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Managing peatlands in Indonesia

Challenges and opportunities for local and global communities

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Key messages

- Indonesian peat swamp forests provide significant benefits at local and global scales. Drainage and conversion of these peatlands into agricultural lands causes considerable and irreversible environmental, social and economic damage, associated in particular with recurrent large-scale fires. Such consequences likely outweigh any short-term private gains.
- Carbon stocks in Indonesia's peatlands, and greenhouse gas (GHG) emissions associated with conversion, are globally significant. Precise evaluation of the role peatlands play in GHG budgets, at subnational, national and global levels, is hampered by methodological divergences and large variations in estimates.
- Economically viable and environmentally sustainable livelihood options for smallholders in Indonesian peatlands are limited, underdeveloped and urgently need to be enabled and expanded.
- The catastrophic fires of 2015 reinforced the Indonesian government's commitments to both reduce peatland deforestation and fires, and rewet and restore degraded peatlands.
- Peatland restoration is a potential solution, but faces economic-social-environmental trade-offs that generate intense disagreement between stakeholders holding divergent interests (e.g. company concessions, communities and local government). Successful peatland restoration will depend on how diverse priorities are reconciled, as much as it will depend on improved governance and technical capacity building.
- Fire management interventions will struggle to achieve their objective of fire-free futures, unless appropriate mixes of sanctions and incentives can be identified to successfully engage diverse stakeholders, including smallholders, agri-business, small- and medium-sized enterprises and absentee investors. Exploring areas of shared concern among diverse stakeholders could provide an entry point for dialogue, action and policy toward change.

Background

Indonesian peat swamp forests cycle and store globally significant amounts of carbon. They provide essential ecosystem services, including regulating water across the landscape and buffering salt/freshwater transitions in coastal areas. They host unique and often endangered species such as orangutans, and provide critical habitats for migratory birds. Local people traditionally benefit from peat swamp forests for timber to build their houses, nutrient-rich wild food and fish to supplement their diet, clean water and access to medicinal plants. These natural riches can also be a source of income and well-being.

Peat forests and the ecosystem services they provide are being transformed at a critical rate - between 2007 and 2015 the rate of loss was 2.6% per year in Sumatra and Kalimantan (Miettinen et al. 2016). Growing demand for arable land, in particular for palm oil production, lack of suitable unused uplands, and the attractiveness of peatlands' availability and flat topography (as opposed to alternative upland steep hills that present erosion risks), have all led to intense conversion and drainage of peatlands in recent decades. Weak and unclear land tenure has likewise prompted overlapping land claims between individuals, communities, companies and governments, consequently facilitating their appropriation. Peatlands now represent a contested frontier region.

In response to global markets, oil palm has become one of the most economically attractive crops to cultivate in humid tropical regions. Yet the national benefits of peatland-generated palm oil, including the full costs associated with degradation, fires and restoration, have not been systematically analyzed. Indonesia is the leading global producer of crude palm oil with a production rate growing exponentially over time (Murdiyarso et al. 2010). The contribution of oil palm expansion to peatland deforestation also tends to follow an exponential pattern (Miettinen et al. 2016), even though oil palm development is not the sole driver behind peat swamp forests disappearing.

Burning is commonly used by Indonesian landholders, including smallholders, small- and medium-sized enterprises and some industrial-scale companies, and is perceived as the most cost and labor-efficient method for removing vegetation. It also temporarily improves soil fertility, reduces acidity and reduces pests. Fires are lit annually during dry months, but on peat soils they easily spread out of control and can become virtually impossible to extinguish. In areas with unclear land tenure, there is little motivation to limit the spread of fire, and there is inadequate capacity to control fires. Recurrent mega-fires, particularly during El Niño years, are of local, national and global concern. The ensuing toxic haze is harmful for human health, child development and increases risks associated with local and international travel. Fire and haze also cause irreversible environmental damage, as well as having a severe impact on the economy.

