Article Case

An Estimate of the Financial Cost of Peatland Restoration in Indonesia

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Abstract

The peat forests of Indonesia have experienced extensive deforestation and degradation over recent decades. High demand for Indonesian timber and plantation development has driven large-scale draining and clearing of peat forest, resulting in extensive fires and smoke haze problems across the region. These fires caused more than 100,000 premature deaths in 2015 alone, increased the pressure on several already threatened species, and placed Indonesia among the top greenhouse gas emitting countries globally. In response, the Indonesian government has launched an initiative to restore more than 2 million ha of peatland between now and 2020. Although there is a substantial body of academic literature that deals with technical aspects of tropical peatland restoration, little is published on the costs of tropical peatland restoration activities. In this study, we examine the case of peatland restoration in the provinces of Kalimantan, Sumatra, and Papua in Indonesia, and propose a restoration activity classification scheme based on fire, drainage, and logging history of peatland areas. We use this scheme to identify the restoration activity needs of different areas and then develop a preliminary gross financial cost estimate for the restoration activities proposed under the national 2-million-ha peatland restoration initiative. We find that it is likely to cost more than US$4.6 billion to complete the national 2-million-ha restoration initiative, which is substantially more than the funds currently allocated to the challenge across Indonesian and international donor budgets.

KEY MESSAGE

This case study informs readers about: (i) the extent and drivers of peat forest degradation in Indonesia; (ii) tropical peatland restoration methods and their application; (iii) how degraded peatlands may be classified to aid restoration; and (iv) how the classification can be applied to estimate the cost of peat forest restoration in Indonesia.

INTRODUCTION

Tropical peatlands are globally important ecosystems. They are rich in biodiversity [1], hold significant carbon stocks [2], have important hydrogeological functions [3], and are an important source of livelihoods for local communities [4]. Indonesia has one of the largest shares of tropical peat forests in the world, storing 57.4 Gt of carbon [2]. The tropical peat forests of Indonesia (Figure 1) are under continuing threat from competing land use and land use change (LULUC) activities, including logging, drainage, fires, and the conversion of forests into industrial plantations [5]. Today, degraded peatlands cover approximately 23% of all land areas in Peninsular Malaysia, Sumatra, and Kalimantan [6]. While forest conversion often occurs with the intention of increasing economic prosperity [7], degradation of peatland ecosystems has been shown to exacerbate poverty, threaten food security, increase rates of biodiversity loss, and make local communities and farmers more susceptible to the negative impacts of the climate change [8]. The recent push for increased conservation of peat forest to realise long-term climate change ambitions has however placed an increased burden on local villages to sustain their livelihoods and cultural practices in the short term [9]. It is therefore important not only to assess the environmental benefits from peat forest conservation and restoration, but to also provide local communities with sustainable peatland-based economic activities [10].

FIGURE 1

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Location of Indonesia's peat forests (highlighted in blue). Adapted from Ministry of Agriculture, "Indonesia peat lands." Accessed through Global Forest Watch on 21 August 2017. Available at www.globalforestwatch.org

The Central Kalimantan Peatland Development Project, later known as the Mega Rice Project (MRP), contributed considerably to peat forest degradation in Indonesia. The MRP was initiated in 1995 by the Indonesian government and aimed to convert more than 1 million ha of tropical peat to rice cultivation [11]. The MRP was however terminated in 1999, as the over-drained peatlands were unable to sustain rice production, leaving vast areas in semi-drained and unproductive conditions [12]. Drainage of tropical peatland that involves the water table falling below around 40 cm is known to cause sustained drying. Drained and dried peatlands are highly susceptible to fires [13]. Drained peat, such as the peat within the MRP area, burns frequently. These fires have had devastating impacts on the landscape and people in the region (Figure 2) [14]. Peatland fires in Indonesia have caused reoccurring air pollution at levels harmful to humans [15] and are estimated to have caused more than 100,000 premature deaths in Indonesia, Malaysia, and Singapore during 2015 alone [16]. They have also had a significant economic impact on Indonesia, with an estimated cost to the Indonesian economy of US$16.1 billion in 2015 [17]. In early 2016, the Indonesian government responded by establishing the Badan Restorasi Gambut (BRG), the Indonesian Peatland Restoration Agency. The BRG's purpose is to restore more than 2 million ha of peat ecosystems in seven Indonesian provinces by the end of 2020 [18]. By doing so, the BRG intends to dramatically reduce the region's peatland fire and smoke haze problem. This case study aims to estimate the minimum financial cost of effectively completing this 2-million-ha peatland restoration initiative.

