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CIFOR

No. 269, December 2019

DOI: 10.17528/cifor/007490 | cifor.org

Is Indonesian peatland loss a cautionary tale for Peru?[1]

A two-country comparison of the magnitude and causes of tropical peatland degradation

Erik Lilleskov[2], Kevin McCullough[3], Kristell Hergoualc'h[4], Dennis del Castillo Torres[5], Rodney Chimner[6], Daniel Murdiyarso[3,7], Randy Kolka[8], Laura Bourgeau-Chavez[9], John Hribljan[5], Jhon del Aguila Pasquel[4,5] and Craig Wayson[10]

Key messages

- Indonesia and Peru harbor some of the largest lowland tropical peatland areas. Indonesian peatlands are subject to much greater anthropogenic activity than Peru's resulting in high GHG and particulate emissions.
- We explored patterns of impact in both countries and compared predisposing factors. Impacts differ greatly among Indonesian regions and the Peruvian Amazon in the order: Sumatra > Kalimantan > Papua > Peru.
- All impacts, except fire, are positively related to population density.
- Current peatland integrity in Peru arises from a confluence of factors that has slowed development, with no absolute barriers protecting Peruvian peatlands from a similar fate to Indonesia's
- If the goal is to maintain the integrity of Peruvian peatlands, government policies recognizing unique peatland functions and sensitivities will be necessary.

1 This Infobrief summarizes findings from the publication by Lilleskov et al. (2019)

2 USDA Forest Service, Northern Research Station, Houghton, MI, USA

3 USDA Forest Service, Northern Research Station, Madison, WI, USA

4 Center for International Forestry Research (CIFOR), Jl. CIFOR, Situ Gede, Bogor, Indonesia

5 Instituto de Investigaciones de la Amazonia Peruana (IIAP), Iquitos, Peru

6 School of Forest Resources and Environmental Science, Michigan Technological University, Houghton, MI, USA

7 Department of Geophysics and Meteorology, Bogor Agricultural University, Bogor, Indonesia

8 USDA Forest Service, Northern Research Station, Grand Rapids, MN, USA

9 Michigan Tech Research Institute, Michigan Technological University, Ann Arbor, MI, USA

10 USDA Forest Service, International Programs, Washington, DC, USA

Current situation of lowland peatlands in Indonesia and the Peruvian Amazon

Peatlands are globally important for the diversity of ecosystem services they provide, not least of which is their ability to take up large quantities of carbon dioxide (CO_2). The CO_2 is converted to organic carbon (C) that is stabilized in the vegetation and in the soil by the anoxic conditions caused by high water tables. Hence peatlands have a tremendous potential to mitigate climate change. Peat accumulation over millennial timescales has stored ~1/3 of the world's soil C on ~3% of its land surface (Page et al. 2011). However, this potential to store C depends on whether peatlands remain as sinks or are converted to sources of CO_2. The vast stores of C in peatlands are vulnerable to any changes in climate or hydrology that result in lower water tables, because this leads to increased oxidation by microorganisms and fire (Turetsky et al. 2015). Peatlands around the world are being drained, usually for conversion to agriculture or tree plantations. This drainage and the subsequent disturbances (fire, logging) or land use conversions have resulted in massive emissions of CO_2 from peatlands, contributing to the rapid rise in concentrations of greenhouse gases in the atmosphere (Limpens et al. 2008).

Indonesia and Peru harbor some of the largest lowland tropical peatland areas on the planet. Indonesia's peatlands are subject to much greater anthropogenic activity than Peru's, including drainage, logging, agricultural conversion, and burning, resulting in high greenhouse gas and particulate emissions. To derive insights from the Indonesian experience, we used geographic information systems to explore patterns of impact in the two countries. We examined Indonesian peatlands in three geographically distinct insular regions (Sumatra, Kalimantan and Papua) with different population and road densities, and compared the factors predisposing to their

