Reducing forestry emissions in Indonesia

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Key points

- Attempts to achieve significant emissions reductions through a plantation expansion programme alone would not be feasible, as planting the number of trees needed to fully achieve emissions reduction targets would require a land area twice the size of Indonesia, even if planted on degraded lands.
- Forest conversion must cease if Indonesia is to achieve emissions reductions through forestry. Expanding production areas (food, oil palm, timber/pulpwood) could undermine emissions reduction efforts if this expansion is based on additional deforestation.
- New plantations should be developed on degraded lands, as expansion of plantations on mineral soil and peatland will significantly increase emissions. It is critical to obtain spatial data about degraded lands; such data should be used to prioritise areas for reforestation and plantation development with dual carbon emissions reduction and economic objectives.
- New plantations developed on degraded lands can make modest contributions to emissions reductions. If industrial plantations are primarily for pulpwood, planting half the degraded land could achieve 8–12% of the emissions reduction target. New industrial plantations for non-pulpwood purposes could contribute 22–33% of the emissions reductions needed.
- Careful spatial planning is required to ensure that expansion of plantation activities does not engender conflicts with local communities and indigenous peoples, but rather that it contributes to enhancing rural livelihoods.
- Government policies to encourage industries to develop new plantations on degraded land will fail to achieve emission reductions without effective law enforcement, monitoring and safeguards to prevent illegal practices; incentives for district government and local stakeholders who have preserved their forest and peatland; and consistent programmes and policies across sectors and agencies.
- Indonesia has a wide range of options in the land use, land use change and forestry (LULUCF) sector for reducing emissions, and these could be pursued more aggressively to achieve greater emissions reductions at low cost. These opportunities involve stopping or reducing deforestation; stopping or reducing peat fires; and stopping peat drainage. Some of these offer possible synergies between sustainable development, poverty reduction and climate change mitigation, and should be prioritised in the national REDD+ programme.

Introduction

The forestry sector must play a central role in achieving the Government of Indonesia's (GoI) ambitious target of reducing greenhouse gas (GHG) emissions by 26 per cent. At the September 2009 G-20 meeting in Pittsburgh, President Susilo Bambang Yudhoyono laid out a vision where significant reductions would be achieved through land use, land use change and forestry (LULUCF), primarily through a 'reforestation rather than a deforestation reduction approach'. At the same time, the GoI has set targets for major investment and expansion in staple food production and commodity plantations such as timber and oil palm – targets that could pose serious risks to effective reductions in land-based emissions. Despite the importance of plantation expansion for long-term development and sustainability of the pulp and paper and oil palm industries, there are trade-offs. Aligning the twin objectives of plantation expansion and carbon emission reductions depends on appropriate allocation of land (i.e. targeting of non-forest, degraded land, known as *lahan kritis*, for plantation expansion rather than deforesting new land) and incentives for degraded areas to be prioritised for plantation development.

In this paper, we look critically at the trade-offs between development pathways based on land-intensive enterprises and climate change mitigation. Without a coordinated approach to multiple objectives, efforts in one area could undermine efforts in the other. For example, potential major investments in processing infrastructure could lead to economic losses if the allocation of land for carbon sequestration results in a shortage of raw materials for these industries. On the other hand, expanding plantation production to provide inputs to processing enterprises could undermine national efforts to reduce GHG emissions if this expansion depends on increased deforestation.

To understand the results of this analysis, it is essential to understand the concept of carbon debt that was introduced by Fragione *et al.* (2008). While mature ecosystems take up small amounts of carbon from the atmosphere and have relatively stable carbon stocks, they store large amounts of carbon in the soil and plant biomass. Thus, converting these ecosystems to cropland or plantations releases CO_2 due to burning, microbial decomposition of organic carbon stored in plant biomass and decomposition of wood, waste and wood products. Small amounts of carbon are stored for the long term in forest wood products like tables or house beams, etc. Paper has a relatively short life cycle and most of the carbon from paper making ends up back in the atmosphere within a year. After carbon is released by fire used to clear land or from decomposition of slash, leaves and roots, there is a prolonged period of continued emissions as coarse roots and branches decay. If conversion results in lower inputs to the soil organic carbon pool, emissions form soils can also persist. This means that in order to claim credit for sequestration, plantations that replace natural ecosystems must first replace the carbon that was lost during conversion before additional carbon storage can be claimed.

The aim of this analysis is to provide order of magnitude information to stakeholders, both national and international, about the potential conflict between the dual objectives of carbon emissions reductions and economic development. This analysis provides important indications of areas where synergies exist and where multiple objectives can be pursued sustainably.

Forests: Status and trends

Challenges in managing forests for emissions reduction include clearly identifying and categorising areas with high carbon stocks, including forests on peatlands outside the Forest Estate (*Kawasan Hutan*),[1] and implementing consistent policies, irrespective of the agency that has jurisdiction over those areas. The Forest Estate accounts for 71 per cent of the total land area of Indonesia; of this, roughly one-third is covered by primary forests, one-third by logged-over areas and one-third by vegetation other than forest (Table 1).