FIGURE 2 Download figure | Open in new tab | Download powerpoint

Peat forest in Central Kalimantan, which was burnt in 2015. After approximately two years, the regrowth is dominated by fern species.

CASE EXAMINATION

Peat Forest Restoration

Degraded peat forests in Indonesia are typically difficult to naturally regenerate without substantial human intervention. Natural regeneration has had little success in several cleared areas, and where successful recovery of woody canopy cover is often a slow and patchy process, which many times results in low species diversity [19]. Assisted restoration can be used to speed up the recovery process. Active restoration is particularly important if the target is to re-establish the pre-existing biotic integrity of species composition and community structures [20]. Appropriate restoration methods are primarily determined by three factors: the peats fire history, the level of the ground water table, and the targeted outcome of the restoration [20, 21]. The intensity and frequency of fires are important as peat experiencing low-intensity fires shows greater signs of unassisted recovery compared to forests experiencing frequent high-intensity fires [22]. The depth of the water table indicates susceptibility to new fires, as peat with water tables deeper than 40 cm are known to burn more readily compared to those that has maintained its hydrological properties [23]. In addition to these factors, the deforestation history and logging methods used are important aspects of peat forest restoration, as poor logging practice can increase an area's vulnerability to fires and susceptibility to pest and disease encroachment [7].

Hydrological Restoration

Fire is a key constraint to successfully restore degraded peatlands [13, 22]. Fire can be prevented by restoring ground water table levels, a process which is commonly referred to as rewetting [24]. While water tables of peat fluctuate naturally throughout the year [24], the objective of tropical peatland rewetting is to restore the water table to a minimum of 40 cm from the surface; this level has been shown to be a critical threshold to reduce the risk of new fires [13]. The most common method of rewetting is to block drainage canals using dams, with the number of dams required being dependent on the features of the canal [13, 21]. In most cases, the damming method used and the associated financial cost of hydrological restoration can be determined by the width of the canal, as given in Table 1.

TABLE 1.

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Cost of hydrological restoration based on estimates from the Peatland Restoration Agency [21].

Canal type	Primary canal	Secondary canal	Tertiary canal	Commodity canal
Canal width (m)	20–30	10–20	4–10	>3
Approximate cost (US$/ha)	15,500–23,500	6,000–8,000	2,000–4,000	400–1,200

Revegetation

Fire prevention through hydrological restoration is an important prerequisite for effective tropical peatland forest regeneration. Forests left to generate naturally are likely to be dominated by a few wind-dispersed plant species or plant species dispersed by small birds [19]. Human-assisted regeneration is often needed to restore peat forests with ecologically sound functional traits [25]. The type of assisted regeneration needed on a particular site depends on how severely degraded the area is [22]. Areas that have been extensively cleared for agricultural production, such as the MRP area, have shown poor signs of recovery. Blackham et al. [19] found that the MRP area could recover naturally, but only in the effective absence of fires, and very slowly and with an overall low species diversity. Several herbaceous species dominating the regrowth in the MRP area, such as ferns, do not feature in mature undisturbed peat forests, at least not to any notable extent. These species may act as a barrier for restoration as they inhibit regrowth of woody plants and can increase the recurrence of fires due to flammability [22].

Enrichment planting of forest species that are rare or absent in a degraded peat forest can assist restoration as it increases the speed of canopy cover recovery and promotes species diversity (Figure 3) [19]. Enrichment plantings may not be suitable in areas that show weak signs of

natural regeneration or that have experienced recent fires. These areas may require fully assisted revegetation using smaller planting distances between seedlings. Planting density partly determines costs, with sparse enrichment planting on degraded peatlands in Indonesia estimated to be between US$235 and US$315 per ha. The cost for enrichment planting increases with density, e.g., 3-m tree spacing between seedlings costs between US$1,225 and US$1,575 per ha in Indonesia [21].

