



Impacts of biofuel demands on carbon dioxide emissions from peatlands

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Version 25 March 2011

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1. Introduction

Global production of vegetable oils, especially palm oil, has increased rapidly over the past years. Increasing demands for vegetable oil for the use as biofuel has further stimulated growth and expansion in this sector. This paper provides information on the issue of greenhouse gas emissions due to conversion of areas with peat soils for vegetable oil production including for biodiesel. The paper will focus on palm oil in Southeast Asia; the most relevant area for vegetable oil production on peatlands, with alarming greenhouse gas emissions as a result.

Definitions

'Peat is dead organic material that has been formed in situ and has not been transported after its formation.'

'A peatland is an area with a naturally accumulated layer of dead organic material (peat) at the surface.' A peat layer can be up to 25 meters thick.

'A mire is a peatland where peat is being formed'¹.

'Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres².' Around 40% of all wetlands are peatland.

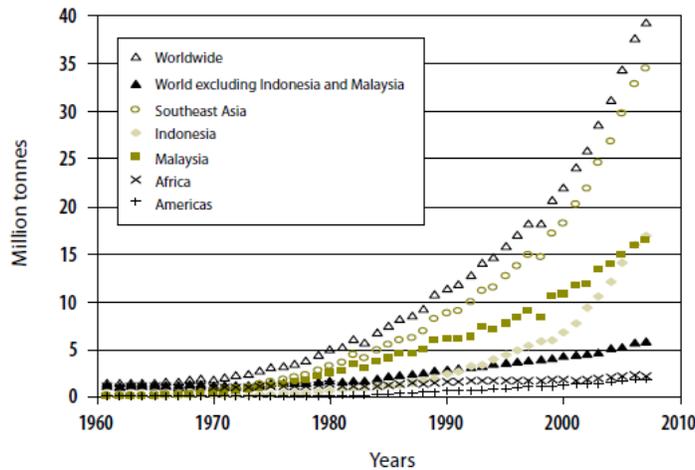
2. Link biofuels and palm oil production

Increasing demands for vegetable oil have contributed to a massive expansion in palm oil production. Increased biodiesel use in for instance Europe, will add directly to this global growth in demand, in prices and in production areas. Of all vegetable oil crops, palm oil is the most productive, with by far the highest energy yields per hectare. According to a FAO study,

¹ Parish, F et al. 2008, Global Peatland Assessment

² Ramsar Convention, article 1.1.

the rapid growth after 2000 has been largely caused to replace the use of rapeseed for biofuels³.



Source: ⁴

Direct use of palm oil for biofuels is relatively limited. The indirect impact will be much greater, as a replacement for rapeseed and other oils now used for biofuels. The figure below gives an indication on what it may mean if the biofuel demands would be directly (or indirectly) met by palm oil.

Total biofuels use in 2008:

Total 10.1 mtoe; of which 81% Biodiesel:⁵

- EU-produced rapeseed oil: 57-70% (47-56% of total biofuels)
- Imported soybean oil: 14%-24% (10-20%)
- Imported palm oil: 11% (9%)
- Waste streams: 5-10% (4-8%)

³ Thoenes, P. (2006): Biofuels and Commodity Markets – Palm Oil Focus. Rome: FAO Commodities and Trade Division. www.rlc.fao.org/es/prioridades/bioenergia/pdf/commodity.pdf

⁴ CIFOR, 2009, The impacts and opportunities of oil palm in Southeast Asia

⁵ European Commission, January 2011: [Recent progress in developing renewable energy sources](#)

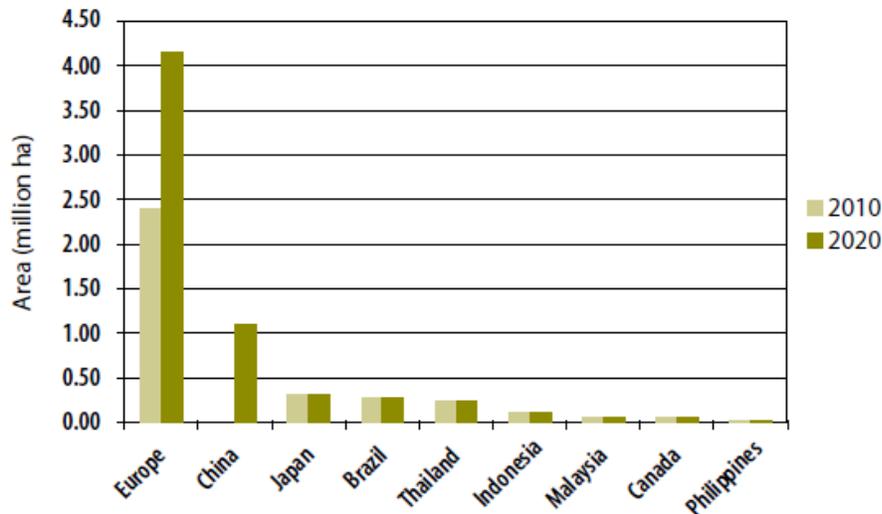


Figure 7. Additional area of oil palm plantations required to meet country-specific biodiesel targets. (Source: authors' calculations based on IEA 2006, Naylor *et al.* 2007)

