Carbon Footprint of Indonesian Palm Oil Production: I. a Pilot Study

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Background

In the last five years Indonesian palm oil production grew by 13.41% per year, with growth in export at 16.24% per year and slow growth in domestic consumption. Oil palm production in Indonesia and Malaysia is now in the focus of the debates on Biofuel and Carbondioxide (CO_2) and other greenhouse gas (GHG) emissions, through its association in the public debate with deforestation and (over)use of peatland. The potential use of palm oil as biodiesel to reduce dependency on, and emissions from, the use of fossil fuel has focused debate on the emissions caused by the conversion of land to oil palm and subsequent steps in the production.

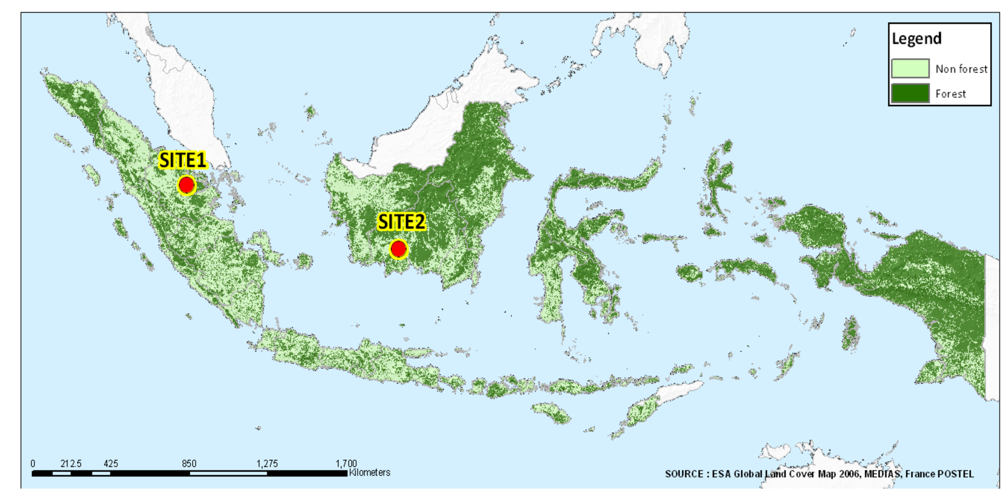
Carbondioxide (CO_2) and other GHG emissions can be attributed to three phases of the production process:

a. the initial conversion of preceding vegetation, usually based on 'land clearing', leading to a 'C debt',

b. the balance of emission and absorption during the growth cycle of the oil palms, leading to a time-averaged C-stock that influences 'C debt' and repay time,

c. transport to the refinery followed by CPO and kernel production, transesterification into biofuel and further transport to the end users.

A comprehensive accounting system on carbon and other GHG emissions of biofuel production of oil palm has to include the whole life cycle assessment (LCA) through a life cycle inventory (LCI) (ISO, 1997).