As elsewhere (e.g. in Europe or North America), sustainable management of peatlands in Indonesia has presented challenges. Unclear accountability, regulations and policies on peatland use and protection, combined with incongruent enforcement of the former has caused massive deforestation and degradation. Peatland fire management interventions and policies have historically underperformed. To meet these challenges, the Indonesian government has recently undertaken high-level efforts and invested billions of dollars to improve management and conservation of the archipelago's remaining peat swamp forests, eradicate fires and rewet and restore degraded peatlands.

This infobrief documents the main findings of past and ongoing research on Indonesian peatlands by CIFOR, CIFOR's partners and other institutions. Our aim is to provide a synthesis of research-based knowledge to a wide range of practitioners, including policy makers; and highlight key gaps for the scientific community. We expect this brief to be useful for strategic planning, national reporting, and policy development and implementation.

Peatland carbon resources

Indonesian peatlands hold huge amounts of carbon in their soil and biomass, especially when in pristine condition. On average, Indonesian peat swamp forests store 220 ± 28 tonnes of carbon per hectare (t C/ha) in the phytomass (alive and dead vegetation) (Hergoualc'h and Verchot 2011), and 668 ± 20 t C/ha per meter depth of peat (Warren et al. 2012). Most of the carbon is found in the soil, with a 1:3 ratio between phytomass and soil, in a shallow 1-meter-deep peat forest. With a mean peat depth of 5.5 m, pristine peat forests in Indonesia store on average about 12 times more carbon than tropical rainforests on mineral soil in insular Asia, according to the Intergovernmental Panel on Climate Change (IPCC) default values. However, spatial variability, limited sample sizes and differences in methods across studies have led to large variations in estimates.

In peat swamp forests, more than 80% of the carbon stored in vegetation is found in standing trees. Therefore, computing the stocks in this pool more accurately is essential to improving the overall carbon stock assessment. Previous estimates of aboveground carbon stock in trees used generic pan-tropical models, which systematically over- or under-estimated the stocks of certain tree species. A new model specific to peat swamp forests within Indonesia allows more precise estimates of aboveground carbon stock in trees from tree diameter measurements (Manuri et al. 2014). Developing such models requires destructive sampling, which is costly, not environmentally friendly and not preferred. Therefore, alternative methods of quantifying carbon stocks, using terrestrial laser scans without destroying trees, are being explored.

Peat carbon stocks are calculated from bulk density (peat mass per unit volume), carbon content and depth. Measuring bulk density is relatively easy and cheap, but measuring carbon content accurately is expensive and requires sophisticated equipment. To overcome this technical limitation, simple cost-efficient relationships were developed to assess peat carbon density (peat carbon mass per unit volume) from bulk density values in peat swamp forests (Warren et al. 2012) and converted peatlands (Farmer et al. 2014). Measuring peat depth in deep peat deposits is arduous. Indirect geophysical methods, like ground-penetrating radar and electrical resistivity imaging, have recently shown themselves to be effective in capturing peat depth and heterogeneity.

Vegetation composition and peat depth vary tremendously across the landscape. Remote sensing tools have attracted strong interest from those looking to account for this variability and reduce costs of field collection. Peatland carbon stock estimates derived from radar images and high-resolution satellite (Landsat) images remain highly uncertain. CIFOR and partners recently developed a model to identify and map wetlands and peatlands in the tropics (and Indonesia in particular), using satellite moderate resolution (MODIS, 235 x 235 m^2) images (Gumbricht et al. 2017). The results indicate that, across the tropics, Indonesia is second in peat area and volume after Brazil. The updated Indonesian peat area (22.5 million ha) is significantly larger than that reported in the official government map (14.9 million ha; Haryono et al. 2011), notably due to previously unaccounted peat deposits in Indonesian Papua. The map (http://www.cifor.org/ global-wetlands/) is interactive and freely available, with registered users able to verify and input data. Airborne LiDAR (Light Detection and Ranging technology, creating three dimensional points) yields precise estimates of peatland topography and vegetation structure. The technology is costly, cannot cover as much area as other remote sensing approaches, and is therefore more appropriate for targeted local assessments and interventions.