There is a relatively small area of forest land outside the Forest Estate. Deforestation rates on these lands are 5 times higher on a relative basis than deforestation inside the Forest Estate. These lands account for 35 per cent of the annual deforestation in Indonesia. Policies affecting these forests fall under the jurisdiction of several agencies with different mandates and priorities. Thus, the way these lands are used, the method for assessing the value of the land, including its carbon value, and the pressure for land cover change

Table 1. Land cover classification by Indonesia's Ministry of Forestry and expected changes with deforestation continuing at current rates

	Forest	Non-forest	Total[a]	Deforestation rate 2003–2006	Relative annual deforestation rate	Forest remaining in 2020
	10^6 hectares			× 1000 ha per year	%	10^6 hectares
Kawasan Hutan (Forest Estate)						
Reserve and protection forests	38.2	9.7	49.6	185.9	0.49	35.6
Production forests	40.9	18.6	60.5	466.6	1.14	34.4
Conversion forests	11.0	11.0	22.4	108.7	0.99	9.5
Total	**90.1**	**39.3**	**132.4**	**761.2**	**0.84**	**79.4**
Non-*Kawasan Hutan* (Non–Forest Estate)	8.3	46.5	55.4	412.9	4.96	2.5
Grand Total	**98.5**	**85.8**	**187.8**	**1174.1**	**1.19**	**82.0**

a Discrepancies in the totals are due to pixels that were obscured by cloud cover or for which there were no data. Source: Ministry of Forestry 2009

1 The Forest Estate is land managed by the Ministry of Forestry (MoF). Not all land in the Forest Estate has forest vegetation cover but all lands within the Estate fall under MoF jurisdiction. There is also land outside the Forest Estate that is covered by forest vegetation that is not managed by MoF.

depend on which agency has jurisdiction. Consistent data on high carbon stock forests and policies to maximise their potential for emissions reductions require strong interagency coordination and alignment of objectives and activities within these areas.

Annual deforestation in Indonesia is currently 1.2 million ha (MoF 2009) and is driven largely by the expansion of plantation crops and pulpwood production. The expansion of agriculture for food production contributes a smaller but significant proportion. If deforestation rates continue at their current pace, forests will disappear in the non-Forest Estate lands in around 20 years and in the production and conversion forests in around 100 years (Table 1). Other estimates suggest that all forest land could be cleared within the next 50 years at current rates (Ekadinata 2010). One way to avoid this outcome and continue to expand agricultural land and plantations is to use degraded forest lands for new planting.

Critically degraded land is abundant in Indonesia and is in dire need of rehabilitation. Forty-one per cent of the forest area of Indonesia (77.8 million ha) is at some stage of degradation (Figure 1). According to MoF, degraded lands are those lands that are severely damaged due to lost vegetation cover and that have lost a significant portion of their ecosystem function, including erosion control, water retention, nutrient cycling, climate regulation and carbon storage. The current definitions applied by the MoF are based on standing volume being below productivity thresholds, actual ecosystem functions are not assessed. Degraded lands are defined as slightly critical, critical and very critical (Figure 1). Statistics are available for critical and very critical lands up to 2006 and show that approximately 35 per cent of these lands are within the Forest Estate (MoF 2009). Thus, a significant portion of forest 'degradation' in addition to deforestation is occurring outside the area managed by the MoF.

This classification will need to be revisited if a serious spatial planning exercise is to be undertaken, particularly in non-Forest Estate lands. Because the classification is based on standing volume, many lands that are being used productively for other purposes by communities are classified as degraded. Additionally, the ecosystem functions in the definition have different thresholds with respect to vegetation loss. Thus it is not clear that the assumed correlation between standing volume and ecosystem function is valid throughout the country. Planning for expanded plantations on lands classified as degraded by the MoF that are outside the Forest Estate must take

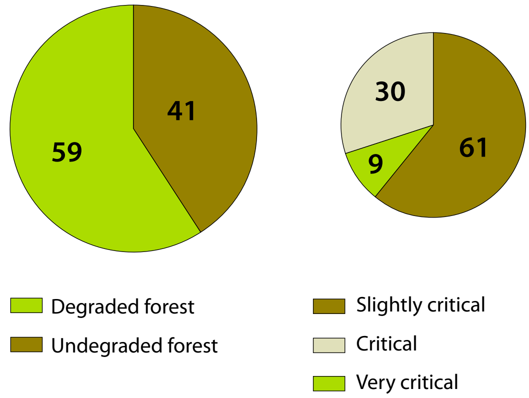

Figure 1. Land cover and degraded land as portion of the total area in Indonesia (MoF 2009)

into account the impacts of such activities on local communities and indigenous peoples.

