Carbon footprint of Indonesian palm oil production:

II. Study design and methodology*

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Key questions

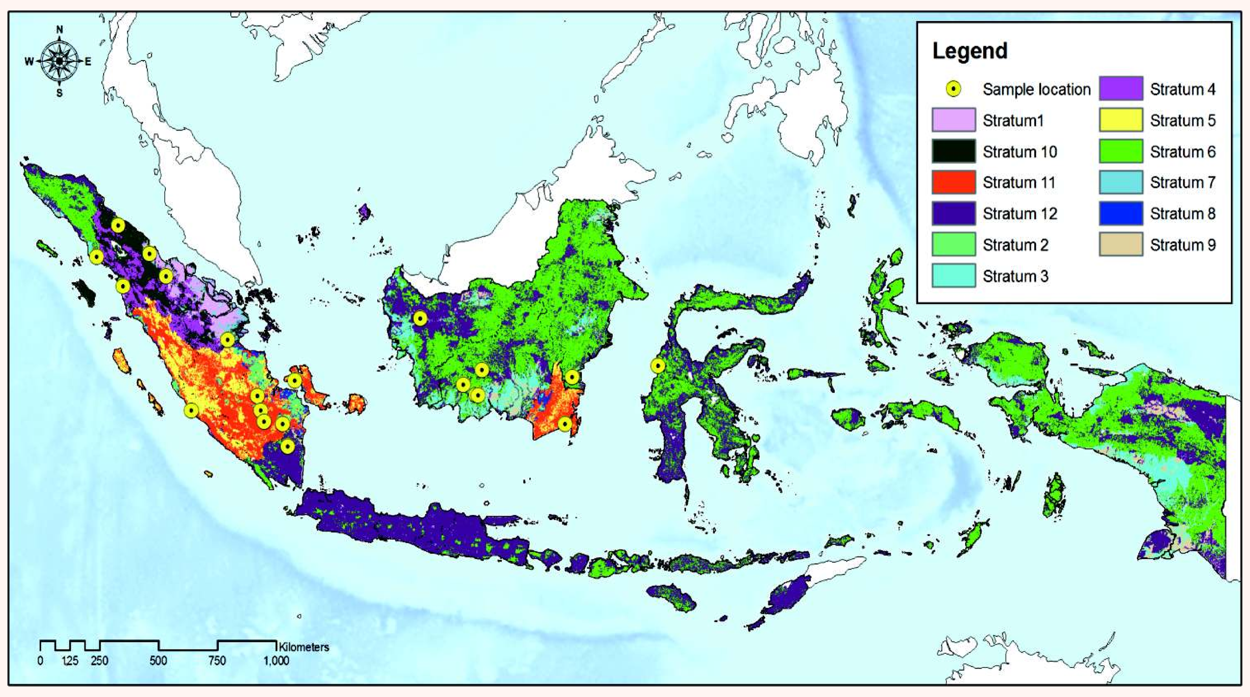
Oil palm–one of the most productive tree crops of the world, at the basis of many food products, and also a potential biofuel, potentially replacing fossil fuel diesel. Following to the completed pilot study (Dewi et al., 2009), second phase of the study has been conducted throughout Indonesia, with the following key questions:

- Does current Indonesian palm oil production, ***on average,*** meet the standards for net emission reduction when used as biofuel?
- How can a palm oil production that meets the standards be identified and recognized?
- How can oil palm production affected the livelihood of people in its vicinity?

Sampling stratification

Sample selection of the study applies step wise cluster sampling using three main criteria: (1) initial land use with two categories: forest and non forest; (2) soil types that is categorized into peat and mineral soil; (3) area density of oil palm in the province Based on those three main criteria the study derived to 12 cluster sample as basis for sample selection. Twenty three oil palm plantations across Indonesia were selected through this process.

Sample parameters			Cluster name
Initial Land use	Soil	Area density of oil palm	
Forest	Peat	High	Cluster 1
		Medium	Cluster 2
		Low	Cluster 3
	Non Peat	High	Cluster 4
		Medium	Cluster 5
		Low	Cluster 6
Non-Forest	Peat	High	Cluster 7
		Medium	Cluster 8
		Low	Cluster 9
	Non Peat	High	Cluster 10
		Medium	Cluster 11
		Low	Cluster 12



Biofuel Emission Reduction Estimator Scheme (BERES)

BERES is an integrated assessment scheme for CO_2 and other GHG emissions of palm oil or other biofuel production, that includes three phases of production processs :

The initial conversion of preceding vegetation into a biofuel feedstock plantation, usually based on 'land clearing'

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

Transport to the refinery followed by processing and further transport to the end users

E = total emissions from the use of the fuel =

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

e_l= annualized emissions from carbon stock changes caused by land use change;

e_{ec}= emissions from the extraction or cultivation of raw materials;

e_{sca} = emission saving from soil carbon accumulation via improved agricultural management;

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;

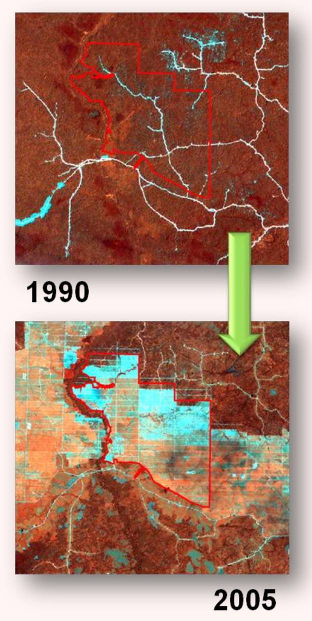
e_{ccr} = emission saving from carbon capture and replacement

