Carbon loss associated with the conversion of tropical peat forests to oil palm plantations

Hergoualc'h, K. and Verchot, L.V.

Center for International Forestry Research (CIFOR)

For further information, please contact k.hergoualch@cgiar.org

Introduction

Despite covering only about 0.25% of the Earth's land surface, tropical peatlands contain around 3% of the global soil carbon (C) stocks and at least 20% of global peat carbon. In their natural state, lowland tropical peatlands support a growth of swamp forest overlying peat deposits up to 30 meters thick. Large areas of tropical peatlands in southeast Asia have been and are to be cleared to establish oil palm plantations. The amount of carbon loss from this conversion is a growing concern in the global context of climate change and is still under debate.

Carbon losses associated with land use change in tropical peat swamps may be assessed from changes in either C flows or C stocks. The first approach (the 'gain-loss' approach), requires the annual rates of biomass (above- and below-ground) accumulation from growth and losses associated with harvest and burning; the annual transfer into and out of dead organic matter and soil stocks prior to and following conversion. The second approach requires estimates of average C stocks in biomass (above- and below-ground), dead organic matter (dead wood and litter) and soil (soil organic matter) prior to and following conversion. This study combines both approaches for assessing C loss from the conversion of forest to oil palm plantation on peatlands.

Methods

We used the 'gain-loss' approach for characterizing C loss from the peat. For this, main C inputs (from litterfall and root mortality) to the peat were balanced by main C outputs (from heterotrophic soil respiration, methanogenesis, leaching, runoff, erosion, and fires) before and after conversion. We applied the 'change in C stocks' approach for estimating C loss from vegetation cover change from aboveground tress only since C flux from litter and roots is already taken into account in the 'gain-loss' approach. The data used for the calculations arise from a literature review on C stocks and stock changes, flows and flow changes associated with land-use change in tropical peatlands of southeast Asia (Hergoualc'h and Verchot [accepted 2010]).

Results

In the intact peat forest, the balance between soil C inputs and outputs returns a peat accumulation rate of 1 Mg C ha^{-1} y^{-1} (Figure 1), which is similar to current accumulation rate of 0.94 Mg C ha^{-1} y^{-1} measured by Page *et al.* (2004) in Kalimantan. In the oil palm plantation, we estimated that C was lost from the soil at 63.9% through heterotrophic soil respiration, 29.1% through initial land clearing fire, 6.9% through soluble and physical transfers and 0.03% through CH_4 emission (using a global warming potential of 25 for CH_4). The balance between soil C inputs and outputs in the oil palm plantation amounts a C loss of 7.4 Mg C ha^{-1} y^{-1} (Figure 1). Therefore, the conversion from intact peat forest to oil palm plantation would represent a total loss from the soil of 8.4 Mg C ha^{-1} y^{-1} or 30 Mg CO_2 equivalent ha^{-1} y^{-1} (Table 1).

Aboveground C stocks in trees is estimated at 198.8 Mg C ha^{-1} in intact peat forest and 24.2 Mg C ha^{-1} in oil palm plantation (Germer and Sauerborn 2008). Considering a 25-year rotation in an oil palm plantation, C loss from vegetation cover change from aboveground C in trees amounts to 7 Mg C ha^{-1} y^{-1} or 25.6 Mg CO_2 equivalent ha^{-1} y^{-1} (Table 1).

Over 25 years, the conversion of tropical peat forest into oil palm plantation represents a total C loss from both biomass and peat of about 56 Mg CO_2 equivalent ha^{-1} y^{-1}, of which 54% arises from the peat.

