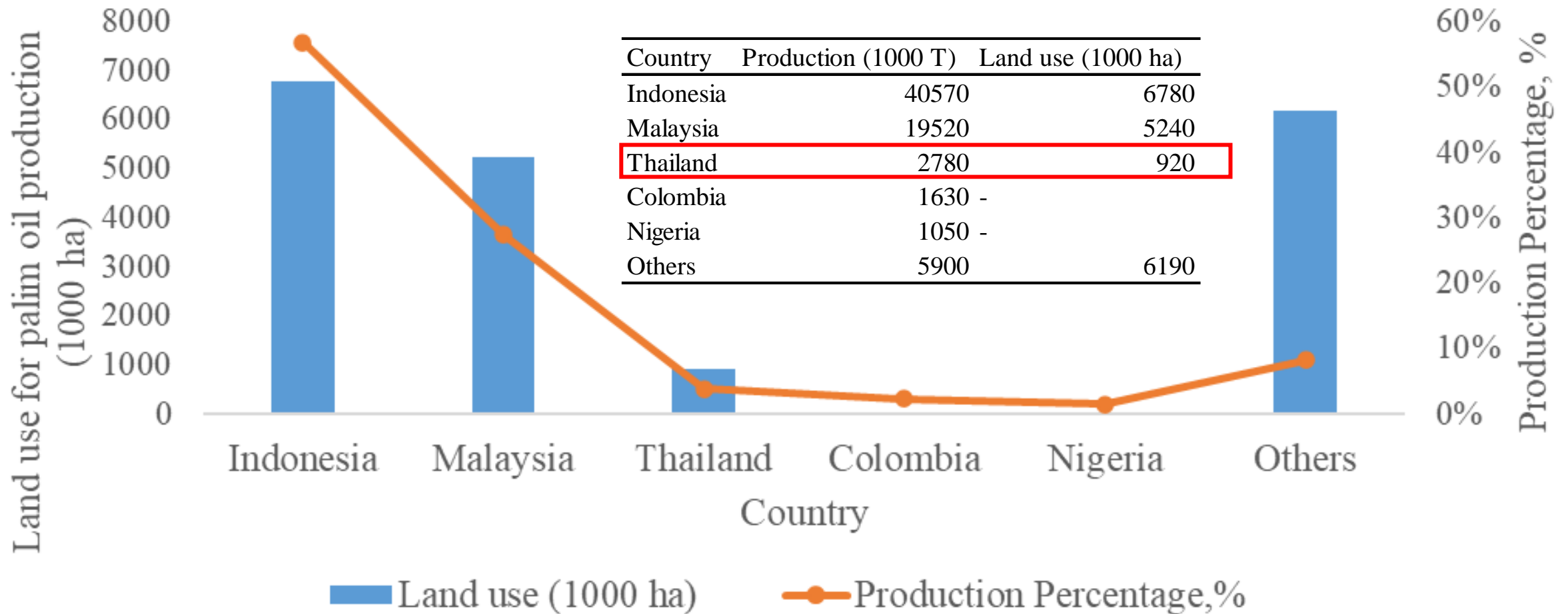
Sunflower
seed oil
9.3%

Others
9.1%

Environmental Impacts of the Oil Palm Cultivation

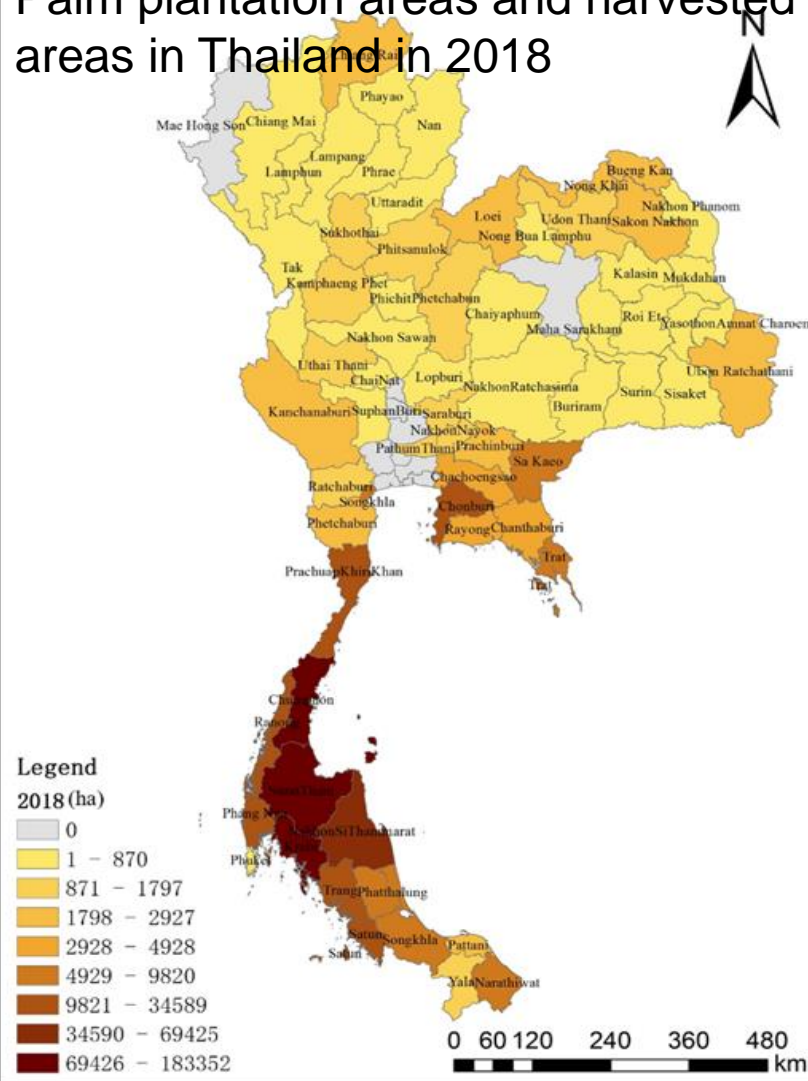
- DEFORESTATION
- AIR POLLUTION
- SOIL AND WATER POLLUTION