FIGURE 3 Download figure | Open in new tab | Download powerpoint

Peat forest in Central Kalimantan, which was burned in the 1990s. This part of the forest has been restored through assisted enrichment planting.

Peat Forest Classification

Classification of peat degradation is not only important as it helps to identify areas of priority; it can also be used to recognise appropriate restoration methods and site-specific requirements. While peat forests can be classified using a broad range of criteria, the classification presented in this case study is based on the peat forests fire, logging, and drainage history as well as its current hydrological condition (Table 2). These parameters were chosen as they are useful indicators of restoration requirements [26], and can, therefore, be used to estimate the financial cost of peatland restoration. The financial costs presented in Table 2 have been gathered through personal contact with the BRG [21]. These numbers lay the foundation for financial cost estimates of peat forest restoration in Indonesia and will be crucial in evaluating the required financial allocation to complete the 2-million-ha peat forest restoration initiative led by BRG. The cost of transportation has not been included in Table 2 and can vary significantly depending on

the accessibility to the restoration site [21].

TABLE 2.

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Restoration classification.

Degradation activity	Canal type	Cost of hydrological restoration (US$/ha)	Cost of assisted revegetation (US$/ha)	Total estimated cost of restoration (US$/ha)
Drained peat with high-intensity fires or high-frequency fires	Primary	15,500–23,500	1,225–1,575	16,725–25,075
Secondary	6,000–8,000	1,225–1,575	7,225–9,575	
Tertiary	2,000–4,000	1,225–1,575	3,225–5,575	
Drained peat with low-intensity fires or clearing	Primary	15,500–23,500	315–1,225	15,815–24,725
	Secondary	6,000–8,000	315–1,225	6,315–9,225
	Tertiary	2,000–4,000	315–1,225	2,315–5,225
Drained and selectively logged peat	Primary	15,500–23,500	235–315	15,735–23,815
	Secondary	6,000–8,000	235–315	6,235–8,315
	Tertiary	2,000–4,000	235–315	2,235–4,315
Drained unlogged peat	Primary	15,500–23,500	–	15,500–23,500
	Secondary	6,000–8,000	–	6,000–8,000
	Tertiary	2,000–4,000	–	2,000–4,000
Drained small-scale agricultural peat (<40 cm water table)	Commodity	400–1,200	1,225–1,575[a]	1,625–2,775
	Commodity	400–1,200	–[b]	400–1,200
Undrained selectively logged or agricultural peat (>40 cm water table)	–	–	–	–

[a]Full revegetation is required for restoration.

[b]Hydrological restoration is sufficient if the aim is to reduce the spread of fires to adjacent peat forest areas.

The BRG Peatland Restoration Initiative

The recently presented Contingency Plan from the BRG shows a peat restoration target of 2,492,527 ha across the seven provinces of Riau, Jambi, Sumsel, Kalbar, Kalteng, Kalsel, and Papua (Figure 4) [27]. The restoration target has been divided after priority, with areas burned during 2015 or later given highest priority for restoration activities. This area, consisting a total of 877,255 ha, represents approximately 35% of the total restoration area. The targeted restoration outcomes differ depending on the licensing status of the area. Burnt areas with production

licenses are to be restored so that production can continue while managing water tables to reduce the risk of fires. The aim is to restore unlicensed and protected areas to near original conditions regarding both hydrology and flora [21].

FIGURE 4

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Map showing the seven provinces where restoration activities will take place (highlighted in green).

The cost for such restoration activities has been estimated assuming that full-assisted revegetation will be required in areas burned after 2015 [19, 22, 25]. We also assume that existing canal structures in production areas are primary, secondary, or tertiary structures, as commodity canals are most commonly found in small-scale agriculture in shallow peat. Assisted revegetation may not be required in areas that have not been burnt after 2015 [21]. Extensive hydrological restoration is required, both for production areas and for protected areas. The cost of restoring the hydrology of shallow peat areas will be considerably lower compared to deep peat, as shallow peat most often has small-scale commodity canals that can be dammed using cheaper methods [21]. Our analysis suggests that the total cost of the restoration initiative will be at least US$4.6 billion (Table 3). This estimate was derived using the lowest likely cost associated with restoring each type of area. It is therefore important to note that the actual cost for restoration may be considerably higher than what we estimate in this case study.