Nevertheless, avoiding converting forest to plantations is important because more than half of the 22 million ha of land slated for plantation establishment by the MoF is forested. Targeting this land use category for plantations will add to national emissions and result in huge carbon deficits for decades to come.

Meeting Indonesia's emissions reductions commitments

The summary of the most recent National Communication to the UNFCCC by Boer *et al.* (2009) quotes two very different emission levels. The first is based on a report by Indonesian organisation PEACE that estimates an emissions level of 3014 million tonnes of CO_2 annually (Sari *et al.* 2007). The second estimate, presented by the GoI, is of 1991 million tonnes for 2005. Differences also exist in the estimation of sources. These differences are significant as are their implications for the resources needed and the options available to achieve the 26 per cent reduction target. We consider both estimates in this analysis.

Our objective in this section is to examine the feasibility of achieving a significant part of the 26 per cent national emissions reduction target through LULUCF, taking into account Indonesia's specific plans to expand production of staple crops, plantation agriculture (cacao, coconut, coffee, fruits, oil palm, spices and tea) and forestry plantations. Since Indonesia does not have an internationally recognised reference emissions level or projections of future emissions growth associated with its development, we look at what is required to achieve reductions against current emissions levels.

First, we review development plans for activities likely to have an impact on land use and land cover and

Box 1. Methods and assumptions for the modelling exercise

For the assessment of potential carbon emissions, it is beyond the scope of this analysis to engage in a complex spatial modelling effort. We simply assume that net carbon emissions associated with forest biomass loss are 185 tonnes of carbon per ha (or 678 tCO_2) for forests on mineral soils (Laumonier *et al.* 2010). For peatlands, we assume an annual loss rate associated with conversion of 8.7 tonnes of carbon per ha per year (Hergoualc'h and Verchot, in press) from the peat in addition to the forest biomass loss and a time horizon of 50 years for emissions calculations. This gives us an estimate over a 50-year period of 620 tonnes of carbon per ha (or 2270 tCO_2) for forests on peat. We do not account for future carbon sequestration in intact forests. For activities on degraded lands we calculate a net carbon sequestration based on the assumption that the existing vegetation on these lands has 5 tonnes of biomass or 2.5 tonnes of carbon.

For this analysis, we conducted a simple modelling exercise using the ENCOFOR Carbon Decision Support tool, which is based on the Graz/Oak Ridge Carbon Accounting Model (Schlamadinger and Marland 1996; ENCOFOR 2010). The objective of the exercise is to estimate the magnitude of carbon emissions to or removals from the atmosphere. We used Intergovernmental Panel on Climate Change default factors where appropriate and local data and expert knowledge where available. We made simple assumptions about organic matter inputs to soils and root:shoot ratios. We ignored the fate of carbon stored in harvested wood products.

then examine the state of their implementation. The three activities we examine are industrial plantations, community plantations and oil palm plantations. For each activity analysed here, we assessed the potential carbon emissions from achieving the plantation targets as well as the potential for these activities to contribute to emissions reductions (See Box 1 for our modelling approach). The difference between whether a particular set of activities will achieve emissions reductions or will contribute to increasing emissions depends on the starting point for the plantation activities because of the concept of carbon debt explained earlier. If plantation activities are undertaken on degraded lands, they will likely contribute to emissions reductions. However, if these activities lead to further deforestation, they will of course contribute to greater emissions.

Industrial plantations (Hutan Tanaman Industri, HTI). The predominant forestry plantation activity in Indonesia is the industrial plantation of Acacia species *(A. mangium and A. crassicarpa)* and Eucalyptus *(E. pellita)*, primarily for pulpwood. Pulpwood plantations make up more than 75 per cent of the HTI concessions licensed by the MoF (MoF 2009). These plantations are generally managed on a short rotation of 6–7 years. Indonesia possesses approximately 4 million ha of industrial timber plantations, which amounts to only 1.6 percent of the total area classified as forest, despite the availability of subsidies for reforestation and HTI plantation development (Barr *et al.* 2010). The MoF aims to add 5million hectares to HTI by 2016 (MoF 2009).

Plantation rates are below the expected rates and are unlikely to achieve the targets for HTI by 2016 (Figure 2). To achieve this target of 5 million ha, more than 714 000 ha should be reforested each year, which represents more than a 10-fold increase in plantation rates. This would increase the production of pulpwood to 64 million m^3 annually by 2025. As current pulp production relies on significant withdrawals of fibre from natural forests, such an increase would render the existing pulp industry self-sufficient in fibre from plantations and enable further capacity expansion (MoF 2006). Anticipating the growing supply of HTI pulpwood, the