- SOIL EROSION
- CLIMATE CHANGE

Land use for palm oil production and production percentage in 2018





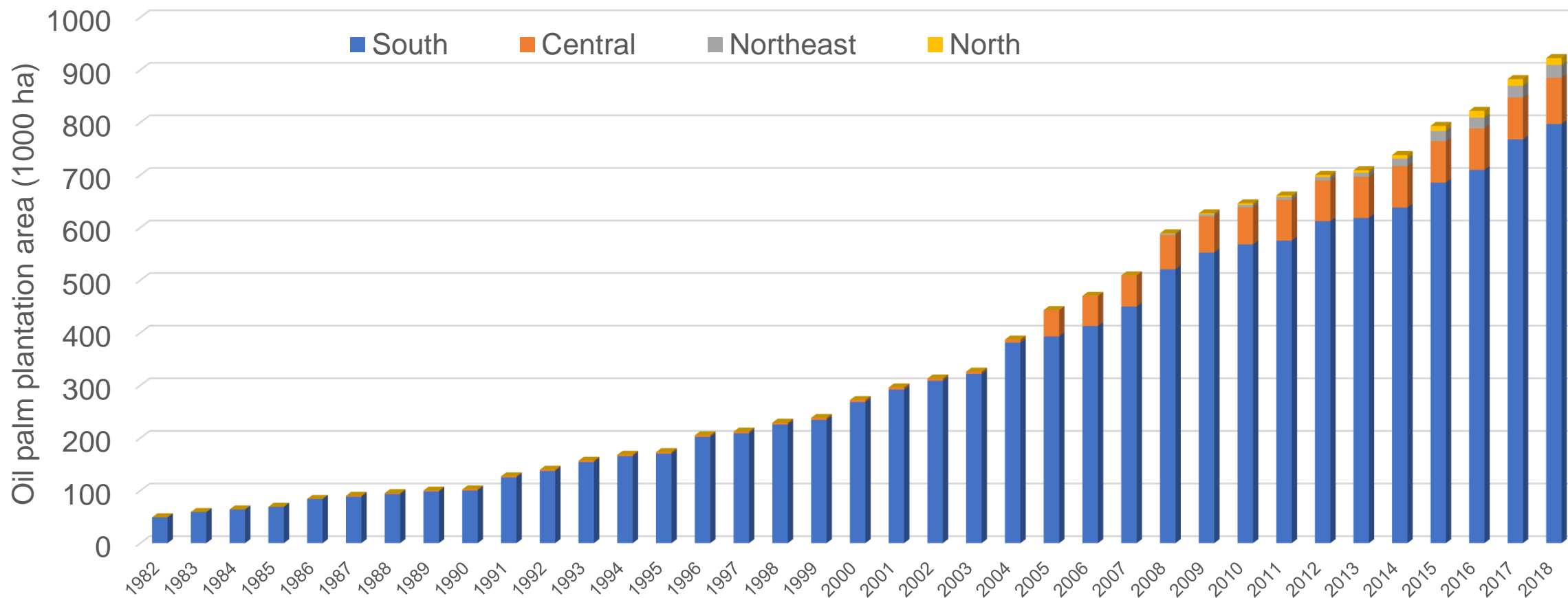
Palm plantation areas and harvested areas in Thailand in 2018