TABLE 3.

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Cost estimates for restoration of the BRG priority restoration area.

BRG area classification	Restoration requirement	Size of area (ha)	Lowest estimated cost (US$/ha)	Lowest estimated total cost (US$)
Licensed production areas burnt post 2015 and drained production	Hydrological restoration of primary, secondary, or tertiary canals	1,410,943	2,000	2,821,886,000

BRG area classification	Restoration requirement	Size of area (ha)	Lowest estimated cost (US$/ha)	Lowest estimated total cost (US$)
areas				
Non-licensed production areas burnt post 2015	Hydrological restoration of primary, secondary, or tertiary canals with full revegetation	396,945	3,225	1,280,147,625
Protection areas burnt post 2015	Hydrological restoration of commodity to primary canal with full revegetation	226,335	1,625	367,794,375
Protection areas with canals	Hydrological restoration of commodity to primary canal with potential enrichment planting	201,457	400	80,582,800
Protection areas with shallow peat and canals	Hydrological restoration of commodity canal with potential enrichment planting	256,846	400	102,738,400
Total		2,492,527		4,653,149,200

Final Comments

Norway has pledged to support the implementation of the BRG restoration plan in Phase II, consisting of activities ranging from mapping, community engagement, peatland-sustaining economic development initiatives, planning, and policy analysis [28]. In May 2016, the Norwegian Government signed an agreement with UNDP to assist Indonesia with up to 34 million NOK (US$4.3 million) as support to establish the BRG [29]. In addition to the Norwegian support, Indonesia has received funds from the US, England, Japan and Germany, and the Netherlands, totalling at a combined sum of US$134.6 million [30, 31]. In 2017, the Indonesian government allocated Rp865 billion (US$64.8 million) to the BRG peatland restoration initiative [32]. The funds that have so far been allocated to the BRG and affiliated programs for peat forest restoration are unlikely to be sufficient to cover the actual cost of restoring the targeted 400,000 ha of peat even in a best-case scenario.

With an average cost for restoration of US$1,866/ha in a lowest estimated cost scenario, the allocated Indonesian and international funds, currently totalling around US$200 million, will only be sufficient to restore approximately 100,000 ha of peat forest. These estimates indicate a stark difference between funding allocated and financing required to successfully restore the targeted 2 million ha of peat, leaving Indonesia to choose between using best practice methods in a smaller area or choosing potentially partial, potentially ineffective restoration methods at more

extensive scales. Further research is required to identify the most cost-effective methods of peat forest restoration, taking current conditions of the peat into account. Incentives for hydrological restoration of peat and sustainable peatland-based economic activities should also be examined to realise an effective implementation of peat forest restoration in Indonesia.

CASE STUDY QUESTIONS

1. How can the Indonesian government work to restore and prevent further degradation of peatland forests while also supporting the livelihoods of local communities and small-scale farmers?

2. What are some of the factors that complicate and constrain effective peatland restoration in Indonesia and how can the Indonesian government and other stakeholders work to overcome those challenges?

3. Peat forest degradation and associated fires can be considered one of the worst environmental issues. The extensive fires in 2015 placed Indonesia among the world top greenhouse gas emitting countries. Do you think peatland restoration in Indonesia should be a national or an international concern? How might other countries assist Indonesia's peatland restoration efforts, if at all?

4. How do you think Indonesia should prioritise restoration if no further international funding becomes available? Do you think they should prioritise restoring smaller areas according to best practice methods, or should they still make efforts to implement restoration activities across the whole targeted area?

AUTHOR CONTRIBUTIONS

Amanda Hansson: Lead on conceptualization, data collection, analysis, original draft, review, and editing. Paul Dargusch: Lead on conceptualization, original draft, review, and editing.

COMPETING INTERESTS

The authors claim no competing interests. Paul Dargusch is a Section Editor at the Case Studies for the Environment. He was not involved in the peer-review of the article.

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