Transformation of Post-Disaster Governance of Indonesian Peatland Wildfires

Post disaster governance in South East Asia

Budiman, I.; Januar, Rizky; Ayunda, Desti; Wicaksono, Satrio; Sari, Eli Nur Nirmala et al

https://doi.org/10.1007/978-981-16-7401-3_5

Chapter 5
Transformation of Post-disaster Governance of Indonesian Peatland Wildfires

Ibnu Budiman, Rizky Januar, Desti Ayunda, Satrio Wicaksono, Eli N. N. Sari, and Dean Affandi

Abstract The Indonesian wildfires in 1997 and 2015, which affected approximately 25–30% of carbon-rich and fire-susceptible peatland in the country, brought negative environmental, humanitarian, and economic impacts. Given that Indonesia has the world's second-largest peatland area, this study analyses the effectiveness of the post-disaster governance of peatland fires from 1982 to 2020. By utilising data from interviews, observations, document reviews, and open-source web apps, this study shows that the country has experienced policy transformation that adapts risk governance principles for peatland management. This transformation affects the effectiveness of the post-disaster governance of peatland wildfires.

Keywords Indonesia · Post-disaster governance · Peatland · Wildfire · Vulnerability

5.1 Introduction

Peat ecosystems are important for carbon storage to support climate change mitigation. Peat degradation and deterioration could cause wildfire disasters and carbon emissions (Hoscilo et al. 2011). Indonesia has the world's second-largest peatland area. The Indonesian wildfires in 1997 and 2015, which largely occurred in carbon-rich and fire-susceptible peatland, released 3.61 Gt of CO2 emissions[1] and resulted in air pollution and haze problems. These problems had negative humanitarian and economic impacts such as disturbance to people livelihood (Huijnen et al. 2016). The 2015 fires accounted for an estimated USD $15 billion of human and environmental damage (Budiman et al. 2020a,b,c). These impacts were also felt in neighbouring countries, such as Singapore, Malaysia, Brunei Darussalam, and, to a lesser extent,

[1]Global emissions bring climate disaster.

I. Budiman (✉)
Wageningen University and Research, Wageningen, Netherlands

I. Budiman · R. Januar · D. Ayunda · S. Wicaksono · E. N. N. Sari · D. Affandi
World Resource Institute (WRI) Indonesia, South Jakarta, Indonesia

A. N. R. Mardiah et al. (eds.), *Post-Disaster Governance in Southeast Asia*, Disaster Risk Reduction, https://doi.org/10.1007/978-981-16-7401-3_5

the Philippines and Thailand. Officially, among the Association of Southeast Asian Nations (ASEAN) member states, the problem is referred to as transboundary haze pollution (Tan 2015).

To reduce the risks of future transboundary haze pollution, a better understanding of the post-disaster governance of peat fires is required. This study investigated the effectiveness of post-disaster governance of peatland wildfires in Indonesia by analysing policy instruments for recovery strategies from post-peatland wildfire disasters in 1997 and 2015. This study builds a linking mechanism between policy adoption and its output and outcome by utilising conceptual frameworks of vulnerability and risk governance.

This research supports disaster risk reduction actions at different levels. Globally, it contributes to the ongoing implementation of the Sendai Framework for Action for Disaster Risk Reduction 2015–2030, which highlights specific challenges of higher vulnerability and risk levels for middle-income countries such as Indonesia (UNISDR 2015). At the ASEAN level, this research is in line with the ASEAN framework on Transboundary Haze and the ASEAN Agreement on Disaster Management and Emergency (AADMER) that serves as a common policy platform for disaster management. AADMER's 2016–2020 Work Programmes highlight land and forest fires as a regional priority for risk management development (ASEAN et al. 2016). Nationally, this study supports land and forest fire management in Indonesia's long-term development plan by The National Development Planning Agency or Bappenas (2019). On a broader scope, this study also provides lessons learned about peatland fire management for supporting Nationally Appropriate Mitigation Actions set by the Indonesian government under the Paris Agreement.