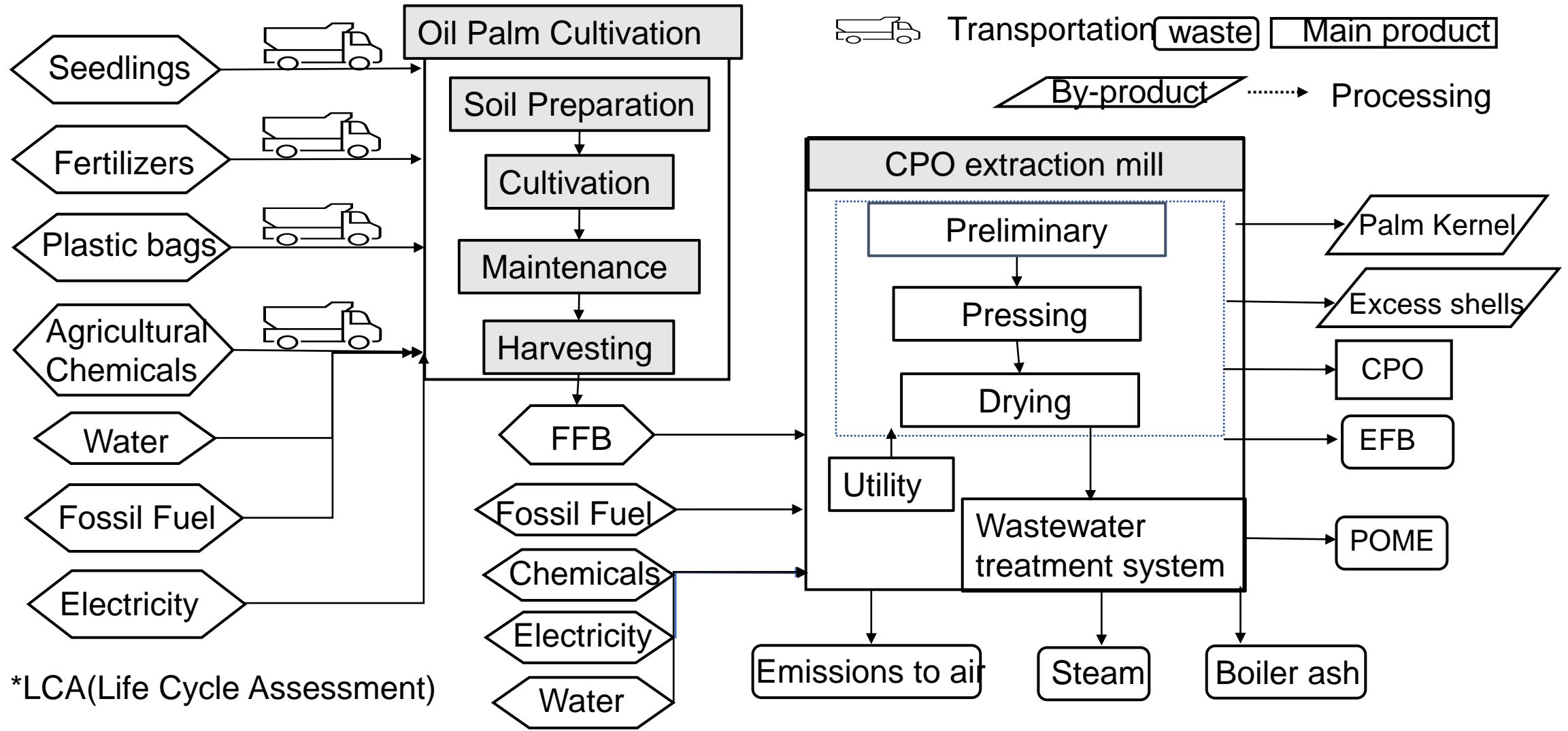
Regions	Planted area (ha)	Harvested area (ha)
North	13236	12147
Northeast	24162	20539
Central	88010	77997
South	796960	703496
Whole Kingdom	922368	814179