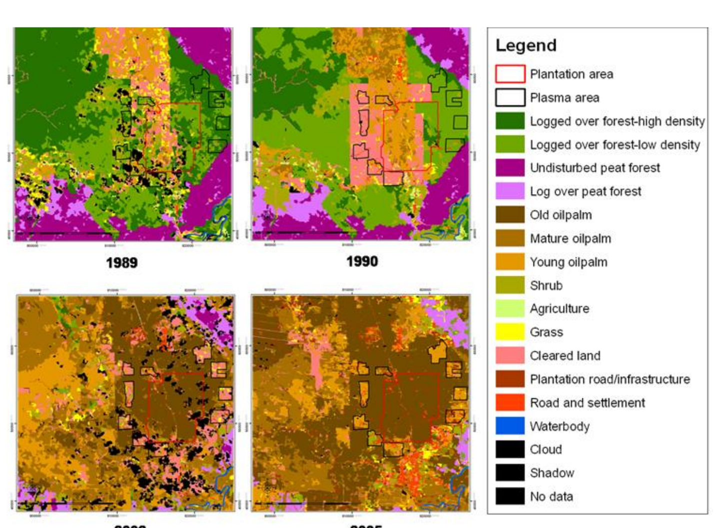


Map of location

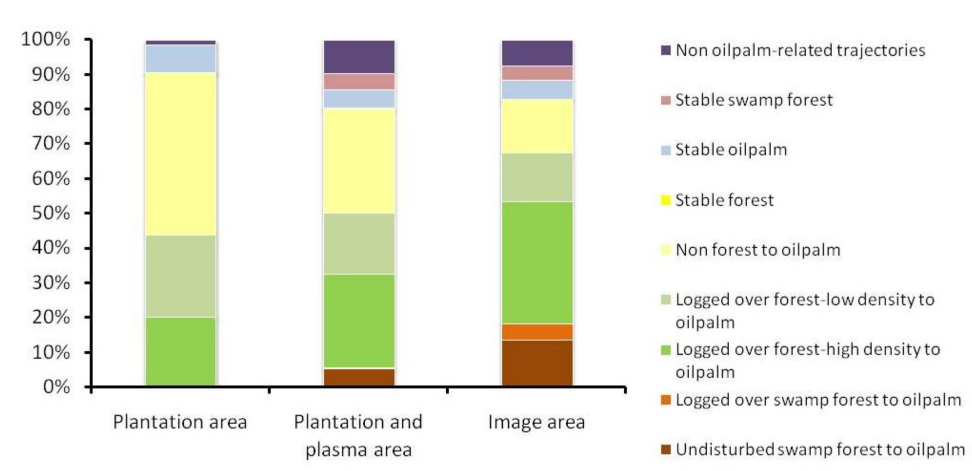
Result

Land cover trajectories

Site 1 (established in the early 1990's) clearly showed that more than 40% of conversions within the plantation area were from logged-over forest, with nearly 50% of it was from high-density logged-over forest area. In plantation-plasma area, almost 50% of oil palm was converted from forest; of those, 27% was from high-density logged-over forest and 5% from undisturbed swamp forest. In the surrounding area, 67% of oil palm was converted from forest. From that amount,12% was undisturbed swamp forest and 34% was high density logged-over forest.

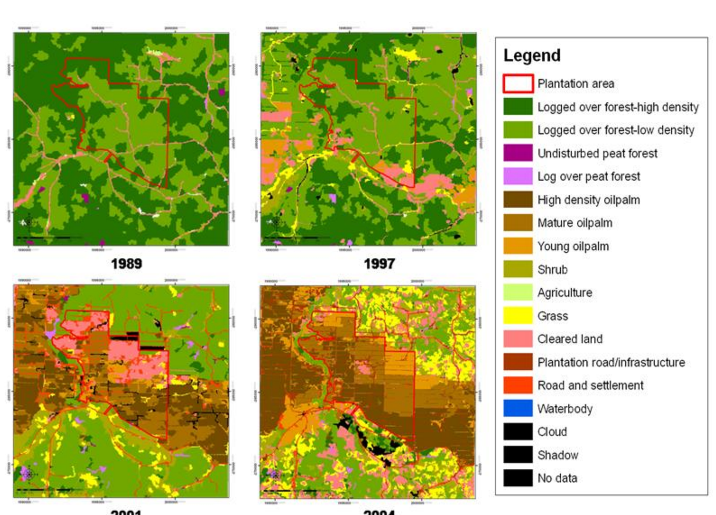


Time series land cover map of site 1

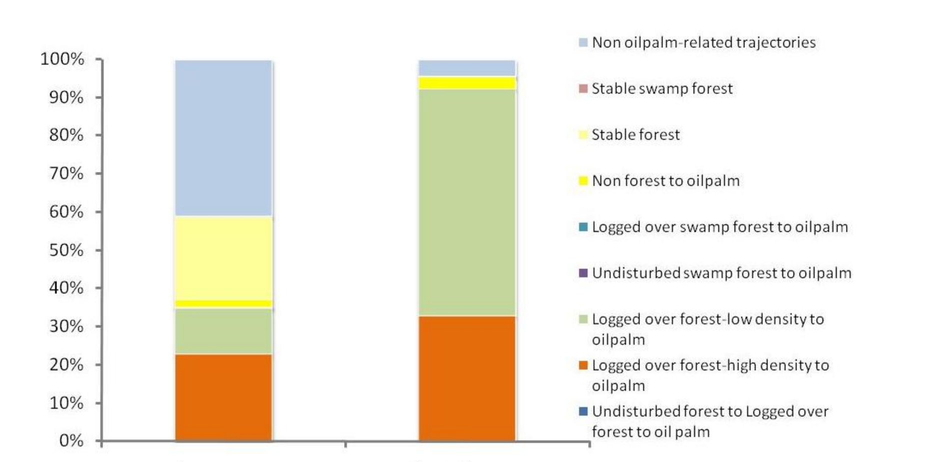


Summary of land cover trajectories in Site 1 and surrounding area

In Site 2 (established in the early 2000's), the surrounding area was still undergoing some logging activity. Conversions from undisturbed forest to logged-over forest is a strong indication of this on-going process. Conversion to oil palm was only located in less than 35% of the observed area. Inside plantation area, more than 90% of oil palm area were converted from forest, 30% of it was high density logged-over forest.