The threats

Deforestation, drainage and conversion to agriculture

Reclamation of peat swamp forests in Indonesia started in the late 1960s. Forests were depleted as a result of large government programs (e.g. transmigration, mega-rice project), unmonitored legal logging in concessions and extensive illegal logging. Drainage canals were built to enable agricultural development and the transportation of logs. These canals provided access deep into remaining unlogged forests. They led to the draining of extensive areas of peatland, leaving them dry and exacerbating fires. To date, just 7% of pristine peat swamp forests remain in Sumatra and Kalimantan (Miettinen et al. 2016) and only Papua holds large areas of pristine peatland. About half of peatlands in Sumatra and Kalimantan are used for smallholder agriculture and industrial plantations (Miettinen et al. 2016), with oil palm accounting for 64% of industrial plantation areas. Pulpwood (*Acacia*) plantations account for the remaining area under industrial management; these are mostly (95%) located in Sumatra (Riau and South Sumatra).

Smallholders are key stakeholders in the peatland landscape, yet improvement of sustainable livelihood options for them has been largely disregarded. Livelihoods of Indonesian smallholders in peatland areas are diverse. They are mainly based on natural resources, including forestry, fisheries, agriculture and mining; with a share of these activities varying widely across regions (Noor et al. 2005). Local communities commonly extract timber and non-timber forest products, such as wild honey, resins and rattan (Anshari and Armiyarsih 2005). The high dependence of some local communities on revenues from timber extraction has induced overexploitation of peat forests and depletion of resources. Timber is usually sold locally at very low prices, especially when derived from illegal operations.

Fish is the main source of protein among households living on peatlands in Indonesia. Local people have developed an array of techniques and tools to harvest fish. These take advantage of variations in peatland topography and river water levels, including flooding events. Some rare fish species (e.g. *arowanas*) are over-harvested as the result of high international demand, putting their continued survival at risk. In addition, freshwater habitat has been severely deteriorated by drainage for agriculture development and other activities, such as gold mining, consequently reducing fish diversity and productivity (Palis 2000).

Agriculture is an important source of income for rural communities. Rearing of livestock (cows, goats, sheep and buffaloes) is small-scale and traditional. Efforts to introduce alternative livestock-based livelihoods for resource diversification have been limited and their success minimal, in part due to high disease prevalence. Agricultural and agroforestry practices are constrained by the hydrology and poor soil properties (high acidity, low nutrient content) of peatlands. Smallholders most commonly use draining and slash-and-burn practices for agriculture. They often take advantage of existing drainage canals built up by logging, oil palm or pulp and paper companies. Crops and trees commonly grown by rural smallholders, especially migrants, include oil palm, rice, rubber (*Hevea brasiliensis*) and rattan. Smallholders prefer to plant rice (as a staple food) and oil palm (as a cash crop), even though the burning and draining practices required to grow these crops bring negative environmental consequences that are extremely costly to reverse. For the cultivation of rice or other annual crops, land is regularly burnt, causing significant soil losses and greenhouse gas (GHG) emissions. This will likely continue, as long as knowledge about the impacts of draining and burning peatlands is low, and while economic options for more sustainable use of peatlands remain limited.

The diverse ways in which peatlands are used by smallholders and larger-scale industries results in wide-ranging GHG footprints; however, all uses that employ drainage lead to long-term huge GHG emissions (Box 1). Drained secondary forest and shallowly drained Sago palm plantations are the smallest emitters. The land use with the highest ecological footprint is the industrial *Acacia* plantation (77 [61; 93] t CO_2e/ha/y). *Acacia* is a nitrogen-fixing species exploited under deep drainage and over short rotation periods (six years). Annual peat emissions of GHG in oil palm plantations, croplands and rice fields are similar in magnitude. However, if farmers burn their land annually to improve soil fertility for rice or annual crop production, peat annual emissions increase tenfold, reaching losses as high as ~600 t CO_2e/ha/y. For oil palm plantations, total emissions over 25 years, including forest vegetation replacement, peat decomposition and losses from one clearing fire, reach 2216 [1,1331; 3,135] t CO_2e/ha (Box 1). Miettinen et al. (2016) estimated that 0.4 million ha of peat swamp forest area was converted to industrial oil palm plantations between 2007 and 2015. Corresponding emissions over the following 25 years are approximately 980 million t CO_2e - 71% of Indonesia's annual emissions for 2002, as reported to the UN Framework Convention on Climate Change (UNFCCC).

