Managing peatlands in Indonesia

Challenges and opportunities for local and global communities

Photo: James Maiden/CIFOR

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KEY MESSAGES

- Indonesian peat swamp forests provide important local and global benefits. Their drainage and conversion into agricultural lands cause considerable and irreversible environmental, social and economic damage.
- Carbon stocks in Indonesia's peatlands and greenhouse gas (GHG) emissions associated with conversion are known to be substantial. However, large variations in estimates hamper a proper evaluation of their role in GHG budgets at subnational, national and global levels.
- Environmentally and financially sustainable livelihood options for smallholders in Indonesian peatlands remain limited and underdeveloped.
- The catastrophic 2015 fires have reinforced the commitments of the Indonesian government both to reduce peatland deforestation and fires, and to rehabilitate and restore degraded peatlands.
- Peatland restoration faces economy-environmental trade-offs. It generates intense disagreement between stakeholders holding divergent interests (company concessions, communities, local governments, etc.). The success of peatland restoration will depend on how diverse priorities are reconciled, but also on improved governance and technical capacity building.
- Fire management interventions may struggle to achieve their remit of fire-free futures. Exploring areas of shared concern among diverse stakeholders might provide an entry point for dialogue toward change. However, appropriate mixes of sanctions and incentives will need to successfully engage these stakeholders, including smallholders, agri-business, small- and medium-sized enterprises (SMEs), and absentee investors, among others.

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Background

Indonesian peat swamp forests cycle and store globally significant amounts of carbon. They regulate water across the landscape and buffer salt/fresh-water transitions in coastal areas. They host unique species such as orangutans and provide 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 medicinal plants. These natural riches are also a source of income.

These forests and the ecosystem services they provide are vanishing at a critical rate (2.6%/year in Sumatra and Kalimantan) between 2007 and 2015 (Miettinen et al. 2016). Growing demand for arable land especially for oil palm, attractiveness in relation to their flat topography (as opposed to alternative steep hills that present erosion risks) and non-active agricultural use have all led to intense conversion over past decades. Further, weak and unclear land tenure have led to overlapping land claims across individuals, communities and companies. Peatlands now represent a contested frontier region.

In response to global market, oil palm has become one of the most economically attractive crops to cultivate in tropical regions. 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 of peat swamp forest disappearance.

Burning is commonly used as the most cost- and labor-efficient method for removing vegetation in Indonesia. It also temporarily improves soil fertility. Fires are lit during dry months; they easily spread out of control and can become nearly impossible to extinguish. In areas with unclear land tenure, there is little motivation to limit the spread of fire. Peat fires in Indonesia occur annually. Recurrent massive fires, particularly during El Niño years, are of local, national and global concern. The ensuing toxic haze is harmful for human health. Fire and haze also cause irreversible environmental and severe economic damage.

Sustainable management of Indonesian peatlands has been a challenge. Related fire management interventions and policies have historically underperformed. To meet these challenges, the Government of Indonesia has recently undertaken high-level efforts and is investing billions of dollars to improve management and conservation of remaining peat swamp forests, banish fires and restore degraded peatlands.

To support these efforts, this Infobrief documents the main findings from past and ongoing research on Indonesian peatlands by CIFOR, the CGIAR Research Program on Forests, Trees and Agroforestry (CTA) and partners. We expect this brief to be useful for national reporting, strategic planning and policy making.