The case study of Indonesian peatland wildfires could help inform other Southeast Asian countries with peatlands, such as Malaysia, the Philippines, Thailand, and Vietnam. Some peatlands in these countries are vulnerable to degradation and deterioration, which could exacerbate transboundary haze pollution. Furthermore, the framework in this study can be adapted to study the post-disaster governance of other disaster types in Southeast Asian countries.

5.2 Methodology

In this study, we utilise the deductive reasoning approach to perform theory testing by "pattern matching", using Indonesian peatland wildfires as a case study. The adoption of deductive procedures represents an important step for reaching conclusions in research findings (Hyde 2000). The theories tested in this study include the cycle of vulnerability (Simon and Dooling 2013) and risk governance (Renn 2017). Both theories are combined and adapted to analyse the transformation process of policy and governance cycle for disaster management on peatland, its degree of vulnerability, and its effectiveness as post-disaster governance of peatland wildfires (Fig. 5.1).

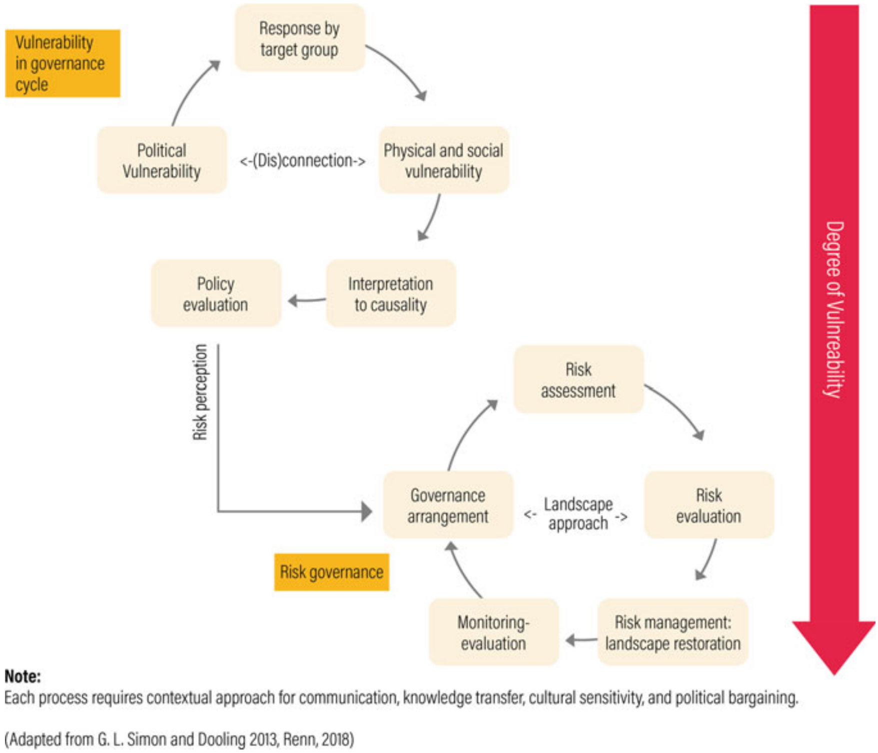


Fig. 5.1 Conceptual framework of the study: transforming post-disaster governance on peatlands. *Source* Adopted from Simon and Dooling (2013), Renn (2018)

5.2.1 Conceptual Frameworks

The cycles of vulnerability assess the (dis)connection[2] between policy or political decisions with on-the-ground situations. To reduce disconnect and vulnerability, a risk governance framework is used to trigger adaptive learning in policy-making and thereby produce impactful intervention (Fig. 5.1).

By applying the vulnerability cycle theory, we aim to understand the (political) drivers behind recurrent wildfire disasters on peatlands in Indonesia. Vulnerability operates in two forms: (1) political vulnerability in either policy or political form where direct experiences of being vulnerable are interpreted and translated within a sphere of complex governance[3] arrangements, political-economic activity, civil society actions, and environmental changes, e.g. mistargeted policy and weak

[2] In the frame of disaster risk reduction.