Currently, most of the palm oil is used for food production or cosmetics; not as a fuel. Palm oil needs additional processing, contrary to for instance rapeseed oil. However, the question if the production of new additional oil palm plantations is really used for biofuels is hardly relevant. The growing demand caused by biofuels causes anyhow an expansion of vegetable oil production areas, instigating either directly (biofuel production) or indirectly (compensating for other oils used as biofuel) a growth in palm oil production.

3. Link palm oil and peatland drainage

These areas were until recently hardly accessible and unsuitable for agriculture as there were only few crops that produced well on these marginal soils (e.g. pineapple). However, oil palms grow relatively well on peat, but they do need relatively deep drainage (minimally 80 cm).

There is a strong focus on development of remaining peat swamp forests to oil palm plantations for several reasons:

- It is more lucrative to develop oil palm plantations in forests than in already deforested area as the harvest of timber provides revenues to develop the plantation.
- Palm oil fruit needs to be processed within hours after harvesting in a mill. The ability to establish plantations is restricted to tropical regions, accessible for global transport, where large plantations can be established in the proximity of a mill, without complicating land use conflicts. In the main production countries; Indonesia and Malaysia, many wetland areas with peat soils qualify for this.
- Remaining peat swamp forests are generally still under government authority and thus do not require lengthy negotiations with hundreds of small land owners that would be encountered in idle deforested land areas.

Some figures: current plantations in Indonesia are for about 25% on peat; in Peninsular Malaysia 9.3%; in Sarawak 23% was on peat in 2002⁶. In Southeast Asia especially in Indonesia, millions of additional hectares have been allocated for new palm oil plantations (estimated growth 300,000 ha per year), and over half of these are located in peatland areas⁷.

⁶ Hooijer *et al.*, 2006 (Peat-CO2)

⁷ Hooijer *et al.*, 2006 (Peat-CO2)

Facts about peat and palm oil in SE Asia (ha), Figures for 2008⁸

	Malaysia	Indonesia
Land area	32 975 800	1,904,44300
Of which peat	2 458 000	22 500 000
Of which degrading	1 200 000	12 500 000
Of which under palm oil (concession area for Indonesia)	510 000 ⁹ -666 038 ¹⁰ .	2 800 900 ¹¹ - 3 358 709
Total palm oil in country ^{note 12}	4 300 000 ¹³	6 500 000
Carbon stock, Mton C	5431	54,016
Emissions, fires excl. in Mton CO2	48	500

Peatlands in SEA: 28.2 of which 22,5 mln in Indonesia¹⁴ and 2,5 mln ha in Malaysia¹⁵.

Malaysia

The oil palm land use in Peninsula Malaysia, Sabah and Sarawak is determined in 2009 using 2008-2009 satellite images. The total area of oil palm detected was 5,010,000 hectares from which 666,038 hectares on peat. This is about 13,3%. According to this study, by far the most palm oil plantations on peat occurred in Sarawak; 437,174. This is over 37%¹⁶.

A recent study by Sarvision commissioned by Wetlands International (February 2011) using satellite images, combined to soil maps and on the ground surveys comes to even higher percentages for Sarawak: 44%¹⁷.

A quick scan conducted by Wetlands International, came to slightly lower, though comparable figures for Malaysia. Palm oil on peat for 2008 is estimated on 510,000ha; mostly again in Sarawak (330,669ha)¹⁸.

The figures about the rapid peatland loss are not questioned by the sector. The sector only states the right to do so, in the name of 'development'. See for instance the [SAPPOA reaction](#).

Future outlook

Of new plantations, a much larger share is on peat. By far, most plantations established after 2005 in Malaysia are in Sarawak. In this province, almost halve the new plantations are on peat⁴.