Fires

Peatland drainage and conversion to agriculture has been associated with severe, uncontrolled peat fires that present significant public health and environmental damages, economic losses, and diplomatic tensions across scales (local to global) and sectors (Carmenta et al. 2017a). Indonesian peat fires and the associated transboundary haze release substantial amounts of toxic aerosols that cause respiratory disease and premature death across equatorial Asia (Koplitz et al. 2016). Peatland fires also release huge pulses of GHG into the atmosphere. Due to both fires and the continuous emissions associated with the land use, land use change and forestry (LULUCF) sector, Indonesia is ranked among the top GHG emitting countries in the world. This is particularly true in El Niño years, such as in 1997, 2006 and 2015.

The 2015 El Niño fires burnt 0.9 million ha of peatland, mostly in the southeastern provinces of Sumatra, the south of Kalimantan and Papua. They released 1164 million t CO_2e between September and October, as much as 84% of Indonesia's reported annual emissions for 2002 (Huijnen et al. 2016). The World Bank estimated that the fires cost

USD 16.1 billion. Yet, with half a million cases of acute respiratory infections recorded, disruption of economic activity, closure of schools and habitat destruction with long-term impacts on ecosystem services, the true cost, now and in the future, remains unknown.

A study on the political economy of fire and haze was conducted to understand the forces driving fires in Riau-Sumatra, a province that has experienced both fires and forest transition to oil palm plantations (Purnomo et al. 2017). Social, political and economic data were collected from surveys in former fire sites, and group discussions were held with key stakeholders. Stakeholders included governments, who develop and implement fire policies; actors involved in business and experienced in using fires; non-governmental organizations, who actively engage on fire issues; local communities, who engage with fire suppression issues; and academics, who actively research fires.

Fire actors – large, medium and small – benefit directly and indirectly from the business of fire, enjoying profits and economic returns at the expense of the environment and local people's health. Findings show that the value of land cleared by slashing (not ready to plant) is USD 665 per ha. This increases to USD 856 per ha when it is burned (ready to plant) and to USD 3077 per ha for land already planted with oil palm. Money made from selling land cleared by fire is mostly distributed to district-level elites, who manage land transactions and organize farmers. Local community members who engage in burning are also paid with these funds. District-level elites receive 68% of the revenue, while individuals who burn land get 22%. Village elites who administer land documents obtain 10%.

These actors exchange information and form complex social networks that can influence decision-making processes at district, national and regional levels. Such elites form protective patronage networks, which hinder the government's capacity to allocate economic resources efficiently, enforce rule of law and maintain justice for all citizens. Patronage networks, profits and high market demand for oil palm incentivize the use of fire and will result in continued fires and haze events. Reducing incentives for large- and small-scale actors to burn land, and increasing enforcement and sanctions against burning, is crucial. Market demand for illegal land for plantations must be reduced and eliminated. Transparency, civil society engagement, anticorruption measures and an efficient government bureaucracy will reduce the effectiveness of patronage networks.

Peatland fire management has become a domestic and international priority, inducing intensely contentious debates, policies and legal proceedings (Carmenta et al. 2017a). Previous fire management interventions (FMI) are numerous, yet have suffered widespread implementation failures. Carmenta et al. (2017a) show that peatland fires generate considerable concern among diverse stakeholders, from local farmers to international policy makers. Stakeholders perceive peatland fires differently in terms of, i) prioritization of the associated benefits and burdens, and ii) perception on the effectiveness of FMI. Many contemporary FMI (e.g. criminalizing further agricultural expansion on peatlands) are perceived to be among the most effective interventions overall, yet these same interventions are also the most controversial amongst stakeholder groups. Stakeholders share concerns over the local health impacts and the potential of government support for fire-free alternatives as a solution pathway. Improved understanding of stakeholder perceptions has potential to: give voice to marginalized communities; enable transparent mediation of diverse priorities; inform public education campaigns, and shape future policy and governance arrangements.