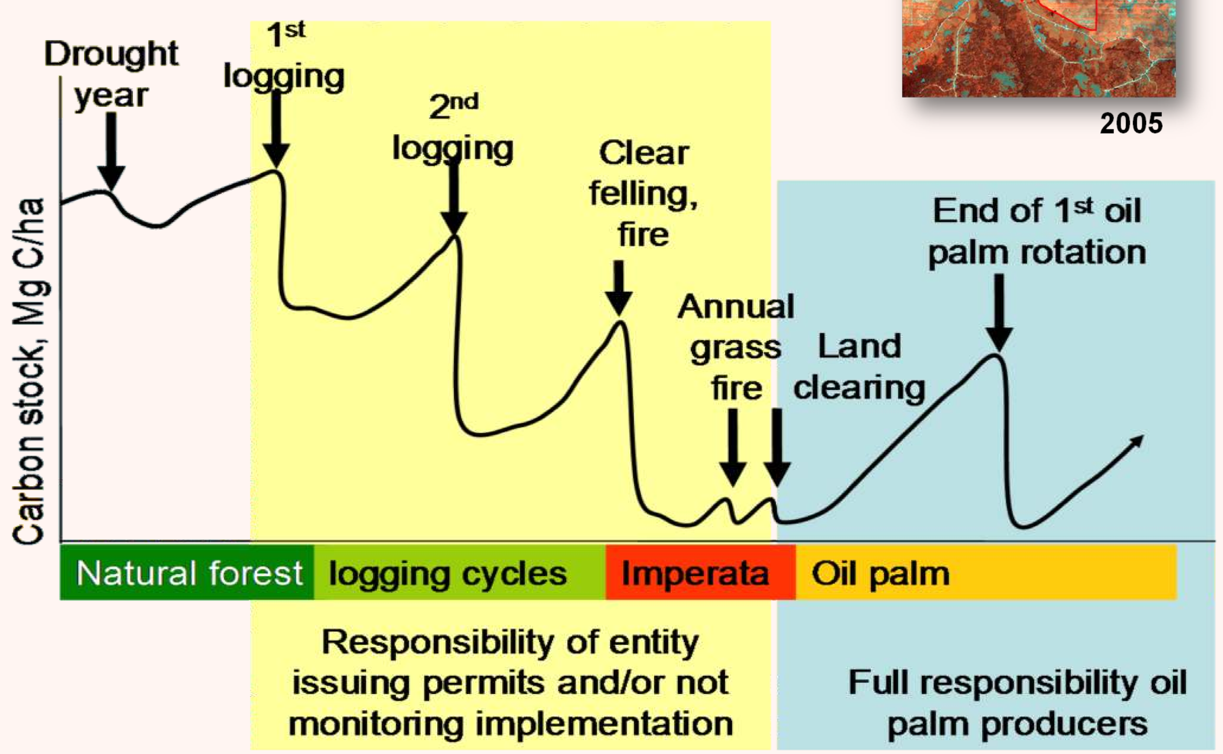
e_{ee}= emission saving from excess electricity from cogeneration

There are four major component in BERES assessment: (1) **Preceding vegetation** and its C-stock, (2) **Soil types** and associated CO_2 emissions: mineral soil (soil texture, pH, elevation and C/Cref) and peat (peat depth and drainage regime) (3) **Management regime** and associated growth and yield levels: level of fertilization and organic waste empty fruit bunch (EFB) and palm oil mill effluent (POME) (4) **Mill** and associated CO_2 emissions: CPO and PKO production rate, processing and transport.

Assessing the preceding vegetation

Land use change and land use trajectories data are required to quantify initial carbon debt of oil palm plantation due to conversion of preceding vegetation. We build our current spatial analysis framework based on understanding that a range of different land cover trajectories can lead to a large variation in initial plantation's carbon debt from land use conversion. Main data source for this phase of study is remote sensing and GIS datasets.





Assessing C-stock variation

Plot level sampling design for oil palm c-stock measurement were based on soil type (peat and non -peat), management type (nucleus, plasma and independent), and year of planting distribution. Based on these factors, 145 of oil palm plots had been selected from 22 plantations.
Plot level sampling design for non oil palm measurement were based on variability of land cover types (forest and non-forest) and soil type (peat and non-peat). Based on these factors, 113 of non-oil palm plots had been selected from 22 sample site.

Type of soil	Type of soil	Number of plots
Forest/Logged over forest	Mineral	37
	Peat	3
Non forest	Mineral	64
	Peat	9
	Total	113

Type of soil	Management	Number of plots
Mineral	Nucleus	82
	Plasma	25
	Smallholder oil palm	19
Peat	Nucleus	16
	Plasma	2
	Smallholder oil palm	1
	Total	145

Socio-economic assessment

Two different aims are to be achieved in the socio economic assessment: (1) profitability assessment of oil palm plantation and bio fuel production; (2) impact assessment (direct and indirect impact) of oil palm plantation on socio-economic of local people at the village level (infrastructure, public facility, income opportunities, land pressure, etc), and at the household level our assesment consist of:

- **Policy Analysis Matrix (PAM)**
  is a matrix of information about agricultural and natural resources policies and factor market imperfections that is created by comparing multi year land use system budget calculated at financial and economic prices.
- **Village study: semi structured interview format**
  infrastructure development, public services employment and income opportunities, land pressure, etc.
- **Household survey: structured interview format**
  to measure the welfare, income portfolio, access to credit, access to market.

Village sample selection considere several factors: (1) the village has historical interaction with the plantation; (2) It has a substantial smallholder oil palm areas after the establishment process.

*) On going research, for internal ICRAF distribution

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