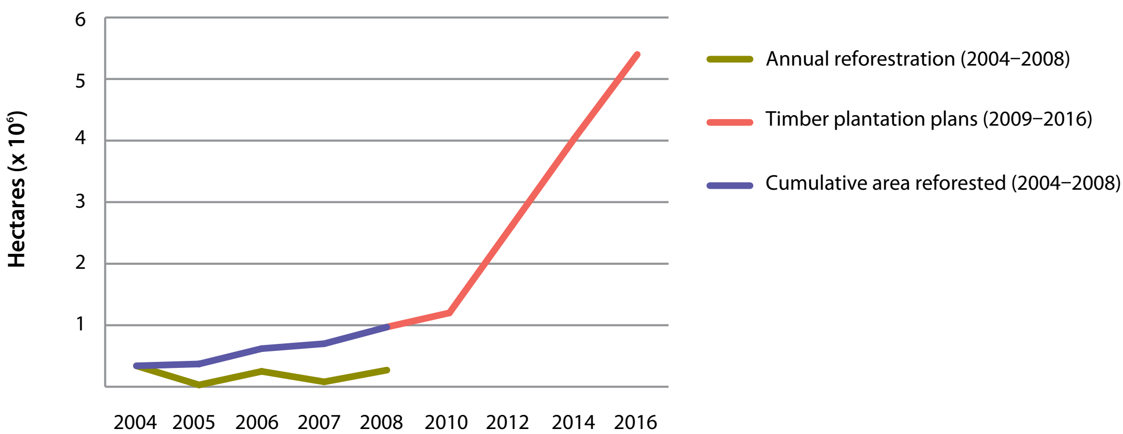

Figure 2. Current and planned reforestation efforts for HTI within the MoF

Figure 3. Existing and planned pulp and paper mills in Indonesia

MoF is currently considering up to 12 new pulp mill project proposals for the total new production capacity of approximately 8 million tonnes of pulp (Figure 3).

Serious concerns about the accuracy of data on current planting rates must be addressed before considering tree planting programmes as an important GHG mitigation strategy. For example, industry observers and some reports suggest that the figures on current and projected HTI timber production rates and plantation development should be doubted (e.g. World Bank 2006). These sources indicate that, of the current cumulative estate reported at 4 million ha, only half is actually fully planted and productive. There are also doubts about the recently reported spike in timber production of HTI shown for 2007 and 2008 in Figure 2 as this is not supported by data on timber plantation development 6–7 years prior (Sugiharto 2007). It is likely that there is some premature harvesting to supply the pulp mills, which means that supplies will not be there in the future. This puts in doubt the veracity of the data and the validity of future projections. However, even if the data are accurate, Figure 2 above illustrates that, given past and current progress made in reforestation, achieving reforestation targets for the purpose of carbon sequestration will be extremely difficult if not impossible. The difficulty of achieving reforestation targets has implications for forest emissions reductions: If pulp and paper mills are constructed and plantations cannot provide an adequate supply to keep them going, the plantations may procure supplies from illegal sources. This is in fact occurring now, creating demand for illegal timber.

HTI plantation development can occur through several scenarios. HTI plantations are predominantly for pulpwood production (MoF 2006); 75 per cent of the licenses issued for definitive plantation forest concessions up to 2005 were for pulpwood concessions. Thus, for this analysis, we focused on HTI pulpwood plantations. We analysed three scenarios for the expansions of pulpwood plantations: plantations following deforestation on mineral soils, plantations following deforestation on peatland, and plantations on degraded Imperata (*alang-alang*) grassland on mineral soils. For plantations established following deforestation on mineral soils, we assumed no change in soil organic matter. Results for the three scenarios analysed are presented in Table 2. These results do not include additional N_2O emissions that

Table 2. Results of the modelled carbon dynamics for 3 scenarios over a 50-year horizon

Scenario	Emissions/removals $tCO_2\ ha^{-1}$	Total emissions/removals million tonnes CO_2
Plantation on mineral soil	830	4130
Plantation on peat soils	2420	12 080
Plantation on degraded grassland	–86	–435

Positive values represent emissions to the atmosphere; negative values represent removals. Emissions and removals are calculated per ha and represent the total cumulative emissions over a 50-year period. Total emissions/removals are calculated assuming that all 5 million ha are successfully planted.

may have been induced by nitrogen fixation from the Acacia trees.

Plantations on mineral soils have large carbon debts due to initial emissions associated with deforestation (Table 2); these emissions are not offset by sequestration during the plantation period. On peatlands, although initial emissions associated with the loss of forest vegetation are similar, total emissions are greater because of sustained CO_2 emissions from the drained peat soils and thus the carbon debt is greater. Because initial carbon stocks are low in the degraded lands, there is modest sequestration in the pulpwood plantations on degraded lands. To help put these sequestration rates into perspective, we calculated the total emissions or removals that would occur if all of the 5 million ha target for HTI plantations was accomplished by the plantations represented in these scenarios in the third column of Table 2.