[3] Governance is defined as a (new) process of governing through various policy instruments and/or institutional arrangements that include both state actors and non-state actors (Stoker 1998).

law enforcement; and (2) material (physical and social) vulnerability, i.e. on-the-ground conditions defined and substantiated through lived experiences and documented through empirical analysis, e.g. wildfires, carbon emissions, health issues, and economic losses (Simon and Dooling 2013). Vulnerabilities are translated from political to material through complex processes. The translation process influences the development of actionable forms of vulnerability, such as ignorance response by target group of policy that can lead to the absence of on-the-ground intervention and disaster (Fig. 5.1).

The actionable forms of vulnerability are considered linking mechanisms between political and material vulnerability. In this study, political vulnerability relates to post-disaster governance that is perceived as recovery strategies from peatland wildfires in the form of a variety of policy instruments, such as regulations, projects, and its institutional arrangements. The disconnect between political and material vulnerability and the lack of policy evaluation create a cycle of vulnerability that propels recurrent episodes of peatland wildfires.

Reducing the degree of vulnerability in the policy cycle and mitigating the risk of future disasters requires an effective post-disaster governance model. The risk governance concept is henceforth proposed as a post-disaster governance strategy (Fig. 5.1). The risk governance emphasises the strategy to cope with uncertainties in complex environmental problems (Renn 2017). Such uncertainties include aspects of techno-scientific knowledge. In the peatland context, techno-scientific knowledge uncertainties are reflected in the recovery techniques after a wildfire (i.e. restoration) and their efficacy to reduce future risk of recurrent fire. To deal with this uncertainty, the risk governance framework proposes the following five steps:

1. Assessing risk perceptions, investigating stakeholders' (especially policy-makers) perception about risk, their reaction to material vulnerability, and their interpretation of the causality to previous policies. This information is important for consideration in preparing institutional arrangements for risk governance on peatland.
2. The establishment of a governance arrangement. This arrangement should have a clear task division among stakeholders and a coordination mechanism in conducting the following steps: risk assessment and risk evaluation of the field situation.
3. Risk assessment and risk evaluation, detailed risk assessment, and risk evaluation produce accurate interventions to manage risks in the form of policy instruments (i.e. risk management). The selection of suitable risk-handling strategies helps to reduce political vulnerability.
4. Risk management: landscape[4] restoration is considered an effective option for risk management on degraded/burned peatland (Bastoni 2019; Blackham et al. 2014; Bonn et al. 2016). Restoration of a peatland ecosystem aims at returning the ecosystem to its historical trajectory (Aronson et al. 1993). Restoration can

[4] The process of regaining ecological functionality and enhancing human well-being across deforested or degraded landscapes. More than just planting trees, it is restoring a whole landscape to meet present and future needs and to offer multiple benefits and land uses over time (IUCN 2014).

be achieved through activities such as blocking canals for rewetting, revegetation, and reducing anthropogenic pressures (Budiman et al. 2020a,b,c; Giesen and Sari 2018; Ritzema et al. 2014). These steps can be combined with other forms of disaster risk reduction, such as the construction of deep wells to be a water resource for firefighting (Turetsky et al. 2015).

5. Monitoring–evaluation—those risk management measures require inclusive and participatory monitoring and evaluation (Granderson 2014).

Other uncertainties include aspects of strategic institutions and politics. Strategic-institutional uncertainties arise from different actors and institutions within the architecture of post-disaster governance, while political uncertainties often come in the form of political attitudes and the direction of policy instruments within and across political regimes (Walker et al. 2003). To deal with these issues, in each risk governance step, all activities must be delivered with effective communication efforts considering the diversity of knowledge levels, social climate, and culture and (political) interest among stakeholders.