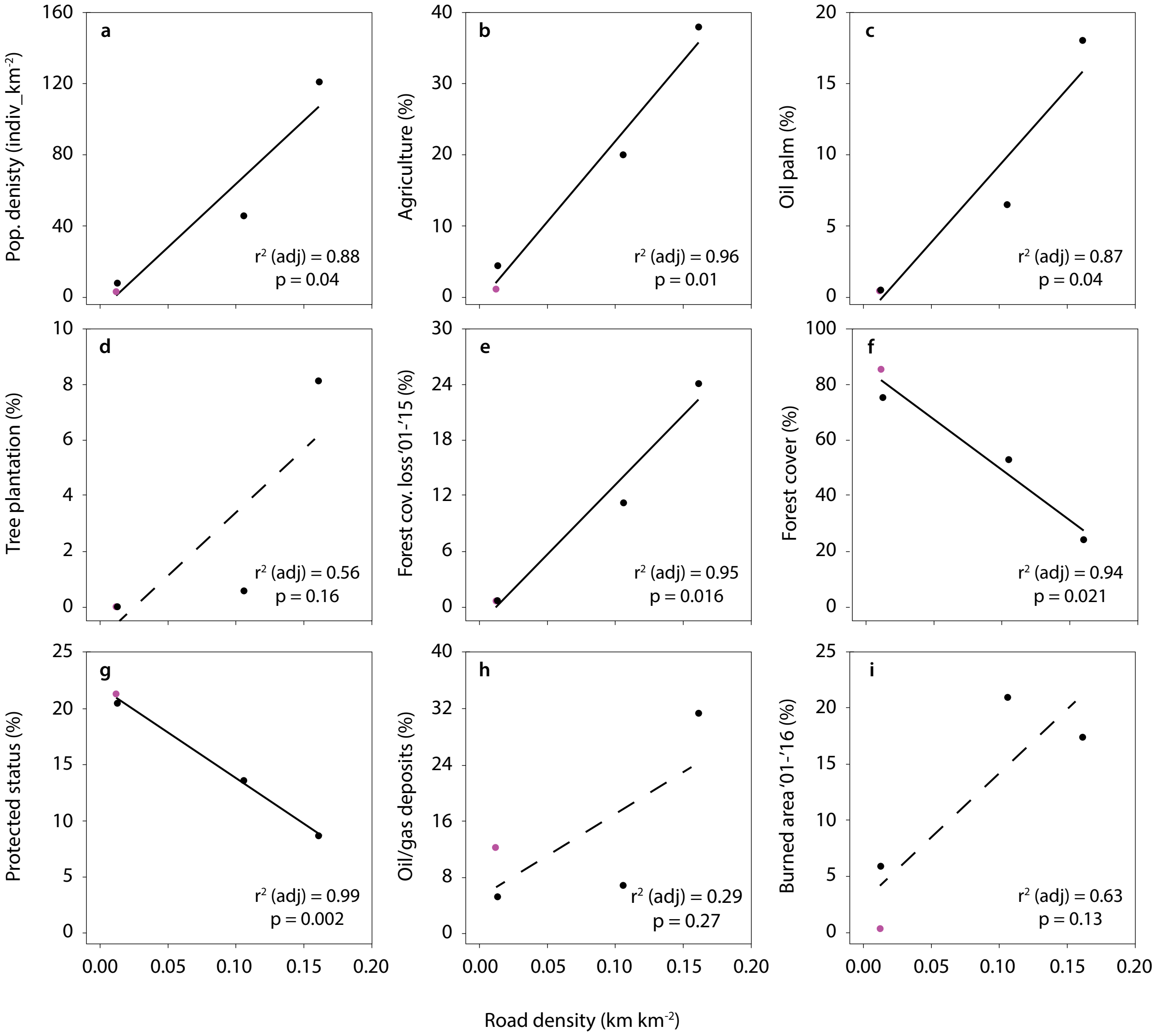

Figure 1. The relationship between road density in peatland areas and other drivers of peatland degradation (a-e, h-i) or protection (f-g). The three black circles are the three Indonesian regions, whereas the pink symbol is for Peru. Note that in c-e the symbol for Peru is in the lower left partially hidden by another symbol. R^2 is the proportion of variation in the vertical axis explained by road density with a maximum value of 1 (so for example an $r^2 = 0.95$ indicates that 95% of the variation in forest cover loss can be explained by road density). The p value is the probability that this is due to chance, with lower p values indicating lower probability. For example, a $p = 0.002$ is a two out of a thousand probability that this relationship is due to chance.

degradation and conversion to those in peatlands in the Peruvian Amazon. Impacts differ greatly among Indonesian regions and the Peruvian Amazon in the following order: Sumatra > Kalimantan > Papua > Peru. All impacts, except fire, were positively related to population density and road density (Figure 1), meaning that the Peruvian Amazon, with the lowest population and road density in peatlands, presently has lower impacts than all three Indonesian regions.