Thailand's oil palm plantation areas from 1982 to 2018

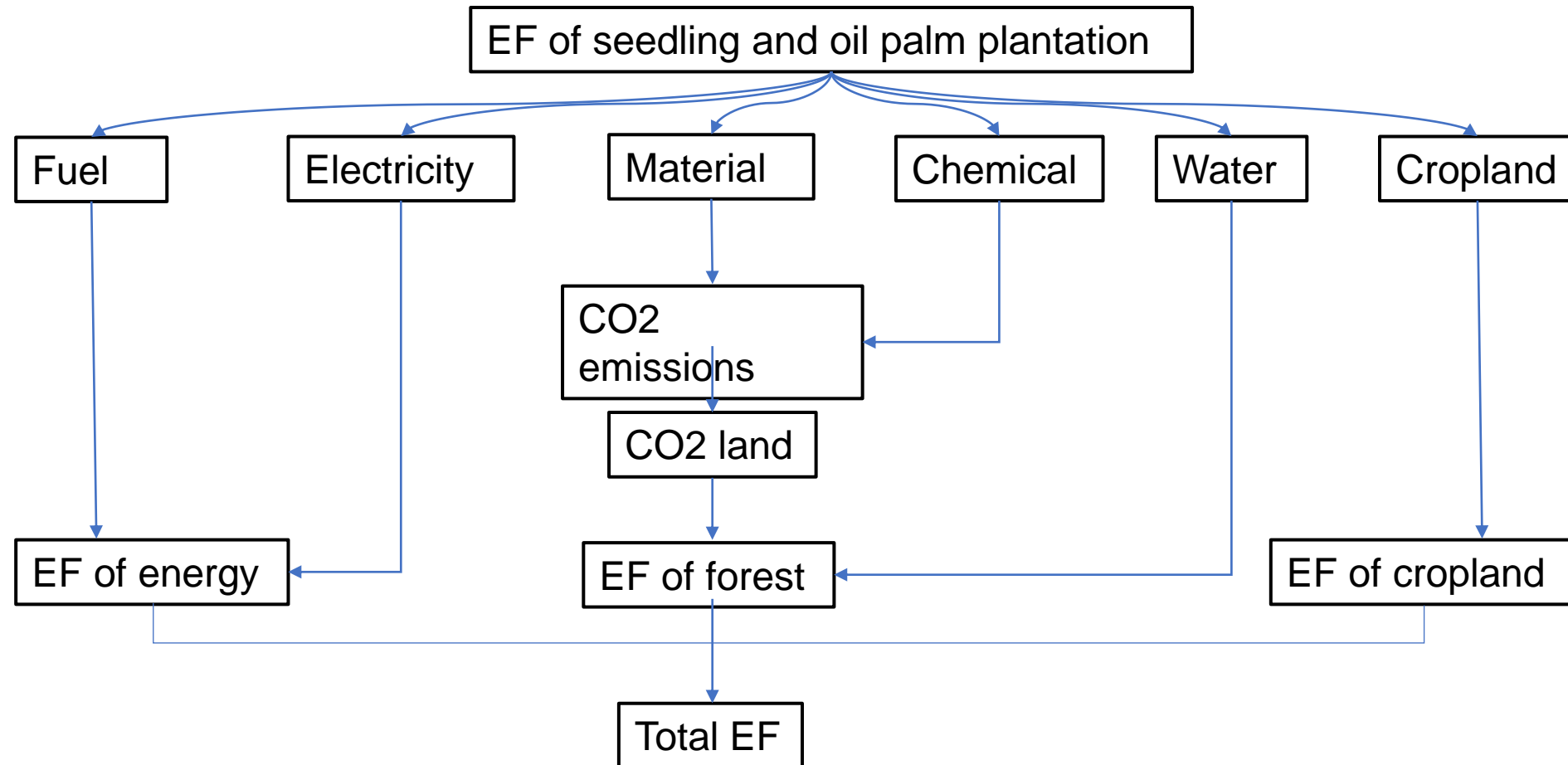


System boundary of the LCA study for CPO production





Ecological footprint calculation of oil palm plantation





GWAPP model: Relevant GHG Calculation formula

Greenhouse gases emitted from FFB production and FFB transport

$$E_{FFB} = E_{FFB,production} + E_{FFB,transport}$$

Greenhouse gases emitted from palm oil production and processing

$$E_{Chemical} = E_{Chemical,production} + E_{Chemical,transport} + E_{Chemical\ packaging,production} +$$