Indonesia

It is currently impossible to come to very exact, undisputed figures on the current palm oil plantations on peatlands in Indonesia. For the simple reason that the complete figures are just not known: not investigated at national levels, or just on concession areas (not actually planted yet) or a few years old. Noting the rapid expansion of palm oil in the country makes figures of 5 years ago by definition a strong underestimation.

⁸ Hans Joosten, University of Greifswald, 2009. the Peat CO2 Picture

⁹ Tropical Peat Research Institute (2009) *Statistics of peatlands in Malaysia*.

Presented at the International Conference on oil palm and the environment;". 14-15 August 2009, Malaysian Palm Oil Board

¹⁰ Omar et al. June 2010 in MBOP TT no. 473. Mapping palm oil on peatland in Malaysia.

<http://palmoilis.mpob.gov.my/publications/TOT/TT-473.pdf>

¹¹ Hooijer et al. 2006, Peat CO2 provides 25% as indication, of all palm oil plantations

¹² CIFOR, 2009. The impacts and opportunities of oil palm in Southeast Asia.

¹³ Wetlands International Malaysia, 2010. Quick scan of peatlands in Malaysia.

¹⁴ Hooijer et al. In Biogeosciences, 7, 1505-1514, 2010

(<http://www.wetlands.org/LinkClick.aspx?fileticket=ZHFgti4IR6o%3d&tabid=56>)

¹⁵ Wetlands International. 2010. A quickscan of Peatlands in Malaysia. Wetlands International Malaysia.

¹⁶ Omar et al. June 2010 in MBOP TT no. 473. Mapping palm oil on peatland in Malaysia.

¹⁷ Sarvision, January 2011, Impact of oil palm plantations on peatland conversion in Sarawak 2005-2010.

¹⁸ Figures of the Tropical Peat Research Institute 2009 in Wetlands International. 2010. A quickscan of Peatlands in Malaysia. Wetlands International Malaysia.

In 2006, of the total 10,337,800 ha under palm oil concession (so not actually planted areas), 2,800,900 ha was on lowland peat¹⁹. A scan conducted by Wetlands International Indonesia in 2011 came, for 2008, to an area of 3,358,709 ha palm oil on peat²⁰. For both, this means that about a quarter of all concessions are on peat. But note that a concession doesn't mean actual production yet! For 2006; an area of the size of 60% of the concessions were productive plantations (estimate; both concessions and small holders).

The size of the 2008 area of actual palm oil on peat is for Indonesia about 2 million ha.

Future outlook

Until recently 'deep peat' (more than 3 meters) was protected by Indonesian law and could officially not be drained. However, a recent Indonesian ministerial decree has all ended this last projection; explicitly to give more room for oil palm by stating that (only) 70% of the plantation should be under 3 meters depth (click here for our press release with links to decree and translation). The decree opens up in fact all Indonesian peatlands for palm oil, besides some protected areas; also deep peat. The decree is estimated to bear relevance on 2.8 million ha deep peat that were protected and now may be converted legally into palm oil²¹.

Indonesia now (early 2011) discusses a two year moratorium on new palm oil on peat, as part of the support of Norway to halt GHG emissions due to deforestation. It is very unclear at this moment where this will go to; also within the Indonesian government, views are not aligned. It could be a two year moratorium for new concessions. Seeing how much concessions are given and wait for development, this would not mean a lot.

4. Link peatland use and carbon dioxide emissions

Greenhouse gas emissions are caused by land use change from forest to oil palm plantations. An additional and separate factor, which is often overlooked, is the question whether the development takes place on a peat soil or not. In South-east Asia all lowland peatland areas are naturally forested with average canopy height of 40m and emergent trees of up to 50 meters, and their conversion to oil palm plantations causes emissions from deforestation.

However, more importantly the peat soil itself constitutes a significant and generally even larger carbon stock than the above ground stock in the forest cover. While the organic carbon in waterlogged peatlands is maintained due to the anaerobic circumstances, drainage exposes the organic carbon to the air. This causes a process of organic decomposition and oxidation of the organic carbon. In oil palm plantations the peat carbon stock is thus impacted by the required drainage, causing a continuous soil carbon emission for as long as the peat is drained.

Examples of carbon content (in C/ha) for various ecosystems²²

	Vegetation	Litter	Soils	Total
Peatland (average)	See below	0	<u>1425</u>	1425+
Tropical rainforest	210	10	100	325
Cool Temperate forest	160	25	140	371
Taiga	82	15	219	320
Tropical Savannah	35	0	55	90

Most tropical peat swamp forests combine both the high carbon store of the tropical rain forest and the peat carbon stock. The average carbon stock for vegetation for peatlands reflects the existence of non forest peatlands in large parts of the world.