Peatland carbon resources

Indonesian peatlands store huge amounts of carbon in their soil and biomass, especially when in pristine condition. Based on our latest estimate, Indonesian peat swamp forests store on average 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 one-quarter–three-quarter proportion for phytomass and soil, respectively, in a shallow 1-meter-deep peat forest. Using Indonesia's peat depth average of 5.5 m, pristine peat forests store about 12 times more carbon than forests on mineral soil, using IPCC (Intergovernmental Panel on Climate Change) numbers for the latest. However, 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 accurately is essential to improve 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. With partners, we developed a new model specific to peat swamp forests. It 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 and not environmentally friendly. We are exploring novel methods of quantifying carbon stocks using terrestrial laser scans without destroying trees. To estimate peat carbon stocks, we must measure the peat bulk density (peat mass per unit volume), carbon content and depth. Peat carbon density (peat carbon content per unit volume) is obtained from bulk density and carbon content values. Measuring bulk density is relatively easy and cheap, but measuring carbon content accurately is expensive and requires sophisticated equipment. To overcome this technical limitation, we developed simple cost-efficient relationships for assessing peat carbon density from bulk density values in peat swamp forests (Warren et al. 2012) and converted peatlands (Farmer et al. 2014).

Before and after: Pristine peat swamp forest in Berbak National Park (left) and eight-year-old oil palm plantation on peat (right) in Jambi, Sumatra. (Photos by Kristell Hergoualc'h/CIFOR)

Measuring peat depth is also challenging, notably in deep peat deposits. Indirect geophysical methods like ground-penetrating radar and electrical resistivity imaging have lately shown 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 to cover this variability, but also to reduce costs of field collection. Peatland carbon stock estimates derived from radar images and high-resolution satellite (Landsat) images remain highly uncertain. Studies using airborne lidar (Light detection and ranging technology creating three dimensional points) produce more precise estimates. However, they are costly and cannot cover as much area as other remote sensing approaches.

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 (225,420 km^2) and volume (1388 km^3) are slightly larger than earlier reported, notably due to previously unaccounted deep peat deposits in Indonesian Papua. The map (http://www.cifor.org/global-wetlands/) is interactive and freely available. We invite the wetland community to collaboratively support this map. Registered users can verify and input data.

The threats

Deforestation, drainage and conversion to agriculture

Reclamation of peat swamp forests in Indonesia started in the late 1960s. Forests were depleted as the result of large government programs (e.g. transmigration, mega-rice project), unmonitored legal logging and extensive illegal logging. Drainage canals were built for agriculture development and transporting logs. These canals provided access deep into remaining unlogged forests, dried extensive areas of peatlands and exacerbated fires. To date, just 7% of pristine peat swamp forests remain in Sumatra and Kalimantan (Miettinen et al. 2016). Only Papua still withholds large areas of pristine peatlands. Almost half (48%) of peatlands in Sumatra and Kalimantan are used for smallholder agriculture and industrial plantations (Miettinen et al. 2016). Oil palm accounts for 64% of industrial plantation area.

Livelihoods of smallholders in Indonesian peatlands are diverse. They are mainly based on natural resources, including forestry, fisheries, agriculture and mining. Primary and secondary peat forests are home to a variety of commercial timber (e.g. *Shorea sp.*), giving rise to small-scale timber harvesting operations. Small teams of six–eight conduct these operations. They are highly selective of the timber for harvest, choosing the largest and most valuable trees. They operate illegally and sell the timber locally at very low prices. The environmental and economic outcomes of small illegal loggers remain to be compared with those of well-organized illegal logging bands, and companies holding large and legal logging concessions.

Fish is the main source of protein among households living on peatlands. 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. Livestock rearing is not common, due in part to high disease prevalence. Numerous efforts to introduce alternative livestock-based livelihoods have had limited success.

Agricultural and agroforestry practices are also 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. However, these practices bring negative environmental consequences that are extremely costly to reverse.

Crops and trees commonly grown include oil palm, rice, rubber (*Hevea brasiliensis*) and rattan. These are important sources of income for rural smallholders. Smallholders prefer to plant rice (as staple food) and oil palm (as cash crop), even though peatlands must be cleared, burned and drained to grow these crops. This will likely continue as long as economic options for a sustainable use of peatlands remain limited.

There are periods of the year when the above livelihood options are limited. As a result, people migrate for months at a time to other areas in search of work, such as in oil palm plantations or in small-scale informal gold mining upstream. This seasonal "off-farm" work is crucial for maintaining income throughout the year.

