

# Lessons learned from Europe's peat management regimes

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**Abstract.** Peatland is an essential natural resource. Indonesia is the target of increased criticism for its commercial management of peatland, especially over the last two decades. These criticisms pivot around the draining of peatland to use for (dryland) agriculture, horticulture, and forestry and include the effects of draining and burning peatland. Criticisms about Indonesia's peatland management focuses on oil palm expansion. While we indirectly address Indonesia's commercial peat management criticisms, our primary focus in this paper is to explore management regimes applied to commercial European peatland management. We seek to compare European management practices asking the question: What can Indonesia learn from seven centuries of European peatland management practices? A comparative understanding will inform an initial guide for defining best management practices. Our findings show that Indonesia, not Europe as we supposed, is uniquely positioned to globally establish sustainable wetland agriculture.

## 1. Introduction

The peatland ecosystem is considered vital for carbon storage and biodiversity and often utilized as commercial agricultural resource [1]. Almost 80% of global peatland now constitutes commercial agricultural use, with approximately 20% retained as natural peatland forest [2]. From 1990 to 2008, 3.83 Mha of global peatland became agricultural land. Of this, 37% was across Russia and 33% was in European countries [3]. In this same period, conversion in Indonesia represented just 13% [2].

Along with the increased use of peatland for agriculture development worldwide, conservationists have increasingly challenged preserving peatland over economic benefits. For over two decades, Indonesia has been criticized over the commercial management of its extensive peatland, both by local and international activists. Criticisms pivot around the draining of peatland to use (dryland) agriculture, horticulture, and forestry with the brunt of criticism concerning peatland use for oil palm expansion. The issues are complex involving the struggle for development across the Global South and the counterforce of environmental campaigning to preserve these valuable assets as a carbon sink.

Further, the debate is not clear-cut and involves many considerations, including commercial, social, developmental, and environmental factors. The livelihoods of communities are at stake as well as



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balancing environmental concerns with development practices. However, what makes the issues more opaque is the apparent bias of environmental campaigns vigorously and emotively misrepresenting the facts and ignoring the latest sustainability practices implemented. These practices include maintaining the maximum groundwater depth and protecting the center of peat domes.

Peatland are increasingly recognized as valuable habitats for wildlife and important carbon stores and have also served as energy sources for centuries. Peatland can no longer be considered a renewable resource due to its very long regeneration time.

Environmental concerns over the use of peatland, while firmly focused on Indonesia, are also global. Peatland extraction continues globally because of high demand from horticulture (growing media and turf) [4], and this causes severe damage in the environment [5]. However, despite having commercially managed peatland since the 13th century, were we assume Europe has accrued extensive institutional knowledge on its various management regimes and yet it appears comparatively unnoticed as an environmental target. Have Europe's historical practices led it to develop more rigorous frameworks and balance with the perception of conservation and commercial values? This paper seeks to assess these frameworks and practices and create best-practice models to establish a more rigorous basis for Indonesia's peatland strategy.

## 2. Distribution and utilization of peatland

### 2.1. Distribution of peatland

The total global peatland area is 420 Mha [4], including 30 to 40 Mha of tropical peatland [5]. Notably, not all swamps are peatland [6].

The first unified peatland map for Europa (figure 1) was recently compiled [7]. It consists of some 96 Mha of peatland, of which about 25% located in the Baltic Sea basin, and nearly 40% is equally divided among the Bothnian Sea, the Gulf of Finland and the Baltic Proper sub-basins [8]. While data on the land-use changes of Europe's peatland is fragmented, some 60 to 80% of its original peatland is converted or excavated for agriculture (50%), for forestry (30%) and biomass extraction (10%) [9].



**Figure 1.** Distribution of European (left) and Indonesian (right) peatland, ranging from  $\leq 1\%$  (light) to  $\geq 50\%$  (dark) [9, 10].