The final step of this analysis is to assess the potential for HTI to contribute to meeting emissions reduction targets. For pulpwood stands planted on degraded grassland, we calculated an average net annual carbon removal rate of 1.7 tCO_2e per ha. Pulpwood HTI do not sequester large amounts of carbon because of the short rotation time and because carbon is not stored in long-term pools after harvest. To fully achieve the target of 26 per cent reductions through this type of plantation activities on degraded lands would require more than 450 million ha (PEACE) or 300 million ha (GoI) of new plantation by 2020; the latter figure being about twice the size of the country. Realistically, if Indonesia were to plant half of its degraded land to HTI, it could offset emissions through increased sequestration and contribute around 8–12 per cent of the emissions reductions target. If Indonesia were to invest in long rotation hardwood plantation (e.g. *Shorea* or teak on a 50-year rotation) to achieve emissions reductions, planting half of the degraded land could offset emissions and contribute to achieving at least 22–33 per cent of the national emissions reductions target.

This analysis shows that even achieving modest reductions through HTI within the timeframe necessary to meet emissions reductions targets would require tree planting to be ramped up by more than ten-fold over current planting rates. We have not assessed trade-offs or the impact of this strategy on sustainable development. However, several studies suggest that expansion of pulpwood plantations in rural areas near villages is incompatible with poverty reduction in most cases, despite the claims of many schemes about improving rural labour opportunities (Pirard and Mayer 2009; Barber 2002; Potter and Lee 1998a). Thus, careful spatial planning must ensure that expansion of HTI plantations does not compromise local development.

Community plantations (Hutan Tanaman Rakyat, HTR). Parallel with HTI expansion, the MoF is seeking to increase the supply of industrial round wood via an accelerated programme of smallholder timber plantation called HTR *(Hutan Tanaman Rakyat)* meant to revitalise the traditional wood-processing sector that produces plywood and saw-timber. These plantations are also being promoted to provide raw materials for the pulp and paper industry (van Noordwijk *et al.* 2007). The programme started in 2007 and by

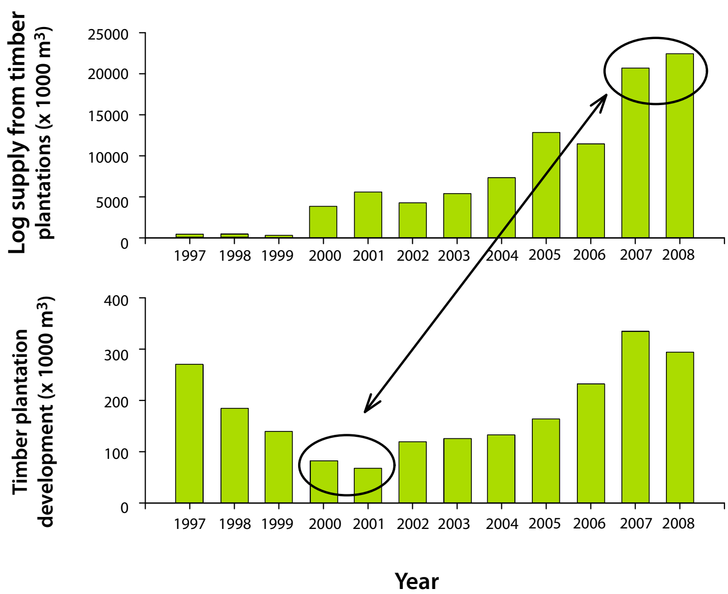

Figure 4. HTI timber production and plantation development showing inconsistencies between decreased plantation areas in 2000 and 2001 and increased log supply in 2007 and 2008 (MoF 2009)

2016 it is expected to establish 5.4 million ha of smallholder timber plantations throughout Indonesia (Kustiawan 2007). However, the implementation of this programme has been slow. Hampered by limited economic benefits and restrictions on land use, only 350 000 ha of HTR have been established out of 1.2 million ha targeted for development between 2007 and 2009 (MoF 2009). This reinforces the assertion that pulpwood plantations are inconsistent with community development objectives in rural areas.

There is also a question of where reforestation would occur. Given that the reforestation programme is run exclusively by the MoF, it must occur within the Forest Estate. However, a significant amount of the degraded land in rural Indonesia lies outside the Forest Estate, and could benefit from agroforestry and other types of economically viable plantation activities. This implies that for some of the emissions reduction target is to be achieved sustainably and by reducing land degradation, agencies outside the MoF will need to be fully involved.

HTR is a relatively new programme and there are no growth data available to model the potential for these plantations to contribute to emissions reductions. However, plantations managed by smallholders generally tend to grow more slowly than industrial plantations and require more technical support from the government. Thus, it is reasonable to expect that these plantations will be able to play an even smaller role in emissions reductions than HTI.