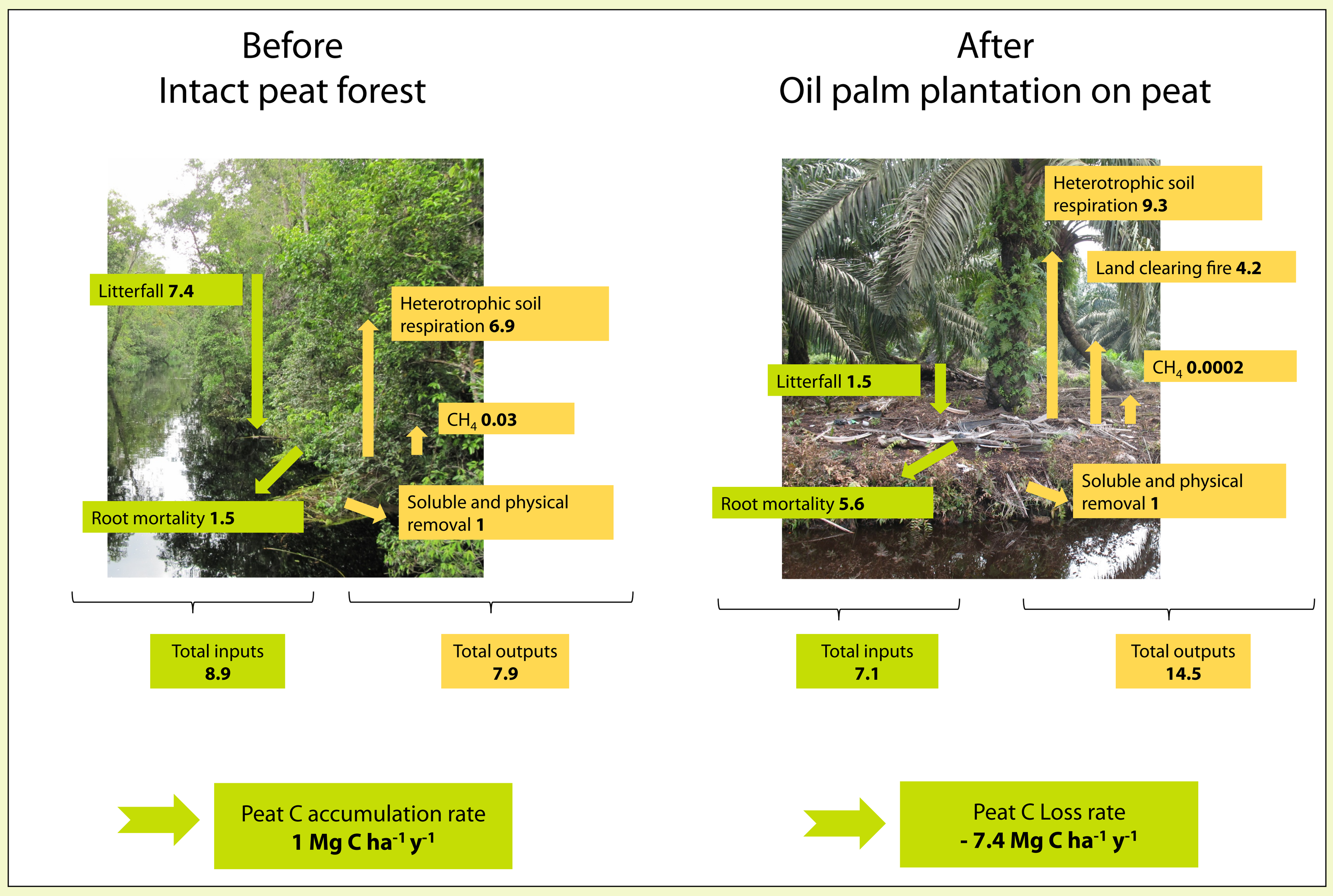

Figure 1: Average peat carbon inputs and outputs before and after conversion. The C balance (inputs – outputs) indicates the rate of peat C accumulation or loss as positive and negative values, respectively. All values are expressed in Mg C ha^{-1} y^{-1}.

Table 1: Carbon loss from peat forest conversion to oil palm plantation over a 25-year rotation.

C pool	C loss (Mg C ha^{-1} y^{-1})		C loss (Mg CO_2 ha^{-1} y^{-1})
Peat	1 - (- 7.4) =	8.4	30
Trees aboveground	(198.8–24.2)/25 =	7	25.6
Total		**15.4**	**55.6**

Conclusion

The amount of C lost from peat forest conversion to oil palm plantation is considerable. This demonstrates the urgent need in terms of global warming to protect tropical peat forests by, for instance, promoting the redirection of economic land use away from peat land to mineral soils, and more specifically on already degraded lands.

Acknowledgements

This work was generously supported by the governments of Australia and Finland and CIFOR.

References

Germer, J. and Sauerborn, J. 2008 Estimation of the impact of oil palm plantation establishment on greenhouse gas balance. Environment, Development and Sustainability 10, 697-716.

Hergoualc'h, K. and Verchot, L.V. [accepted 2010] Stocks and fluxes of carbon associated with land-use change in tropical South East Asian peatlands: a review. Global Biochemical Cycles.

Page, S.E., Wust, R.A.J., Weiss, D., Rieley, J.O., Shotyk, W. and Limin, S.H. 2004 A record of late Pleistocene and Holocene carbon accumulation and climate change from an equatorial peat bog (Kalimantan, Indonesia): implications for past, present and future carbon dynamics. Journal of Quaternary Science 19, 625-635.

CIFOR

Australian Government
AusAID

FORMIN.FINLAND.FI
MINISTRY FOR FOREIGN AFFAIRS OF FINLAND