Indonesia's commercial use of peatland is considerably lower compared to various other regions in the world. It uses about 6 Mha (33%) of its 18.5 Mha of peatland for agriculture [2]. Meanwhile, peatland use in various regions is as follows: Asia (89%), the Americas (75%), Europe (67%), and Africa (65%). Russia, which has about 137 Mha of peatland, manages 130 Mha (94%) of its peatland for agriculture. And the US, with about 22 Mha of peatland, exploits approximately 120.5 Mha (55%) for agriculture [2]. Moreover, while Indonesia's agricultural use of peatland is dominated by oil palm plantation (covering area 3 Mha or 20% of its peatland) it is also used for horticulture and renewable energy [3]. Indonesia's peatland can be divided into nine types, i.e., primary forest (3 Mha), secondary forest (30.5

Mha), shrub (3 Mha), fallow (0.5 Mha), agroforestry (0.5 Mha), plantation (3 Mha), agriculture (0.5 Mha), and others (0.5 Mha) [11]. Since 1865, Indonesia's peatland has been known to be quite extensive. Based on its latest peatland map, the total peatland area in Sumatera, Kalimantan, Sulawesi, and Papua is about 15 Mha [12]. This number is much smaller than that of the 1976 mapping, estimated at 17 Mha [13]. Sumatera has the most peatland, about 60.5 Mha or 43% of Indonesia's total peatland area. The least peatland located in Sulawesi, about 25 Mha or <1% of the nation's total peatland area. Overall, peatland is predominantly thin-layered, having <1 m thickness (30.5 Mha), followed by medium peatland having >1 m thickness (3 Mha) [10].

## 2.2. Utilization of peatland

Peatland conversion and draining raise additional issues, such as decreased environmental functions and increased carbon stores' oxidization. This conversion contributes to increasing GHG emissions [14]. When peatland is drained, aerated, limed, and fertilized or peat extraction occurs, the organic matter decomposes quickly and turns into a source of greenhouse gases (GHG) [15]. The draining process on peatland development has caused carbon losses ( $100 \text{ t CO}_2 \text{ ha}^{-1} \text{ year}^{-1}$ ) on average within the last 25 years [7]. However, according to Indonesian peat researchers, this  $\text{CO}_2$  emission calculation is too large due to the argument that the analysis of carbon loss is based on peatland subsidence and considered as organic carbon loss. Subsidence is a function of compaction, erosion, and decomposition of peat or organic material. Carbon loss in the decomposition process has the least contribution to subsidence than compaction and erosion [1].

Indonesia's coastal lowlands extend over 36 Mha and hold significant development potential when meeting targets set to produce food and industrial crops. Lowland areas – especially the vast areas of peat swamp forest (22 Mha), freshwater swamp forest (10 Mha), and mangrove forest (3 Mha) – are also crucial for biodiversity. Peat swamp forests are rapidly disappearing, with less than 10% expected to remain forested in Sumatera and Kalimantan unless mitigated soon. Mangrove forests are also rapidly declining, with almost half of them having disappeared by 2010. The remaining mangrove consists of degraded, secondary forests [16].

As an example of Indonesian management practices, Dayak farmers in Central Kalimantan have only used shallow peats with  $\leq 50 \text{ cm}$  (locally named *Petak Luwau*) for their cultivated areas near the riverbanks. They construct dams (*Tabat*) and freshwater fishponds (*Tatah* and *Beje*) using wood constructions to maintain the water tables in their peatland farming. In this traditional shifting cultivation system to obtain fertile and feasible peatland for cultivation, they also implement the traditional canal system (*Sistem Handil*). They use this constructed water management system from the riverbanks to about 3 km inland through slash-and-burn practices to prepare their lands. They also apply schedules to manage their farms, including, for instance, burning activities for clearing lands at the end of the dry season (middle to end of August) by considering the weather and peat dryness conditions [18]. Emissions from the peatland utilization are relatively small at only 2% [19].