¹⁹ Hooijer et al. 2006. Peat- CO2 .

²⁰ Wetlands International Indonesia: calculations in 2011.

²¹ Estimate Wetlands International Indonesia Programme

²² Parish, F. et al. 2008, Global Peatland Assessment

Oil palms cannot survive in un-drained waterlogged peatlands. Minimal drainage for oil palm growth in peatlands is around 60 to 80 cm, but generally drainage is much deeper and can reach several meters, especially if no water control structures are used.

CO₂ emissions from biofuel production on peatland²³

Table 1: Energy yield and emission factor of typical biomass fuel crops on peat soil

Crop	Net yield [GJ ha ⁻¹ a ⁻¹]	Emission factor (without peat) [t CO ₂ /TJ]	Emissions from peat [t CO ₂ -eq ha ⁻¹ a ⁻¹]	Emission factor (with peat) [t CO ₂ /TJ]
Palm oil (SE Asia)	-	22 ^{a)}	86 ^{b)}	600 ^{c)}
Maize, net energy (Germany)	165 ^{d)}	-	40	240
Maize, biogas (Germany)	45 ^{e)}	-	40	880
Miscanthus, net energy (Germany)	213 ^{d)}	3 ^{g)}	25	115
Miscanthus, hydrogen (Germany)	4 ^{f)g)}	-	25	625
Sugar cane, ethanol (Brasil)	140 ^{h)}	9 ^{h)}	80	570
Sugar cane, net energy (Florida)	155 ⁱ⁾	-	55 ^{j)}	350
Coniferous wood, net energy (Scandinavia)	15 ^{k)}	-	3.4 ^{l)}	225

To compare: emissions for conventionals

Fuel	Emission factor [t CO ₂ /TJ] ^{a)}	Emission factor incl. fugitive [t CO ₂ /TJ] ^{b)}
Peat	106	-
Coal (anthracite)	98,3	-
Fuel oil	73,3	81,1
Natural gas	52,2	53,9

Notes:

^{a)} IPCC

^{b)} Elsayed et al. 2003, Essent 2007.

In most cases, and as a conservative estimate, the relationship between drainage level and the peat subsidence rate is linear and yields an emission of 9t/ha/yr CO₂ for each 10cm of additional drainage up to a depth of 50cm when subsidence levels off. Scientific data (that separate soil carbon oxidation and carbon emissions from plant respiration) on emissions from areas with deeper drainage is limited, and in some areas it seems to remain constant at around 45t/ha/yr, but in other studies much higher emissions have been found of up to 90 tonnes/ha per annum at 1 meter drainage.

For palm oil (needing deep drainage), 40 tonnes of CO₂ per ha/yr is a most conservative estimates, with 70 tonnes as a likely estimate²⁴. These emissions may last – depending on the depth of the peat – for several decades.

With Roughly 2,7 million ha palm oil on peat in Malaysia and Indonesia in 2008 and emissions between at the lowest 40 tonne ha/yr and likely 70 tonne, we come to emissions of about 100-200 mln tonne CO₂/yr for palm oil on peat.

In addition, peat areas around a drained plantation degrade as well.

²³ Couwenberg, J. 2007, Biomass energy crops on peatlands: on emissions and perversions. IMCG-newsletter 2007-3 p.12-15

²⁴ Couwenberg et al. 2009. Global Change Biology. [Volume 16, Issue 6](#), pages 1715–1732, June 2010. Greenhouse gas fluxes from tropical peatlands in south-east Asia

Additional impact of palm oil on degraded peatlands

The loss of the total carbon stock of peatland areas is greatly accelerated by establishment of plantations such as palm oil that need deep drainage.

In official logging concessions in most parts of Indonesia and Malaysia the current method to remove logs and bring in logging equipment is via a rail system. This has only limited impact on the peat swamp forest and does not cause any drainage or emissions from the soil. However, a substantial part of the natural and selectively logged forests are subject to illegal logging. Illegal loggers generally dig canals into the peat soil to enable transport of equipment and logs. The drainage depth of these canals is limited and moreover, the drainage intensity (density of the drainage structure) is much lower than in oil palm plantations. In illegally logged areas the logging channels will be found at irregular intervals at relatively large distance (often 500 meters to several km) from each other, with an average resulting emission of around 15 tonne CO₂ per year²⁵. The canals may also gradually fill in with debris from the forest and as a result of soil subsidence over time their depth decreases. Plantations on the other hand require a regular network of primary, secondary and tertiary canals, which will not fill in naturally by debris but will be actively maintained and deepened to compensate for any soil subsidence (from compaction and oxidation). Once areas are drained for palm oil production, emissions will be much higher.