Oil palm plantations. The third, and most ambitious, plantation expansion policy initiative in Indonesia is focused on dramatically increasing the area planted to oil palm and raising the production of crude palm oil over the next 1–2 decades. In 2008, according to the Ministry of Agriculture (MoA), Indonesia possessed 7 million ha of oil palm plantations and produced about 18 million tonnes of crude palm oil. Although information on planned expansion targets varies, overall the targets seem to be very high. GoI sources state that 18 million ha of new oil palm plantation may be developed by 2020 (Kementrian Lingkungan Hidup 2009); NGO sources round that figure up to 20 million ha (e.g. Oxfam 2008).

Oil palm is a lucrative business, especially on peatlands. A 10 000 ha plantation on mineral soil earns US $30 million over 25 years, while on peat the profit is US $40 million. However, oil palm plantation in Indonesia has led to deforestation and other associated negative impacts (Sheil 2009; Yuliani *et al.* in press, see Box 2). Such plantation expansion is likely to lead to significant deforestation of standing and primary forests and loss of carbon stocks. Oil palm plantations store around 50 tonnes of carbon her ha in aboveground biomass (Dewi *et al.* 2009). If all conversion were to come from primary forests on mineral soils, emissions would be approximately 10 billion tonnes of CO_2, but if the conversion were on peatlands, emissions would be four times higher. If, however, only degraded land is targeted for oil palm development and if such a policy is strictly enforced, oil palm may be able to contribute to emissions reduction efforts.

We modelled the same three scenarios as above for HTI with oil palm either replacing forest or being established on degraded lands (Table 3). We assumed a 25-year rotation and used the biomass accumulation equation of Dewi *et al.* (2009). As for the pulpwood cases, plantations on mineral soils have large initial emissions associated with deforestation which are not offset by sequestration during the plantation period. On peatlands, total emissions are greater because of sustained CO_2 emissions from the drained peat soils. Because carbon stocks are low in the degraded lands, modest sequestration occurs in oil palm plantations on degraded lands with mineral soils. To help put these sequestration rates into perspective, we calculated the total emissions or removals that would occur if all of the 18 million ha target for oil palm plantations was accomplished by the plantations represented in these scenarios in the third column of Table 3.

These results suggest that expansion of oil palm on mineral soil and peatland will significantly increase emissions, while expansion on degraded lands with

Table 3. Results of the modelled carbon dynamics for 3 oil palm scenarios over a 50-year time horizon

Scenario	Total emissions/removals $tCO_2\ ha^{-1}$	Total emissions/removals million tonnes
Plantation on mineral soil	620	11 160
Plantation on peat soils	2200	39 600
Plantation on degraded grassland	–100	–1800

Positive values represent emissions to the atmosphere; negative values represent removals. Emissions and removals are calculated per ha and represent the total cumulative emissions over a 50-year period. Total emissions/removals are calculated assuming that all 18 million ha are successfully planted.

Box 2. The unaccounted impacts of oil palm plantation on local people and biodiversity in and around Danau Sentarum National Park[2]

Danau Sentarum National Park (DSNP) is the largest wetland in Asia, consisting of 83 interconnected seasonal lakes interspersed with various types of swamp forests, peat swamp forests and lowland dipterocarp forests (Giesen and Aglionby 2000). More than 2500 households rely on these wetlands and forests for their livelihoods (Indriatmoko in press). In 2007, the district government issued permits for 18 oil palm plantations in and around the wetlands, including in the buffer zone for the national park, water catchment areas and in swamp forests with deep peat. These plantations will clear over 100 000 ha of primary and secondary forests, creating significant risks of pollution, eutrophication and siltation of the Danau Sentarum wetlands. Of the 211 fish species found in the Park (Kottelat and Widjanarti 2005), at least 104, among them fish with high economic value, require clear water with high oxygen content. Land clearing also threatens wildlife in and around the park, which includes at least 12 species of reptiles, 78 species of birds and 44 species of mammals categorised as threatened by the IUCN Red List Database.

The oil palm plantations will reduce the quality of forest and water resources, which support fisheries and beekeeping, the main sources of income for more than 2500 households inside the park. Traditional practices, including cage culture fishery (US $3.5 million per year), arowana breeding farms (US $7–14 million per year) and organic wild-bee honey farming (US $90 000 per year), will be put at risk. At the local level, significant changes to river quality and flow will damage micro-hydropower operations that provide cheap, sustainable and clean energy to villages. At the provincial level, damage to DSNP's hydrological function may worsen floods along the Kapuas watershed, which is home to more than 3.2 million people and 6 major cities and towns in West Kalimantan.

Many argue that oil palm is a promising way to improve local people's livelihoods by creating employment. Yuliani et al. (in press) shows that not all costs have been considered in the analysis that led to this conclusion. The anticipated environmental damage will adversely affect traditional ways of living and earning livelihoods. It is unclear whether the economic and ecological trade-offs are worth the cost to the local community.