## 3. Commercial utilization of European and Indonesian peatland

The degradation and conversion of Europe's peatland over the past 50 years are more rapid than ever before [20], with countries in western Europe (like Germany and the Netherlands) having mainly degraded peatland while for others only 30 to 40% of their peatland are intact today [19]. The degradation of peatland is ongoing in numerous European countries (such as Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Poland, Sweden, and United Kingdom) [21, 22], leading to significant environmental issues (such as flooding and greenhouse gas emissions) and social issues (including rural unemployment and disintegration) [21-24]. Extensive peatland in central and eastern Europe are being abandoned due to soil degradation, high drainage costs, and changes in economic and political conditions [21].

Large-scale, commercial peatland utilization for agriculture in Indonesia started with the Tidal Rice Opening Project (*Proyek Pembukaan Pesawahan Pasang Surut*) in 1969, inspired by the successes of rice farming on tidal lands (including peatland) by Bugis and Banjar farmers [5]. Conversions of large

areas of Indonesia's peatland have taken place over the last three decades into industrial and smallholder cultivation systems [25]. On the other hand, Indonesia's primary utilization of peatland concerns the cultivation of crops, with the main crops being oil palm, timber for paper & pulp, and rice.

Tension remains in the classification of high-intensity mainly extractive use versus low-intensity (mainly cultivation) commercial use [26, 27]. Indonesia's peatland use then classified as low intensity uses of peatland. However, large tracts of low-intensity cultivation still accrue high environmental and social impacts. For example, around 12 Mha of peatland (mainly in northern boreal and temperate zones) were drained for forestry, and no long-term timber plantations on tropical peatland match this [26]. They posit Indonesia's 30.5 Mha of oil palm and timber cultivation on peatland [12] is a low intensity use of peatland, but we see the impacts of such extensive areas under cultivation are nevertheless high.

### 3.1. Fuel extraction (Europe)

Tracing the extraction of biomass/energy (turf) from European peatland takes us back to the pre-Roman period, where well-established supply chains existed from late medieval times in rural regions in Flanders, Belgium [28]. The traditional, manual cutting of large peat blocks/sods, which continues up to the present throughout many North-European countries, is often associated with this practice. The high-intensity industrial variant (milling) is less romantic: it involves draining a peatland, removing its vegetation, tilling its surface, and leaving it to dry until harvesters gather the biomass for processing into briquettes [29, 30].

Biomass extraction reduced significantly in the last quarter of the nineteenth century, as coal replaced turf [27]. An estimated 200 Kha (in 2010 and 2019) of Europe's peatland is currently partially or fully degraded due to biomass mining [31, 32]. A significant 29 Mm<sup>3</sup> in 2010 (up from 13 Mm<sup>3</sup> in 2005/2008) of peat was extracted for European biomass [22, 33], with the leading producers being Belarus, Finland, and Ireland. Once peatland is exhausted, it is converted to agricultural, forestry, recreational, and restoration lands. For instance, the Reeuwijk Lakes in The Netherlands are the result of flooding after biomass/turf extraction in the 1700s (see Figure 2, below).

We encountered no recent papers on the environmental degradation from biomass extraction for fuel, while production estimates tend to be contradicting (up to a factor of one thousand). However, most sources agree that about 35 Mm<sup>3</sup> of biomass for fuel was extracted throughout Europe in 2005, with Finland and Ireland as the leading producers [22, 29]. We estimate this to equate to 60 to 85 Kha year<sup>-1</sup> of peatland lost throughout Europe, while peatland degradation may be up to 0.52 Mha annually.

Biomass extraction for fuel was an integral part of local traditions in most (Northern) European countries, and it remains to be so in many of them [8]. While some countries/districts have entirely ceased the practice or are in the process of doing so, legal and illegal biomass extraction for fuel continues despite ongoing calls in the media for boycotts. The absence of a discussion about states and smallholders' economic dependence on biomass extraction for fuel [31, 32] is noteworthy, and Europe appears to have no overarching policy regarding this commodity.