The opportunities

Over the last six years, Indonesia has made important commitments toward reducing its emissions from peatlands. In 2011, the government put into effect a two-year moratorium to prevent new concessions from converting peatlands, in particular, to plantations and logging areas. The peatland area protected under the moratorium spanned 11.2 million ha (out of a total 20.2 million ha of estimated Indonesian peatland); this included all peatlands, including those shallower than 3 m that had previously been unprotected (Murdiyarso et al. 2011).

In 2013, the moratorium was extended for two years. Following the catastrophic El Niño-related fires of 2015, the moratorium was revised in 2016. The revision set out a total ban on peatland clearing, even in existing concessions, and also banned the use of fire for land clearing. In addition, it had measures for planting in recently burned areas, aimed at future restoration.

The effectiveness of the moratorium in reducing peatland conversion remains to be determined. On the one hand, the most recent analysis on peatland cover change is not favorable. Out of the 0.9 and 0.4 million ha of peat swamp deforested between 2007 and 2015 in Sumatra and Kalimantan, respectively, 45% and 67% were turned into industrial plantations (Miettinen et al. 2016). On the other hand, the moratorium in the context of the REDD+ agreement between Indonesia and Norway prompted prominent changes in the politics of forest management in Indonesia (Seymour et al. 2015). According to CIFOR research, diverse stakeholders consider the moratorium effective, but it is one of the most chronically contested FMI (Carmenta et al. 2017a).

The Nationally Determined Contribution (NDC) of Indonesia submitted to the UNFCCC at the end of 2016 targets GHG emission reductions by 29% of business-as-usual emissions (scenario 1) in 2030, or 41% with international support (scenario 2). Emission reduction is focused on the LULUCF sector, which accounts for 60% of total emission reduction. Scenario 2 aims at restoring more than 2 million ha of peatlands, and rehabilitating 12 million ha of unproductive lands (mostly on mineral soils), by 2030. It sets an ambitious target of 90% tree survival rate in restored peatlands and rehabilitated lands. Clear incentives for restoring degraded and burnt peatlands are needed. For the concession and community, the tangible economic benefits of restoring lands are yet to be fully identified and realized – some immediate benefits of rewetting efforts include a reduction in fire risk and toxic haze.

As part of his commitment to stopping haze from forest and land fires, Indonesian President Joko Widodo, in addition to extending the moratorium, established the Peatland Restoration Agency (Badan Restorasi Gambut, BRG) in January 2016. Between 2016-2020, the BRG is tasked to coordinate and facilitate the restoration of 2.4 million ha of degraded and burnt peatlands in seven key provinces (Riau, South Sumatra, West Kalimantan, Central Kalimantan, South Kalimantan, East Kalimantan and Papua). The core of targeted areas is in concessions (58%), the remainder is in state and community lands.

The BRG aims to systematize peatland restoration through rewetting and revegetation. It proposes canal-blocking activities to rewet the peatlands in priority areas such as burnt areas and peat domes, and supports revegetation with endemic plants or alternative crops that can tolerate flooded conditions (paludiculture). Paludiculture in Indonesia could be implemented at different scales and with different objectives (Dommain 2013). At the small-scale, wet intercropping and wet agroforestry could provide food for communities and their livestock, while blocked drainage canals could be used as fish ponds. In deeply flooded areas, reeds could be planted for local bioenergy and fiber production. Alternatives to large-scale deeply drained plantations (such as *Acacia* plantations), include plantations of *Sago* palm; native rubber (*Dyera polyphylla*), locally named swamp Jelutung or Pantung; *Shorea sp.* that produce illipe nut, used as a cocoa butter substitute; swamp forest native species for commercial timber production; and *Macaranga* for pulp and paper production. Trials are required to test the feasibility of the above options. Paludiculture can only be successful through engagement of key stakeholders, notably the industry sector. Improvements in the value chain, and technical knowledge for high productivity, are also necessary to render these commodities more financially attractive.