The study further shows that illegal practices in the establishment of these new oil palm plantations were widespread. These include clearing and nursery planting without permits, failure to conduct environmental impact assessments and illegal logging with the objective of reclassifying an area as degraded, thus simplifying permit procedures. Local people reported they felt manipulated into signing documents to hand over land through false promises, threats and the influence of alcohol. The lesson here is that law enforcement and consistent programmes and policies across sectors need to accompany any plantation expansion scheme in order to protect local communities and indigenous rights.

mineral soils could play a modest role in emissions reductions. Oil palm is a low biomass tree crop with relatively short rotation periods. We calculated an average annual carbon removal rate of 2.0 tCO_2 per ha using the results from the model. To fully achieve the 26 per cent reductions target through this type of plantation activities on degraded lands would require an area larger than Indonesia. Realistically, if Indonesia were to plant half of its degraded forest land to oil palm, it could offset emissions and contribute to achieving around 9–14 per cent of the national emissions reductions targets.

The GoI (2010) announced a moratorium on forest and peatland conversion for plantations and that it would provide incentives for industries to develop new plantations on degraded land. To succeed, this plan will require improved law enforcement and incentives for district government and local stakeholders who have preserved their forest and peatland. Several studies (Colchester *et al.* 2006; Lynch and Harwell 2002; Potter and Lee 1998a and 1998b; Yuliani *et al.* in press) have reported illegal practices by brokers to change the classification of forested land to degraded land, thereby making that land eligible for conversion to plantations of oil palm or other commodities. Without law enforcement and consistent programmes and policies across sectors, this plan will not reduce emissions.

Oil palm expansion is also a major source of district government revenue, and some local stakeholders perceive plantation expansion as a potential source of income, although these expectations have not been

2 This box summarises a paper by Yuliani *et al.* (in press) on the Danau Sentarum National Park.

met in many cases. Although industries will receive incentives under the new plan, it is unclear whether district governments and local stakeholders will also gain from preserving their forest and peatland. Several authors (Heri *et al.* in press, Prasetyo 2008) have reported that the lack of forest preservation incentives is an underlying cause of land degradation.

Competing agricultural land uses. According to FAO statistics (http://www.faostat.org), which report harvested areas for different crops, agricultural area in Indonesia has been growing at around 0.5 to 1.4 million ha per year since 2000. In addition to oil palm, areas planted with other crops such as cacao, cereals, coconut, fruits and rubber are all growing rapidly. For example, Indonesia currently harvests 12.3 million ha of rice per year and since 2000 the harvested area has been growing by slightly more than 100 000 ha per annum. This is in line with MoA plans to expand the harvested area by 0.37 per cent and production by 0.85 per cent annually (GoI 2005). At current rates of increase, harvested areas will expand by 8–10 million ha by 2025. This expansion is likely to compete directly with expansion of HTR and HTI for land, but it could also locally increase pressure on forests and spur increased emissions. The planned expansion of rice cultivation and production of other crops in Papua province, for example, could lead to significant additional deforestation emissions.

To summarise, Indonesia has plans for significant expansion of food production, oil palm plantation and timber and pulpwood plantations. It is struggling to meet planting targets, particularly in the industrial plantation sector. However, if these targets are met, these new production areas will account for 35–40 million ha of additional land being brought into production, or about 16 per cent of the national territory. Attempting to achieve emissions reductions through expanded tree planting offers some opportunities for synergy with these plans, particularly if new plantation efforts target degraded lands.

In 2006, approximately 47 million ha of degraded forestland in Indonesia were classified as very critical (MoF 2009). The three provinces of West, Central and South Kalimantan as well as Riau Province in Sumatra account for a large share of this land – 23 million ha in total. All of these regions have oil palm or pulp and paper mills that could expand to process what is produced in new plantations. Such land, however, is likely to be less attractive to timber and oil palm investors because there are no forest assets to liquidate to fund plantation operations. Thus, incentives for land swaps and plantation mosaics must be introduced and implemented. Alternatively, this land may be attractive to small-scale producers who have limited means to clear and prepare the land. It is equally important, though, that the government ensures that these incentives are used for the purposes for which they are allocated and learns from past lessons when reforestation incentives have failed (Barr *et al.* 2010). Additionally, if a strategy of expanding plantations on degraded lands were pursued, the government would need to look carefully at this land and make decisions on a case by case basis as some land may already be devoted to production and changes in land use planning could engender conflicts with local communities.

Investing in the expansion of traditional Indonesian forestry and agroforestry systems, such as the *damar* systems of Java and Sumatra (De Foresta *et al.* 2004; Poffenberger 2006), may offer the best opportunities for carbon sequestration and poverty alleviation. However, achieving a significant portion of the 26 per cent emissions reduction target only through reforestation – be it for timber or for palm oil – is impossible, even if all plantation development happens on degraded land. Furthermore, expanding production areas could undermine emissions reduction efforts, if this expansion is based on additional deforestation. Given the magnitude of the effort required, it is clear that plantations alone cannot provide adequate emissions reductions for Indonesia to meet its emissions reductions targets in the forestry sector.