$$E_{Chemical\ packaging\ waste,transport} + E_{Chemical\ packaging\ waste,disposal}$$

$$E_{Energy} = E_{Fossilfuel} + E_{Electricity}$$

$$= E_{Fuel,production} + E_{Fuel,transport} + E_{Fuel,combustion} + E_{Electricity}$$

$$E_{Wastewater} = E_{Wastewater,treatment} + E_{Sludge,treatment} + E_{Wastewater,discharge} + E_{Sludge,final}$$

$$E_{Wastewater,treatment} = \sum_i Q_{ww,i,y} \times COD_{removed,i,y} \times MCF_{ww,treatment,BL,i} \times B_{O,ww} \times UF_{BL} \times GWP_{CH_4}$$



Relevant GHG calculation formula

$$e_p \left[\frac{kgCO_2eq}{ton} \right] = \frac{(E_{Energy} + E_{FFB} + E_{Chemical} + E_{Wastewater}) \left[\frac{kgCO_2eq}{yr} \right]}{yield\ product \left[\frac{ton}{yr} \right]}$$

Processing

- Emission from energy consumption, FFB production and transport, from wastewater and from further operating supplies and inputs must be taken into account.
- Calculation per ton product(dry matter),if in moist content, calculation of dry content.

Verification of

- Consumption of electricity, process-specific inputs and heat, fuel used for heat production.
- Wastewater
- Yield of main product and co-products.
- Emission factors and sources.

*E=Emission



EF calculation

$$EF = EF_{direct} + EF_{indirect}$$

$$EF_{direct} = EF_{Cropland} = S \times e_p$$

$$EF_{indirect} = EF_{forest} + EF_{energy}$$

$$= EF_{water} + EF_{CO_2} + EF_{fuel} + EF_{electricity}$$

$$EF_{water} = (W/FP) \times e_f$$

$$EF_{CO_2} = \sum C m_i \times e_{fCO_2} \times 0.266 \times e_f$$

$$EF_{fuel} = (F/EP) \times e_f$$

$$EF_{electricity} = \sum_i \frac{P_i}{EP_i} \times e_f$$

Oil Palm Cultivation

Weighted average life-cycle GHG emissions of oil palm FFB by regions

The southern region emits the least amount of GHGs from 1 ton of FFB.

The overall trend is decreasing from north to south.

Regions	GHG emissions (kg CO ₂ eq/t FFB)		
	Minimum	Maximum	Average
North	114	167	141
Northeast	126	231	189
Central	69	149	112
South	102	102	93



Palm Oil mill process

Comparative GHG emissions for 1 tonne CPO with biogas emissions and without allocation

Output	Boiler emissions	Electricity from grid	Diesel	Mill consumption	Transportation of diesel to mill	Biogas	Total with
GHG emissions for 1 tonne CPO(without allocation) kg CO ₂ eq	64.01	0.50	-	12.19	12.11	911.62	1004.3

*Without biogas recovery, the amount of greenhouse gases emitted per ton of CPO produced during palm oil processing is 1004.3 kg.



EF of oil palm plantations

EF of north has the highest value, and north region requires more material and energy.

EF of Forest is the highest percentage of the overall.

Regions	EF of oil palm plantation (gha/ha-year)			
	EF of energy	EF of forest	EF of cropland	Total
North	0.987	23.2	0.402	24.6
Northeast	0.843	21.1	0.402	22.4
Central	0.703	20.8	0.402	21.9
South	0.21	17.0	0.402	17.6
Weighted average	0.591	19.3	0.402	20.3



Ratios of economic benefits to EF

USD/gha (2009-2018)

Regions	USD/gha (2009-2018)		
	Minimum	Maximum	Weighted Average
North	20.7	83.1	39.7
Northeast	23.1	86.4	46.9
Central	25.2	91.1	59.4
South	30.4	107.2	69.3
Average	24.9	115	53.9