Factors that make Indonesian peatlands highly susceptibility to disturbance include peat doming (which facilitates drainage), coastal location, high local population, road access, government policies that permit peatland conversion, lack of enforcement of protections, and dry seasons that favor extensive burning. The main factors that could reduce peatland degradation in the Peruvian Amazon compared with Indonesia are geographic isolation from coastal population centers, more compact peatland geomorphology, lower population and road density, more peatlands in protected areas, different land tenure policies, and different climatic drivers of fire. Factors that could enhance peatland degradation in the Peruvian Amazon include oil and gas development, road expansion in peatland areas, and an absence of government policies explicitly protecting peatlands. There is good reason to believe that if the Peruvian Amazon peatlands were more extensively penetrated by roads, they would experience a similar fate to Indonesian peatlands. For example, the peatland areas of Peru with greatest land-use change are smaller areas in closer proximity to road-associated population centers in the southern Amazon.

Although population and road access were excellent predictors of peatland degradation, we do not mean to imply an immutable causal relationship. Clearly the trajectory of development and other impacts can be modulated by other factors, especially government policy and enforcement of laws. Peru could differ from Indonesia by its development of peatlands via government policies that affect the rate of population movement, road building, peatland drainage, and land-use change in the most important areas of peatlands.

However, at present Peru seems to be following a similar set of development policies to those of Indonesia in the late 20th century in regard to the lack of explicit legal or regulatory protection of peatlands from development. Other than in formally protected areas, policies addressing agricultural development of the Amazon do not explicitly protect peatlands. Of particular importance, since 2000 the Peruvian government has promoted oil palm expansion, with a series of policies in place supporting its development (Peru, Ministerio de Agricultura 2012; 2016).

One agricultural practice that has greatly increased the extent of fires in Indonesia is peatland drainage using ditches and canals (Page et al. 2002). Domed tropical peatlands, because they are raised above the regional water table, are especially susceptible to drainage by ditching compared with undomed peatlands (Baird et al. 2017). Adoption of similar practices in Peru could greatly increase the likelihood of fire impacts, especially in domed peat forests. Peruvian Amazon peatlands are a mixture of domed and undomed peatlands (Lähteenoja et al. 2009), and so likely vary in their susceptibility to drainage. Although peatland drainage is not common presently in the Peruvian Amazon, we are not aware of any prohibition of such activities.

As with its agricultural policies, we found that Peru's road planning decisions did not include mention of the environmental sensitivities of peatlands. Recent legislation indicates that the Peruvian government plans to expand the road infrastructure in proximity to the largest expanse of intact peatlands in the country; it has declared the construction of the Iquitos-Saramiria highway along the entire northern edge of the Abanico del Pastaza, the largest Ramsar site in the Peruvian Amazon, to be of "public necessity and national interest" (Peru, Congreso de la Republica 2017). This project would link this entire northern Amazonian region to the coastal road networks, which could lead to the intentional or illegal expansion of deforestation and agricultural activities into these peatlands. This would follow the Indonesian pattern of peatland degradation via population migration, deforestation and intensified land uses. In a global analysis delineating a rational plan for global road development, this region was identified as having high environmental value (without even considering peat carbon stocks) and low agricultural value, making it a high priority for continuance as a roadless area (Laurance et al. 2014).