Conversion from peat forest to agriculture either by smallholders or the industry leads to long-term massive emissions of greenhouse gas (GHG). Annual peat emissions of GHG in oil palm plantations and rice fields are similar in magnitude (Box 1). Notwithstanding peat annual emissions in rice fields increase by a factor 10 (591 [293; 893] instead of 50 [7; 97] t CO2 equivalent/ha) if we consider that the farmer burns its land annually to improve soil fertility. The same is true for annual croplands cultivated by smallholders. The industrial land use with the highest ecological footprint is *Acacia* plantation (77 [61; 93] t CO_2 equivalent/ha). *Acacia* is a nitrogen-fixing species exploited under deep drainage and over short rotation periods (six years).

Total emissions over 25 years, including forest vegetation replacement, peat decomposition and losses from one clearing fire, are as high as 2216 [1,1331; 3,135] t CO_2 equivalent/ha for oil palm plantations (Box 1). Miettinen et al. (2016) estimated 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 about 980 million t CO_2 equivalent, or 71% of the Indonesian 2002 annual emissions reported to the UN Framework Convention on Climate Change (UNFCCC).

Fires

Each fire event on peatland releases huge pulses of GHG into the atmosphere, and increases the risk of future fires in surrounding areas. Due to fires and continuous emissions associated with land use, land use change and forestry (LULUCF), Indonesia is ranked among the top GHG emitter 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 peatlands, mostly in the southeastern provinces of Sumatra, the south of Kalimantan and Papua.

Our results show that the Indonesian fires released 1164 million t CO_2 equivalent between September and October 2015, i.e. 84% of Indonesia's annual emissions reported for 2002 (Huijnen et al. 2016). The World Bank estimated 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 impacts on ecosystem services, the true cost is unknown.

CIFOR and partners studied the political economy of fire and haze (Purnomo et al. 2017) to understand the forces driving fires in Riau-Sumatra, a province that has experienced fires and forest transition to oil palm plantations. We collected social, politic and economic data from surveys in former fire sites and held group discussions with key stakeholders. Fire stakeholders included governments, which develop and implement fire policies; business communities experienced in using fires; non-governmental organizations, which actively engage on fire issues; local communities, which 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 rents at the expense of the environment. Findings show that the value

Smoke, allegedly from a fire used for land clearing, billows at a palm oil plantation at Tripa peat swamp in Nagan Raya, Aceh province, Indonesia, 1 October, 2012. (Photo by Dita Alangkara/CIFOR)

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 planted with oil palm.

Money made from selling land cleared by fire is mostly distributed to local elites at the district level, who manage land transactions and organize farmers. Local community members who engage in burning are also paid with these funds. Local 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. These 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, anti-corruption measures and an efficient government bureaucracy will reduce the effectiveness of patronage networks.

The opportunities

In 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 peatlands area solely and newly given protection under the moratorium was 11.2 million ha out of 20.2 million ha in Indonesia (Murdiyarso et al. 2011). The moratorium covered all peatlands, including those shallower than 3 m that had previously been unprotected.

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 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 peatlands 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 still a highly contentious management intervention.

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 concentrated in 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% survival rate in restored peatlands and rehabilitated lands. Clear incentives for restoring degraded and burnt peatlands are needed. Indeed, the tangible economic benefits to the concession and community from the restored lands are questionable.

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 (BRG) in January 2016. The BRG coordinates and facilitates restoration of 2.4 million ha of degraded peatlands from 2016-2021 in seven key provinces (Riau, South Sumatra, West Kalimantan, Central Kalimantan, South Kalimantan, East Kalimantan and Papua). The targeted areas are located in concession, state and community lands.