Table 4. Emissions and emissions reduction opportunities through LULUCF

	PEACE report data		GoI data	
	M tonnes	%	M tonnes	%
Total emissions	3014		1991	
Emissions reductions to reach target	784	26%	518	26%
Emissions reductions possible from:				
Stopping peat fires	1353	45%	451	23%
Stopping deforestation	564	19%	–	–
Stopping LUCF emissions	–	–	675	19%
Stopping peat drainage	512.4	17%	–	–

Other LULUCF options for achieving reduction targets

The LULUCF sector offers several opportunities for achieving significant emissions reductions through means other than the expansion of plantations. In Table 4 below, we examine a number of sources of emissions and look at their contribution to Indonesia's emissions. The magnitude of the contribution indicated the magnitude of the emissions reductions that can be achieved by eliminating the source. We use the two sets of figures provided in the PEACE report (Sari 2007) and the executive summary of the Second National Communication (Boer *et al.* 2009). The results show that Indonesia could easily surpass its 26 per cent reductions target through activities like fire suppression and peatland protection.

Stopping peat fires. Peat fires are a major source of emissions from Indonesia, particularly during El Niño years. These fires are largely anthropogenic and can be reduced by addressing local land conflicts and building local capacity for better fire management (Dennis *et al.* 2005; Murdiyarso and Lebel 2007). Eliminating these fires could reduce national emissions by 23–45 per cent. Indonesia currently has support from the Asian Development Bank and is making investments in policy changes and capacity building for fire suppression. Increasing these investments and accelerating capacity building could have emissions reductions payoffs.

Stopping peat drainage. To cultivate oil palm or Acacia on peatland, these areas must be drained. As the surface peat layers dry out, they shrink and become compacted. In severe instances peat domes collapse. These changes lead to increased oxidation of the organic matter stored in these soils and high CO_2 emissions. The PEACE report estimates that peat drainage is responsible for 17 per cent of national emissions. Thus, stopping peat drainage could contribute significantly to national emissions reductions. Other activities on drained peat, such as reflooding drained areas, could reverse emissions and sequester carbon (Couwenberg *et al.* 2009). No data are available on sequestration rates at the moment, but the experiences of projects like the Kalimantan Forests and Climate Partnership should be providing that data in the near future.

Stopping deforestation/LUCF emissions. The PEACE report indicates that deforestation emissions make up about 19 per cent of national emissions. Indonesia's Second National Communication does not separate deforestation emissions from the LUCF category, but the MoF reports that current deforestation rates are 1.2 million ha per year. Using this number and some rough estimates of average carbon loss associated with deforestation (Laumonier *et al.* 2010), we estimate that for the scenario taken from the Second National Communication the 26 per cent national emissions reduction target could be fully achieved by reducing deforestation. Indonesia would need to reduce the current rate by around 550 000 ha, or roughly 50 per cent, annually.

Conclusion

This analysis suggests that Indonesia is unlikely to meet a significant portion of its emissions reductions targets simply by expanding its plantation programme. The magnitude of the effort required and the problems with meeting current, more modest plantation targets do not augur well for a future where tree planting is a central part of an emissions reduction strategy. Nevertheless, this analysis indicates that the expansion of plantations has a limited and conditional place within a comprehensive land use strategy for reducing emissions.

GoI plans to expand land intensive production systems over the next 15 years, and at least 30 million ha of land must be made available for new plantation ventures during this period. Despite criticism and doubts from various quarters, such production-intensive expansion can be met sustainably provided several conditions are met. Key among these are:

- clearing forest to establish plantations should be avoided;
- maximising the use of degraded land, particularly severely degraded areas (lahan kritis), for new plantations; and
- providing incentives for district and local stakeholders to preserve forests and peatlands in their areas.

Spatial data about where the degraded land is and whether it can be converted to uses to reduce emissions are critical for an effective emissions reduction plan. Such data should be used to prioritise areas for reforestation and plantation development with dual carbon emissions reductions and economic objectives. To reduce and/or stop deforestation both in and outside the Forest Estate, consistent policies and capacity to implement those policies are needed at the MoF as well as other agencies with regulatory and enforcement authority over land covered with forests but not included in the Forest Estate. Interagency consistency with respect to land use policy and coordination in spatial planning will be essential for success in reining in GHG emissions.

Indonesia has a wide range of options in the LULUCF sector for reducing emissions and these could be used more aggressively to achieve greater emissions reductions at low cost. These opportunities include stopping or reducing deforestation, peat fires and peat drainage. Peat drainage is closely connected to areas where oil palm and pulpwood plantations will develop, because peat is frequently drained for plantation development. Some of these opportunities offer possible synergies among sustainable development, poverty reduction and climate change mitigation, and should be prioritised in the national REDD+ programme.

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