The relatively large area of Peruvian Amazon peatlands that are underlain by oil and gas deposits, in combination with low population density, creates the potential for a fundamentally different development trajectory from Indonesia; that is, expanding the development of these deposits would stimulate migrant population incursions into the region, followed by peatland degradation, especially if linked to continuous road networks (Finer et al. 2008; Roucoux et al. 2017). One approach that minimizes such incursions is roadless oil and gas extraction projects, also known as the 'offshore inland development model', which uses alternative forms of transportation such as helicopters to access drilling sites and eliminates access roads associated with pipelines (Finer et al. 2015). Finer et al. (2013) evaluated and found such practices feasible for the province of Loreto, which contains the majority of Peru's peatland area.

Although Peru is developing policies related to both mitigation of greenhouse gas emissions and wetland conservation, these policies may not address peatlands' unique sensitivity to disturbance from drainage and

Table 1. Candidate policy options that would align with the sustainable management and development of peatlands in Peru, including enabling conditions, and key next steps.

Candidate policy option	Enabling conditions needed for policy to be effective	Key next steps needed to assess option
1. Develop new or revised comprehensive legislation to protect peatland functions and services	Coordination among land-management agencies; recognition of value of peatlands	Charge National Committee on Wetlands to lead synthesis of state of tropical peatland science, development impacts on greenhouse gases, public health, etc. and policy options
2. Conduct rational road network planning that includes environmental impacts	Planning infrastructure; institutional ability to enact road planning process	Identify areas that should remain roadless based on a rational planning process (see Laurance et al. 2014); include peatlands in decision-making process
3. Consider oil and gas exploration via roadless development in sensitive areas	Regulatory authority or corporate commitments	Based on #1 and 2 above, identify key regions for implementation of roadless approach
4. Quantify value of carbon and other ecosystem services in peatlands and reflect those values in land-use decision making	Scientific expertise available to evaluate peatland ecosystem services, emissions	Generate estimates of C accumulation in intact peatlands and greenhouse gas emissions from different land uses using Tier 1 factors; develop and apply higher tier (2,3) approaches
5. Incorporate fire risk into the peatlands development planning process	Planning infrastructure, adequate models, information to parameterize models	Develop experimental and modeling approaches to assess current and future fire risk, environmental and public health consequences
6. Ban drainage of peatlands for forestry and agriculture	Communication between land-use planning agencies	Summarize literature on drainage impacts on peatland ecosystem function, emissions, as basis for regulations
7. Include unique sensitivities of peatland ecosystem services in agricultural and forestry planning	Adequate assessment under #4 and #5 above	Apply Tier 1 (2,3) estimates of emissions and different scenarios of carbon valuation from #4 to peatland land-use planning process
8. Encourage development of markets for sustainable products from peatlands	Sustainability certification for peatland land use, knowledge of products	Identify potential certifiers; review literature on current products, markets, strategies; avoid perverse incentives (e.g. for road development)
9. Improve enforcement of laws against illegal logging or other degradation of peatlands	Funds to allocate toward enforcement	Evaluate resource allocation to, and effectiveness of, enforcement in Peru; perform risk analysis; base staffing on risk analysis
10. Manage protected areas for peatland conservation and to prevent illegal logging or extraction, etc.	Funds to allocate toward protected areas	Evaluate resource allocation to protected area management; perform risk analysis to guide staff allocation
11. Expand indigenous territories combined with sustainable natural resource management in peatland areas	Information on how indigenous territories affect peatland land use practices	Evaluate mechanisms by which sustainability is integrated in the management of indigenous territories (e.g. Green Climate Fund efforts)
12. Participate in carbon markets or other international mechanisms that value C sequestration in peatlands	Valuation of intact peatland C in markets or by partners; willing partners, existing markets; coordination with other conservation efforts	Continue to develop international partnerships; support efforts to include peatland carbon in markets

intensive land use. For example, the 2015 National Strategy for Wetlands (Peru, Ministerio del Ambiente 2015) covers many functions of wetlands, but does not mention their unique capacity to store carbon or regulate greenhouse gas fluxes; it does not even mention the existence of peatlands as a wetland type. Further, the new Peruvian National Strategy for Forest and Climate Change seems to encourage peatland drainage and conversion to agriculture, stating that "providing advice to implement … technologies … to drain wetlands … can reduce the migration of the indigenous and peasant population to fertile soils and/or non-deforested areas" (Peru, Ministerio del Ambiente 2016; our translation).