The 2015 fires renewed interest in securing fire-free futures for peatlands. In addition to government actions, a number of new institutions have emerged that can help achieve this target. For example, the Fire Free Alliance (FFA) provides a platform for diverse stakeholders to share knowledge and to scale-up and coordinate efforts across the private sector.

Peat degradation and fires are most often blamed on either small-scale farmers or agro-industry. Stakeholder groups with interest in and relevance to peatland management in Indonesia include sub-categories of landholders, notably absentee investors and landholders, which are largely overlooked in related debates and fire management interventions (FMI) (Carmenta et al. 2017a).

Research indicates that a number of leading contemporary FMI, for example, the moratorium on peat development, revoking licenses of rogue companies and rewetting peatlands, will likely encounter challenges. The challenges will result from the multiple stakeholders who hold divergent perspectives, priorities, knowledge and interests related to peatland management. Future FMI will need to address the perceptions and preferences of these diverse groups (e.g. small-scale farmers, absentee investors, agri-business, local elites) to change behavior and develop landscape management schemes (Carmenta et al. 2017b). Multi-stakeholder negotiations and dialogues to define acceptable compromises are important enablers of effective policy development. Appropriate mixes of incentives (e.g. payments to communities to reward fire-free practices), disincentives (e.g. penalties for burning) and innovations (e.g. implementation of risk-based early warning tools, training of fire brigades) will thus need to be defined. Ongoing research continues to examine factors (social, geographic, institutional) linked to high performance of FMI on the ground.

Recommendations

Conservation of remaining peat swamp forests in Indonesia, and the sustainable management and restoration of peatlands, necessitate integrated cross-sectoral approaches that require transparent dialogue between stakeholders to negotiate the complex tradeoffs of environmental and economic imperatives.

The location, land cover and tenure status of areas protected under the moratorium, and areas targeted for restoration and rehabilitation, should be transparently and rigorously communicated to all stakeholders involved in these initiatives. There is also a need for clearly defining restoration versus rehabilitation, and providing detailed information on initiatives that fall under one or the other category.

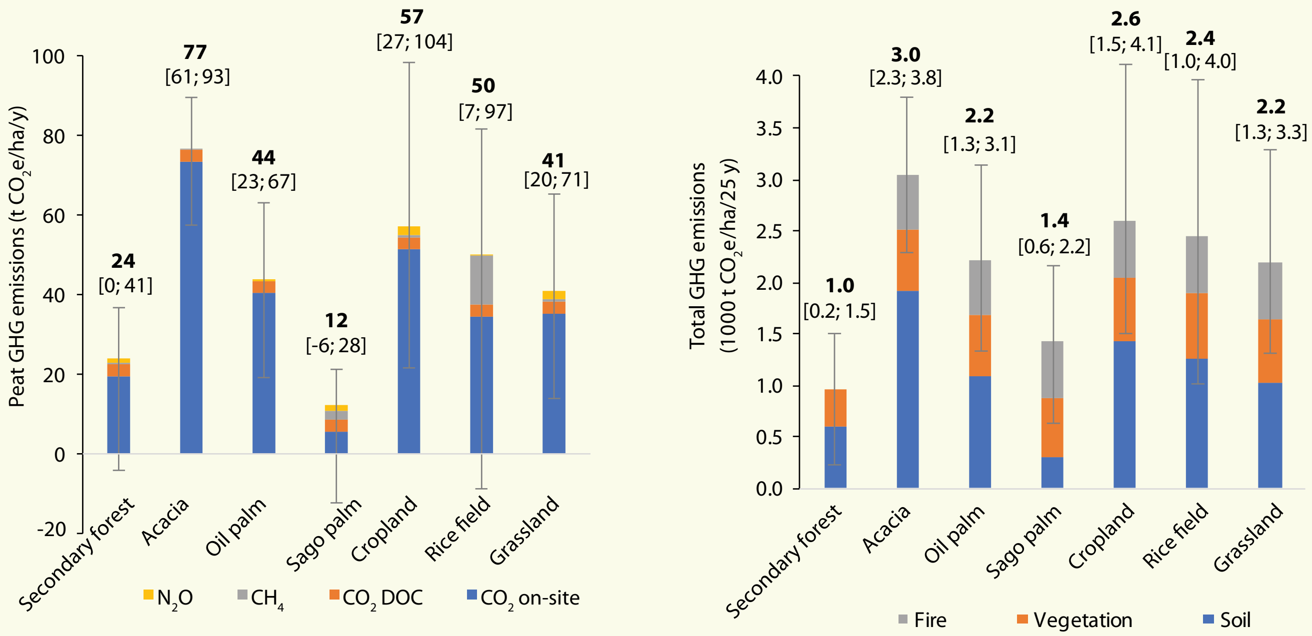
Incentivizing local economies, community empowerment, capacity building on peat management and law enforcement are key strategies for peatland conservation, restoration and fire prevention. But it is also necessary to encourage institutions and mechanisms that can generate the much-needed behavioral change of other stakeholders, including large-scale agri-business, small- and medium-sized enterprises and absentee investors.