**Figure 2.** Google Earth's historical images show (left) Sluipwijk in South-Holland, The Netherlands, surrounded by peat excavation sites turned to lakes (December 2005) and (right) Anklam in Western Pomerania, Germany, with peat excavation to the east (December 2001).

### 3.2. Growing media extraction (Europe)

Europe's peatland extraction for growing media emerged in the 1970s as an economical alternative to loam [4]. In general, growing media extraction is mechanical, similar to biomass milling: draining peatland, removing their vegetation, tilling the surface matter, and leaving it to dry. Vacuum harvesters then collect the bio-media. Less commonly, large peat blocks or sods are cut and milled to produce coarser material [29, 30]. Continually repeated, this high-intensity extraction strongly degrades or removes all of the peat over time.

Concerns over the impacts of biomass extraction for growing media soon emerged, as it destroys both wildlife habitats and archaeological artifacts [4]. An estimated 200 Kha of peatland throughout Eastern Europe is now partially or fully degraded due to media biomass extraction [31, 32]. About 37 Mm<sup>3</sup> of growing media was extracted in 2017 (up by 30% from some 29 Mm<sup>3</sup> in 2005) for growing media, with the primary producers being Belarus, Finland, and Ireland [34]. As with peat for biomass, once peatland is exhausted, it is converted to mainly dry-land agriculture, forestry and restoration lands.

As with biomass extraction for fuel, we found no recent environmental degradation estimates from biomass extraction for growing media. Our sources indicate that in 2005 approximately 29 Mm<sup>3</sup> of biomass was extracted for growing media throughout Europe, mainly from producers in Finland, Ireland, and Sweden [29]. This equates to 50 to 75 Kha of peatland lost annually throughout Europe, while peatland degradation may cover well over 200 Kha year<sup>-1</sup>.

Despite the ongoing campaigns against biomass extraction for growing media, the practice continues with peat which is considered a chief commercial resource [4]. The foremost replacements for peat are bark (pine and spruce/larch mixes), wood fiber, coir, and selected composted green wastes. Whereas Europe has no overarching policy regarding this commodity, several large-scale producers apply the (voluntary) "Responsibly Produced Peat" standard [19]. These big producers and distributors consider the ethical and environmental issues to be sufficiently important for investors and marketing to pursue policies and standards for the sustainable use of peatland [4].

### 3.3. Oil palm cultivation (Indonesia)

While oil palm has been cultivated in Indonesia for well over a century now [37], its cultivation on peatland emerged during the '80s [38-40]. In general, oil palm cultivation relies on draining the peatland, removing the vegetation, and planting young oil palms. Once the palms produce viable fruit bunches (after about five years), fruit harvesting occurs every three months. As the palms become too tall to harvest, they are cleared, and young palms are (re)planted [37]. While this activity is classified as low intensity use of peatland, about 3 Mha of peatland in Indonesia are now under oil palm cultivation (see figure 3, below) and have a high impact on peatland management.

Oil palm dominates plantations on peatland constituting (3 Mha) or 20% of Indonesia's total peatland. There is a significant increase if compared to only 10.5 Mha in 2010 [1]. Indonesia's oil palm cultivation on peatland rapidly expanded between 1990 to 2020, increasing from 0.5 Mha (12% of its total oil palm area) in 1990 to about 2 Mha (18%) in 2010 [15, 37]. The current main areas of oil palm cultivation on peatland are Sumatera with about 10.5 Mha and Kalimantan with almost 0.5 Mha [15].



**Figure 3.** Google Earth's historical images show (left) Ularbemban in Indragiri Hilir, Indonesia, with oil palm cultivation on peat to the south (December 2004) and (right) Kanamit in Pulang Pisau, Indonesia, with large-scale rice cultivation to the west (December 2005).