According to our analysis, Peru has approximately 50% more of its peatlands under formal conservation status than Indonesia (21% vs. 14%). This in itself could have a significant limiting influence on the peatland development trajectory for Peru, assuming that these protections are enforced. Additionally, in Peru there is a stronger tradition of formal assignment of land tenure to indigenous communities (Blackman et al. 2017) than in Indonesia. Significant areas of forested land are in indigenous territories, and this may provide some protection against deforestation and forest disturbance (Oliveira et al. 2007, Blackman et al. 2017). However, because even protected areas and indigenous territories are susceptible to illegal logging and other impacts, it is critical to understand the factors that influence enforcement of protection. In Peru, legal logging concessions have been associated with illegal logging activities outside of concession boundaries (Finer et al. 2014). Therefore, one of the key factors in maintaining peatland integrity in protected areas is the effective management of logging concessions outside of protected areas, and adequate resource allocation for effective management of the protected areas themselves (Watson et al. 2014).

Policy options moving forward

There is a growing recognition of the need to consider peatland C storage and accumulation as part of systems of C credits (Pearce 2007; Dunn and Freeman 2011; Tanneberger and Wichtmann 2011; Morel and Morel 2012). Given the especially high belowground C density of these ecosystems, there is high potential for C-based conservation, for example, via initiatives such as reducing emissions from deforestation and forest degradation (REDD+; Yamamoto and Takeuchi 2016; Graham et al. 2017) and those promoted by the Green Climate Fund (Roucoux et al. 2017). In Peru, given its lower population density and associated lower economic activity, combined with ongoing efforts to address indigenous rights (White 2014), these efforts could have a higher probability of success.

Direct exchanges between Peruvian government policy makers and experts on peatland ecosystem science and management would facilitate the transmission of lessons learned from Indonesia and other countries. Existing Peruvian institutions such as the National Committee on Wetlands and government agencies could partner with the Indonesian Peatland Restoration Agency (BRG) as well as the international scientific community, serving as a conduit for expert advice on peatland science and management that would allow Peru to benefit from the experience of Indonesia. One option would be to form an advisory council on peatland ecosystem science and management that could advise the National Committee on Wetlands and other appropriate bodies. This body, as well as individual government agencies, could also obtain access to expertize via exchanges of knowledge and information on peatlands issues across pan-tropical countries, for example, through the Global Landscape Forum (https://archive.globallandscapesforum.org/peatlands/) and the Global Peatlands Initiative (https://www.globalpeatlands.org/; Crump 2017), as well as via direct exchanges with the BRG and the Indonesian government.

We conclude that current peatland integrity in Peru arises from a confluence of factors that has slowed development, with no absolute barriers protecting Peru's peatlands from a similar fate to Indonesia's. If the goal is to maintain the integrity of Peruvian peatlands, there is a need for government policies that recognize peatlands' unique functions and sensitivities. Because Peruvian lowland peatlands are at present sparsely populated and relatively undeveloped, there is an opportunity to follow a different trajectory of peatland development from that of Indonesia. We include a summary of policy options that could have a large impact on the trajectory of development in peatlands of Peru (Table 1).

Peru seeks to maintain the functional integrity and ecosystem services of these peatland ecosystems, especially their long-term potential to remove and store atmospheric carbon in organic matter, the lessons learned from Indonesia's experience point toward an alternative development model built on policies that explicitly recognize the unique fragility and value of intact peatland ecosystems. Options include limiting or prohibiting road access, agricultural development on peat, and peatland drainage; developing efforts for valuation of intact peatlands; expanding peatland-rich formal protected areas and indigenous territories; and determining priority areas for expanded enforcement.

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RESEARCH PROGRAM ON Forests, Trees and Agroforestry

This research was carried out by CIFOR as part of the CGIAR Research Program on Forests, Trees and Agroforestry (FTA). 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, INBAR, ICRAF and TBI.

FTA's work is supported by the CGIAR Trust Fund: cgiar.org/funders/

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