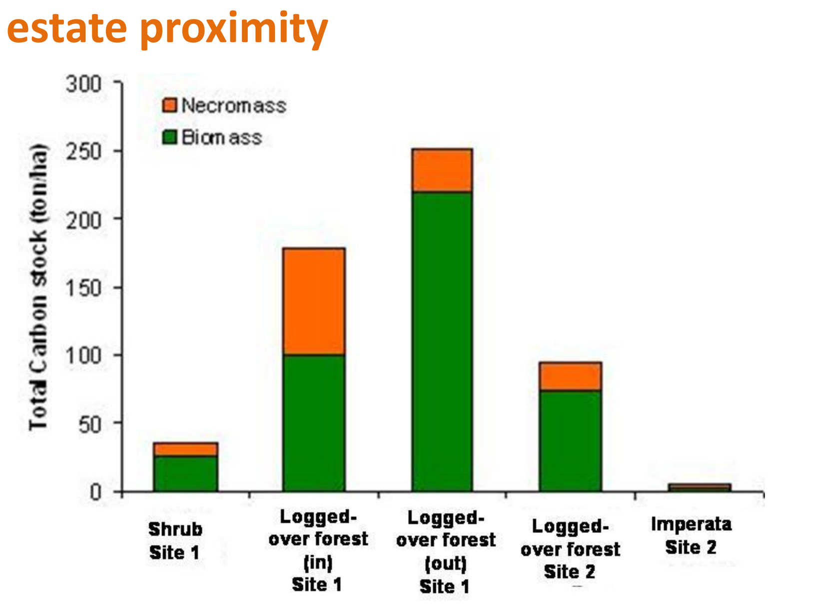
Time series land cover map of site 2



Summary of land cover trajectories in Site 2 estate and surrounding area

C-stock estimation of non-oil-palm in the estate proximity

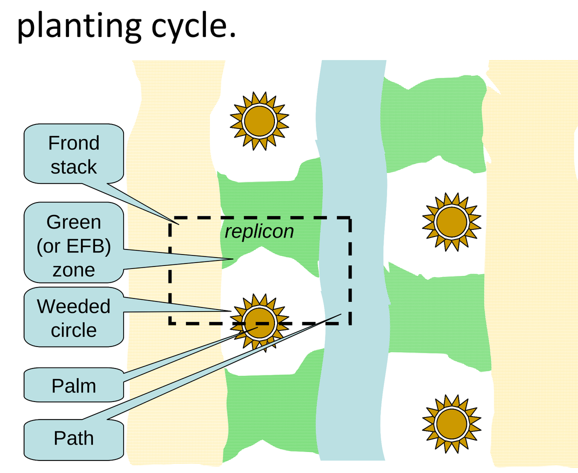
Above ground C-stock in logged-over forests in Site 1 and Site 2 are markedly different. Logged-over forests in Site 1 contain much higher number of large trees which leads to much higher C-stock than those in Site 2. It is interesting to note here that whilst the total aboveground C-stock in logged-over forest in Site 1 nucleus plantation is almost double than those in Site 2, those from living biomass is comparable.



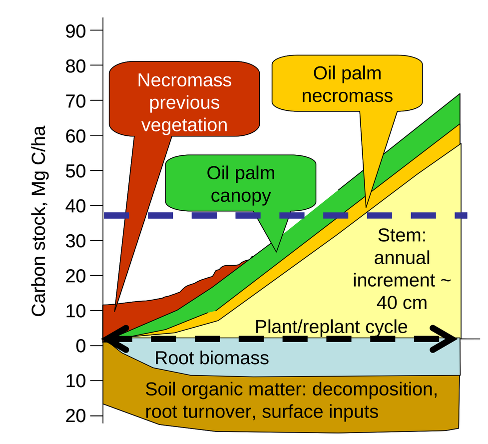
C-stock in non-oil palm land cover within nucleus and plasma oil palm plantation in Site 1 and within nucleus plantation in Site 2

Time-averaged C-stock of oil palm at plot level

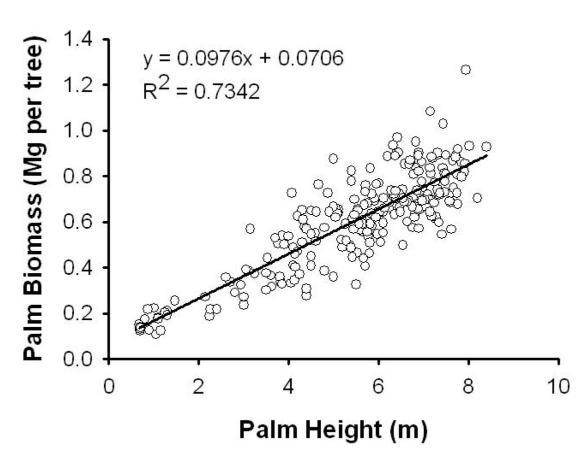
Time-averaged C-stock of oil palm plantation was estimated comprehensively, taking into account all components of total biomass of oil palm, soil organic matter, preceding necromass, current necromass, root, understorey, recycling and other additional organic inputs. Therefore, sampling for measurement was designed to cover variation in factors that determine each of the components. Four zones are distinguished within the palm system, and used for a stratified random sampling (two samples per strata per tree). The total palm biomass was estimated through allometric equation. Aboveground C accumulation in oil palm biomass was estimated of about 5 t C ha^{-1} per year. The aboveground time-averaged C-stock of oil palm plantation is similar between the two estates i.e., 38.8 ton ha and 39.2 ton ha respectively for site 1 and site 2, with 25 years planting cycle.