The environmental impacts of oil palm cultivation depend significantly on the vegetation that exists before new oil palm plantings. When (degraded) forests cover peatland, the conversion of that peatland has serious environmental impacts, and emissions can double or triple [41, 42]. When cultivating previously deforested peatland, emissions generally reduce [3] by 50 to 75% [43-45]. Above-ground carbon stocks increase by 25% [46]. Little to no information is available on the amount of peatland converted for oil palm but estimates of the leading causes of deforestation throughout Indonesia indicate that 15 to 35% is directly associated with oil palm cultivation [38, 47, 48]. This fraction is likely lower for peatland, around 15 to 20%, often situated in lowland areas, and more prone to other human interventions.

The criticism of oil palm cultivation on peatland has been particularly strong, with many arguing that it does not preserve the peat [37]. Public and private initiatives agree and set moratoria for new land use permits on peatland and require conservation and rehabilitation of peatland [49-51]. Estimates indicate that Indonesia can supply the global demand for palm oil without conversion of forest and peatland [52]; hence there is no actual need for future conversion of intact peatland or degraded forests.

### 3.4. Rice cultivation (Indonesia)

Rice cultivation on wetlands is a low-intensity activity and a long-standing tradition among Indonesia's local communities, passed down through the generations. Generally, peatland must be fully cleared from existing vegetation and tree stumps. However, with some 4 Mha wetlands cleared (0.5 Mha by the government and 3 Mha by non-governmental organizations) [12] and mainly cultivated for rice production in 1995 [53], rice cultivation is a high-impact commodity on peatland management. Similar to oil palm cultivation, the impact of rice cultivation on peatland depends on the existing vegetation. In most cases, the industrial cultivation of rice is implemented in degraded peatland areas with little or no remaining tree cover [54].

Industrial rice cultivation on peatland began in Central-Kalimantan through the (1969 to 1991) Tidal Rice Development Project (*Proyek Pembukaan Pesawahan Pasang Surut*) and further expansion occurred from 1995 to 1999 through the One Mha Peatland Development Project (*Proyek Pengembangan Lahan Gambut Sejuta Hektar*). Further expansion into wetlands is planned for October 2020 in Central Kalimantan, with the first phase (30 Kha) planned for more rice cultivation [55]. However, it must be stressed that not all wetlands are peatland. Initially, Indonesia aimed to cultivate 5 Mha of wetlands in South Sumatera and Kalimantan between 1968 and 1984. Additional expansion into wetlands is planned for October 2020 in Central Kalimantan, with the first phase (30 Kha) planned for more rice cultivation [55]. However, we emphasize that not all wetlands are peatland. To manage peatland sustainably, Indonesia will develop a large-scale zero waste rice estate in salfic acidic soil instead of peatland.

## 4. Lessons learned from peatland management in Europe

Contrary to what we expected, Europe's current peatland management practices provide no sustainable options for Indonesia. The majority of European peatland management practices concern high-intensity extraction of biomass for fuel and growing media. Therefore, most European peatland is degraded and even lost over time. Nonetheless, there are lessons learned regarding sustainable peatland management for further consideration.

The industrial management of peatland inevitably leads to environmental degradation, either through biomass extraction for fuel/growing media or through drainage of peatland for the cultivation of dryland crops [29, 56]. Sustainably drained peatland is a fallacy: most peatland is originally rainwater fed, and long-term draining will lead to land loss. It will subside too much to drain anymore, or only the mineral subsoil remains [2]. Peatland degradation after drainage is generally irreversible, and interventions are required to prevent further degradation and environmental, economic, and social repercussions. Hence, (deep) peat is unfavorable for dryland agriculture and estate crops as currently practiced in Indonesia, and a new management approach such as paludiculture is needed [4, 16].