The highest value in the south

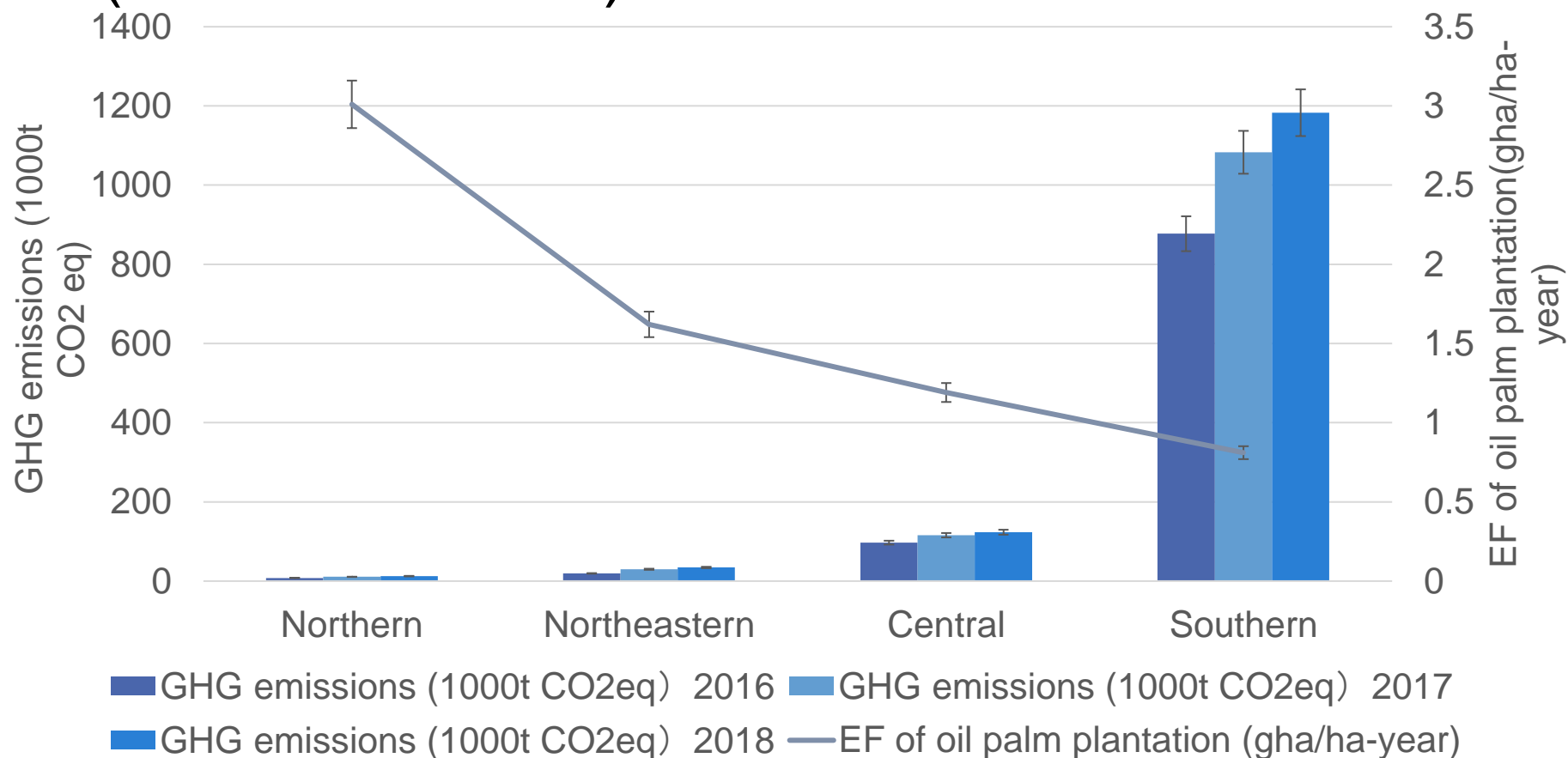
Gradually increasing from north to south

Central and South above average

GHG emissions and EF of Thailand's four major oil palm plantation regions (FFB harvested)

The South has the most greenhouse gas emissions.

The southern EF has the lowest value.





- The yield of FFB per unit area of oil palm plantation in southern Thailand is high, and 3165kg of FFB can be harvested per rai, which is three times that of the north.
- The amount of greenhouse gases released by each ton of FFB harvested in southern Thailand is 93kg, while that in the north is 141kg.
- South Thailand has a lower total EF value and a higher ratio of earnings to EF. This reflects that the sustainable cultivation of oil palm in the south is higher than that in the north.
- Oil palm planting in the north has a large investment and low output per unit area, but the greenhouse gas emissions are high. The South is the opposite, so large-scale oil palm cultivation in the North is not recommended.



Reference

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Data source: the Office of Agricultural Economics <http://oaezone.oae.go.th/view/22/index/TH-T>