Developing a variety of wetland-adapted livelihoods and financially viable agro-business options is urgent and imperative. New models of peatland management require rigorous analysis of, and research on, the environmental, economic and social outcomes of the alternatives. Coordination between actions at the local scale and planning at a larger scale, notably investment channeling, will be essential for effective implementation (Carmenta et al. 2017b).

Indonesia is the tropical country with the most comprehensive data on peat carbon and GHG fluxes. Even though new initiatives have emerged for improving peatland mapping, disturbance level identification and ecosystem carbon stocks assessment, knowledge on the GHG footprint of existing drained lands is based on sporadic data, whilst knowledge on the GHG footprint of restored lands is inexistent. Research into this and other areas should rely on credible, accurate and standardized methods.

Before and after: Pristine peat swamp forest in Berbak national park (top) and an eight-year old oil palm plantation on peat (below) in Jambi, Sumatra (photos by K. Hergoualc'h)

Box 1. Average [min; max] annual peat emissions of greenhouse gas (GHG) (left) and total GHG emissions from forest conversion over 25 years (right)



Peat GHG emissions in drained land uses (left) were computed as the sum of emissions of carbon dioxide (CO_2) from peat decomposition on-site and dissolved organic carbon (DOC), methane (CH_4) and nitrous oxide (N_2O). Emissions of N_2O from nitrogen fertilizer application were not considered due to the high variability in application rate across land use categories. All emission factors were taken from the IPCC Wetland supplement, Chapter 2. CH_4 and N_2O were converted to CO_2 equivalent (CO_2e) using their respective global warming potentials of 86 and 268 over a 20-year time horizon and with climate-carbon feedbacks. Total emissions from forest conversion over 25 years (right) included emissions from the peat taking place annually (Soil) and following one land clearing fire (Fire) and emissions from forest vegetation replacement (Vegetation). Annual soil emission rates were taken from the left subpanel, and emissions from fire from the IPCC Wetland supplement, Chapter 2. Emissions from vegetation replacement used aboveground biomass averages from Hergoualc'h and Verchot (2011), and assumed a similar biomass in Sago palm as in oil palm plantations, and in grasslands as in croplands. We considered that no fire had burnt in the drained secondary forest.

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The CGIAR Research Program on Forests, Trees and Agroforestry (FTA) is the world's largest research for development program to enhance the role of forests, trees and agroforestry in sustainable development and food security and to address climate change. CIFOR leads FTA in partnership with Bioversity International, CATIE, CIRAD, ICRAF, INBAR and TBI. FTA's work is supported by CGIAR Fund Donors.

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