The BRG aims to systematize peatland restoration and regeneration. It proposes canal-blocking activities in fire-prone landscapes and supports alternative crops that can tolerate flooded conditions. Agricultural commodities that thrive without draining peatlands include, but are not limited to, native rubber (*Dyera polyphylla*, locally named swamp Jelutung or Pantung), rattan, candlenut (*Aleurites moluccanus*, or Kemiri) used in local cuisine or as a source of oil for e.g. cosmetic products, and (Borneo) illipe nut (*Shorea sp.*) used as a cocoa butter substitute. With improvements in the value chain and technical knowledge for high yields, these commodities can be made more financially attractive. For instance, candlenut is potentially economically competitive with palm oil.

The 2015 fires renewed interest in securing fire-free futures on peatlands. A number of new institutions, in addition to government actions, 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. CIFOR research identified 12 stakeholder groups with interest in and relevance to peatland management. These include sub-categories of landholders, notably absentee investors, which are largely overlooked in related debates and fire management interventions (FMI).

Research indicates that a number of leading contemporary FMI will likely encounter challenges. These include, for example, the moratorium on peat development, revoking licenses of rogue companies and reflooding peatlands. The challenges will result from the multiple stakeholders who hold divergent perspectives, priorities 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.

Multi-stakeholder negotiation and dialogue to define acceptable compromises are important enablers of policy. Appropriate mixes of incentives and disincentives will thus need to be defined. We identified areas of agreement between otherwise distinct groups to center on issues of health, quality of life and environment – perhaps providing entry points for a dialogue toward change. Ongoing research at CIFOR examines factors (social, geographic, institutional, etc.) linked to high performance of FMI on the ground.

Recommendations

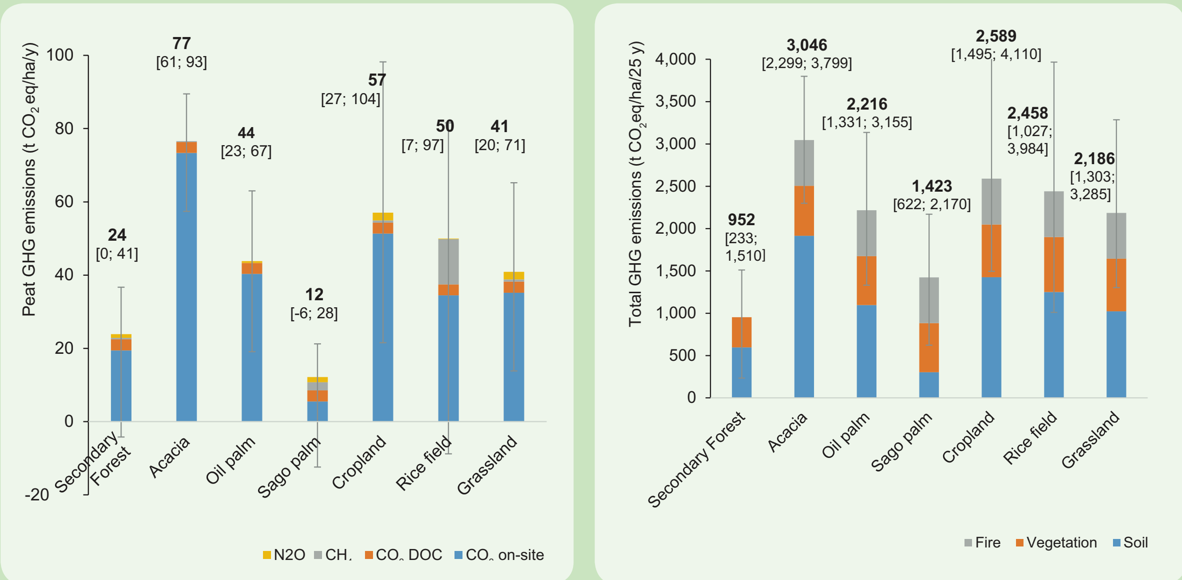
Indonesia is the tropical country with the most comprehensive data on peat carbon. However, it is essential to improve peatland mapping, disturbance level identification and ecosystem carbon stocks assessment, especially at subnational and local levels. Knowledge on GHG footprint of existing drained lands is based on sporadic data. Knowledge on GHG footprint of restored or rehabilitated lands is inexistent. There is, therefore, a clear need for improvement in this area.