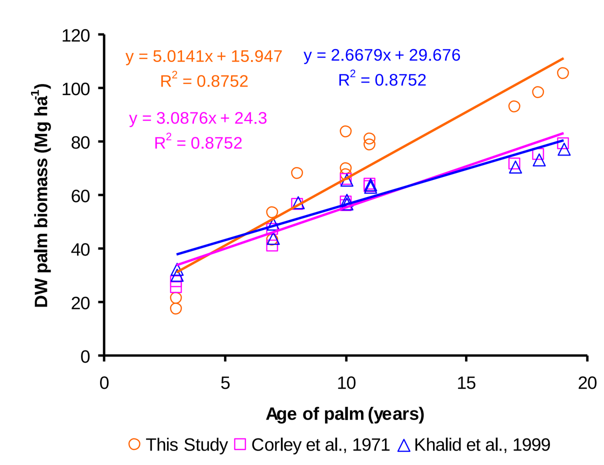
Sampling stratification of above and belowground C-stock



Time-averaged C-stock in oil palm plantation from each component



Allometric equation as a function of palm height to estimates palm biomass



Correlation between age of palm and palm biomass (Mg ha^{-1})

Up-scaling and carbon debt from land use conversion

In general site 1 estate's emissions and sequestration per unit area are higher than those in Site 2 in each of the region under study. The sequestration per unit area in Site 2 within the estate area is lower than that of Site 1 because of the differences in percentage of total areas which were planted by the end of this study period (91% in site 1 estate and 84% in site 2 estate). Emissions from plasma areas in site 1 are 35 % lower than that of the estate due to more conversions from land cover of higher C-stock initially.

Site (area*)	Total area (ha)	Annual sequestration	Annual emission	Net annual emission	Total annual sequestration	Total annual emission	Total net annual emission
		Ton ha^{-1} per year			Ton per year		
Site 1 (estate)	5,746	-2.82	35.32	32.50	-16,227	202,975	186,748
Site 1 (plasma)	19,364	-1.00	23.72	22.72	-19,359	459,373	440,014
Site 1 (image)	52,145	-0.30	24.02	23.73	-5,764	465,197	459,433
Site 2 (estate)	3,651	-0.02	12.41	12.39	-55	45,297	45,242
Site 2 (image)	16,899	-1.84	20.35	18.51	-31,171	343,972	312,801

Estate: considers only the nucleus estate area; Plasma: considers plasma area; Image: considers the large surrounding areas of estate and plasma

Conclusion and Recommendation

In order to address carbon debt, threes level of engagement from plantation companies could be taken, while international rules are still under discussion:

- To avoid carbon debt, conversion should be conducted from shrub and grassland with an aboveground C stock of less than 40 ton C ha .
- To reduce/minimize carbon debt, companies should set aside conservation areas which are hot spots of C-stock, to allow natural succession to happen and therefore to achieve co-benefit of biodiversity conservation as well as reducing C-stock emission.
- To neutralize, rehabilitate larger areas in different places to achieve comparable sequestration, buy Certified Emission Reduction (CER).

While in the first phase of this study we focused on method and hypothesis development, in the on-going second phase of this study we would like to capture variabilities in Indonesia in terms of carbon footprint from oil palm plantation due to land conversion, plantation management, socio-cultural factors and geography. We have conducted field measurements in 23 estates distributed in 3 island in Indonesia (Ekadinata et al., 2010). The data analysis is currently underway. In this second phase, we will also conduct some growth modeling to include several cases of plantation management .

Two important outcomes of the studies are: (i) the increased awareness and capacity of estate management in estimating carbon footprint from oil palm plantation and its impact on climate change, (ii) better informed international regulation process and guidelines for best practices at national and management level.

Reference

Ekadinata, A.E., Khasanah, N., Rahayu, S., Budidarsono, S., and van Noordwijk, M. 2010. Carbon Footprint of Indonesian Palm Oil Production: II. Sample Design and Methodology.
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