5. Scientific discussions about emission figures?

The large scale drainage of tropical peatlands represents a rather new situation. The alarming annual peat fires that have occurred during the last two decades, involving huge fluctuations in drought and fire intensity distribution related to the el Niño and La Niña oscillations placed quite some scientific challenges for accurately estimating the annual averages of peat fire related emissions. Recent studies have revealed that the first estimates of these emissions as published in *Nature* and by Wetlands International may have been over-estimates, but correctly identified the magnitude of the problem. Wetlands International now uses the recent lower estimate of 400 Mton CO₂ per year for peat fire related emissions in Indonesia²⁶.

The problem in oil palm plantation areas is however not so much the fires but the ongoing emissions due to decomposition and oxidation of the peat soil. Several studies have all come to similar conclusions and suggest emissions between 500 and 600 Mton CO₂ for Indonesian drained peatlands. A report from the Indonesian government has compared the different studies and now uses the estimate of 1 gigaton of CO₂ emissions as indication of the country's total emissions from peat decomposition and fires²⁷.

6. Public and sector wide criteria on peatland use

RSPO

The palm oil sector tries to create a supply line of sustainable palm oil, via the Round Table on Sustainable Palm Oil (RSPO). Only about 5% of all production is currently certified.

This round table has though no criteria on GHG emissions and not on peatland use. Overlooking this major environmental issue is a major weakness of the RSPO. Currently (2010-2011) a Greenhouse gas working group and below this, a peatland working group are working to come with additional criteria.

So far, attempts to formulate criteria on the use of peatlands for all or even new plantations was blocked by the producers in the RSPO. ILUC is not addressed either.

²⁵ Hooijer et al, 2006 (Peat-CO₂)

²⁶ G. Van der Werf, 2009 in *Nature Geoscience* **2**, 737 - 738 (2009): CO₂ emissions from Forest loss.

²⁷ Indonesian Climate Council, 2009. Indonesia's greenhouse gas abatement curve.

RSB

The Round Table on Sustainable Biofuels is still quite limited in the number and magnitude of their members. It has formulated in June 2010 the criterium that biofuel blends achieve 50% lower lifecycle GHG emissions compared to a fossil fuel baseline. There is no inclusion (yet) of emissions due to peatsoil carbon losses, not of ILUC impacts.

EU-RED

The Renewable Energy Directive excludes the use of biofuels produced on carbon rich wetlands or previously undrained peatlands (cut off date 1-1-2008). Regarding the latter, peatland areas cannot produce biofuels if further drainage of previously undrained soil layers (also vertical) is involved.

These criteria exclude the use of all peatlands for palm oil as it is impossible to produce without affecting new (deeper) peat soil layers.

There is no certified palm oil supply line yet, excluding all palm oil from peatlands. This means that there is currently no palm oil available that meets the RED.

Indonesia: moratorium peat for palm oil

Under pressure of the Norwegian donor investing in measures to avoid emissions from the Indonesian forests; the Indonesian governments considers a two year moratorium on peatland conversion for palm oil.

This has not been decided yet and may just result in the decision to not-grant new concessions for palm oil on peat, for two years only. This would be a quite meaningless decision, noting the many unused concessions and noting the short period. There is though hope for a more absolute moratorium.

7. Conclusion

- A rapid expansion of palm oil plantations takes place in Malaysia and Indonesia due to increasing global demands for vegetable oil. Part of this is a reaction to the expected opportunities and growth in the biofuel market.
- National legislation does not protect carbon rich ecosystems (forests, peatlands).
- A large share of the carbon rich peatlands are currently reclaimed and drained for palm oil; rough estimate 150,000 – 200,000 a year in the area of Malaysia and Indonesia.
- sometimes this happens in intact (peatswamp) forests, sometimes in already logged areas. In both cases, additional annual emissions caused by the plantations are very high, adding tens of tons of carbon dioxide per hectare per year.
- Emissions from drained peatland areas are a factor that continues for decades or even hundreds of years (depending on the peat depth) until the entire carbon stock is gone.
- Several studies are conducted on the impact of drainage of peatlands on greenhouse gas emissions. While average emission totals of the irregular and fluctuating peatland fires occurrences are under discussion, there is widespread consensus on the emissions from peat decomposition due to drainage.
- The RED in fact excludes the use of all palm oil from peat. As long as there is no certified 'clean' palm oil yet meeting the RED criteria, there is in fact no palm oil available yet meeting the RED.