Developing a variety of wetland-adapted livelihoods and financially viable agro-business options is requested. A rigorous analysis of the environmental and social outcomes of the alternatives should be conducted *a priori*. It should consider local and subnational circumstances.

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 details on initiatives that fall under one or the other category.

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

Box 1. Average [min; max] of annual peat emissions of greenhouse gas (GHG) (left) and total emissions of GHG 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 within land use categories. All emission factors were taken from the IPCC Wetland supplement chapter. CH_4 and N_2O were converted to CO_2 equivalent 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. 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 burned in the drained secondary forest.

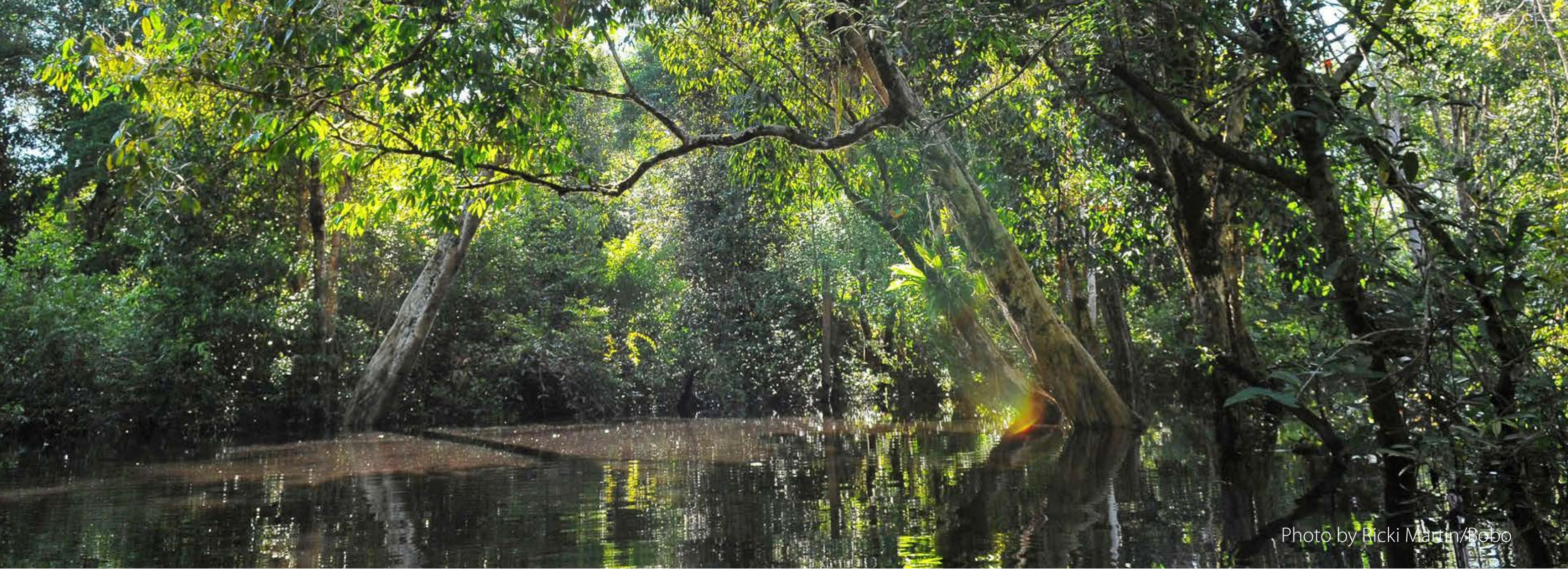


Photo by Ricki Martin/Bobo

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