Private standards for the sustainable management of peatland have gained some traction in Europe, with the Responsibly Produced Peat standard providing basic criteria for industrial managers and supply chains [4, 36]. While industrial peatland management is the main driver of peat degradation in a 2013 survey [57], the International Peat Society's strategies for responsible peatland management [31, 32], for instance, have little substance. In stark contrast, numerous public and private initiatives in Indonesia set strict limitations for the industrial use of peatland [58]. The (mandatory) moratorium on protected forest and peatland and the (voluntary) Palm Oil Innovation Group are but two examples. While in the case of oil palm, such initiatives indeed complemented improving oil palm management in Indonesia [38], this was less so the case for improving forest management.

In this context, the institutional settings of initiatives are crucial, with private/voluntary initiatives having a more limited impact than public/mandatory initiatives. As consumer concerns over Europe's peatland management remain low, private initiatives find little traction, and public initiatives are not initiated. Data on peatland degradation and conversion remains fragmented, with the same rough estimates used for 2010 as well as 2019 [33] despite a significant increase (30% for growing media) in annual extraction rates [32]. Indonesia, on the other hand, has well established institutional settings for the management of peatland. Its Peatland Restoration Agency (*Badan Restorasi Gambut*) is the pivot in improved peatland management, with supporting legislation providing an essential foundation.

The divergence between the centuries of Europe's peatland extraction starkly contrasts (continually) with the frenzy over decades of Indonesia's peatland cultivation. The 20 to 30 years of anti-palm-oil campaigning have created significant consumer concern, mainly by pursuing the false causation of oil palm destroying tropical forests and butchering iconic species like the orangutan [39]. Nevertheless, more subtle campaigning, like the false narrative, that the industry hides oil palm behind 200 to 400 "different names" (read different derivatives/ingredients), should not be discounted [59]. Popular social media platforms like Facebook and Twitter and more credible media like Mongabay are now actively used to pursue a blanket boycott of palm oil.

Europe recently proposed a new paradigm for peatland: paludiculture [16, 18]. Indonesian smallholders have practiced this for decades (if not centuries). Examples include illipe nut, jelutong, and sago cultivation [16, 59]. Other wetland crops show potential for restoring and conserving peatland through industrial management, including timbers, medicinal plants, and food crops. Nevertheless, purists point out that restoration efforts using dryland species (particularly acacia, hevea rubber, oil palm, and pineapple) and other non-peatland species cannot be considered paludiculture [16]. Thus, Indonesia may need to move beyond paludiculture and develop a concept for the sustainable management of all its wetlands; we suggest the term 'hydriculture'.

## 5. Conclusions

Europe's concern over unsustainable peatland management appears a case of "do what we say, not what we do." The agricultural/industrial use of peatland, and the negative environmental effect thereof, is standard across the world. Even in Europe, the unsustainable exploitation of peatland has destroyed both wildlife habitats and archaeological artifacts. Applying European current management practices of peatland thus is not a viable option for Indonesia. Some lessons can be learned, such as developing public and private standards that are inclusive of local characteristics.

Having the fourth largest peatland area globally, Indonesia must uphold the sustainability of the environment, such as maintaining high(er) groundwater tables. As the pioneer for setting the mandatory Indonesia Sustainable Palm Oil (ISPO) standard, Indonesia needs to continue implementing the Action Plan of ISPO under Presidential Instruction number 6 of 2019 and ISPO certification under Presidential Decree 44 of 2020. Indonesia's Peatland Restoration Agency is uniquely positioned to become the gold standard for managing peatland and other wetlands.

Politically, it is also essential to signal Indonesia's commercial management of peatland concerns low-intensity usage, is less extensive and spans several decades only. Whereas Europe's management concerns high-intensity usage, is more widespread and spans many centuries.

Indonesia, therefore, is uniquely qualified to set the gold standard(s) for sustainable wetland agriculture – here coined hydriculture – and a) champion sustainable wetland management, b) pilot voluntary criteria for industrial and smallholder management of wetlands, and c) implement mandatory standards to ensure compliance by the whole industry.

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