When completed, these steps and processes are expected to reduce material vulnerability. For example, successful restoration could increase the water table[5] and soil moisture on peatland. This rewetted peat could decrease the extent of fire spread (Ritzema et al. 2014,1998).

The conceptual framework described in Fig. 5.1 has both spatial and temporal dimensions. Adaptive learning within the framework is possible via knowledge transfer mechanisms between each (administrative) unit or between governance arrangements. Such learning can help upscale the adoption of risk governance strategies in wider areas. Good risk governance in an area may serve as a lesson learned for adjacent areas. Temporally, stakeholders need enough time to perceive and understand both forms of vulnerability and reduce its degree in the cycle of post-disaster governance.

In short, two areas of synthesis inform our conceptual framework and analytical approach: (1) the temporal and spatial dynamics of political and material vulnerabilities and their cycle, and (2) the role of risk governance in the development of peatland-related policies to affect material vulnerabilities such as wildfires. Risk management measures are considered as linking mechanisms between policy adoption and its outcome (i.e. reduction of fires).

5.2.2 Data Collection and Data Analysis

Data collection were done in 2019. authors utilised qualitative, quantitative, and spatial data from the academic literature, policy documents, project reports, interviews with key stakeholders, open-source web applications, media monitoring,

---

[5] Peatland water table depth is an important control on runoff production, plant growth, and carbon cycling. Many peatlands have been drained but are now subject to activities that might lead to their restoration, including the damming of artificial drains (Holden et al. 2011).

and direct observations at peatland management-related meetings and peatland restoration sites.

Within this research, it was conducted interviews with 39 key stakeholders: policymakers (Ministry of Environment and Forestry, Peatland Restoration Agency, local governments), NGOs (Wetlands International, local NGOs), academics (Bogor Agriculture University, Sriwijaya University), development professionals, private sectors, and community representatives, all of whom were selected through a combination of purposive and snowball sampling.[6] Semi-structured questions were asked in these direct interviews, each of which took approximately 1–2 h.

Direct observations were made via note-taking at peatland restoration sites and peatland management-related meetings that involved key stakeholders. The interview questions and observation points focused on indicators related to the conceptual framework. In addition, a desktop review of related research papers, project reports, and policy documents about peatland wildfires and peatland management was completed to help verify the findings from interviews and observations.

To analyse the collated data, a two-step coding process using NVivo was undertaken to generate a description of the situation and themes for analysis based on indicators in the conceptual framework. The collected data was organised into several keywords based on the research objective and conceptual framework. The first coding applied to the interview transcripts, observations, policy documents, and programme/project reports. It was intended to analyse the cycle of vulnerability in post-disaster governance of peatland wildfires. Afterwards, the second coding was conducted to analyse the adaptation and adoption of risk governance strategies in the post-disaster policy and its governance arrangement.

For spatial data, the data was collected from open-source web applications, such as the PRIMS[7] website for data on restoration activities and the University of Maryland[8] (Giglio et al. 2018) and the Ministry of Environment and Forestry[9] for the burned area products.

To ensure data integrity, authors utilised consistent estimates or assumptions that were given to the same phenomenon or indicators in each aspect related to post-disaster policy and its governance arrangements. This approach was applied during interviews with respondents, and was adopted the same indicators, criteria, and data requirements to confirm or verify study findings. To maintain data validity, multiple inquiry methods were utilised. Biases were minimised by triangulating multiple sources of evidence. Authors carefully analysed the linking mechanism between the indicators of political and material vulnerabilities as the subject variables in the study.

---

[6] It started with purposive sampling that is also known as judgmental, selective, or subjective sampling. This is a form of non-probability sampling in which researchers rely on their own judgement when choosing stakeholders to participate in the study. The process then continued with snowball sampling and chain-referral *sampling*, a nonprobability *sampling technique* where interviewees from purposive sampling suggested future subjects from among their acquaintances.

[7] See, https://prims.brg.go.id/dasbor.

[8] See, http://modis-fire.umd.edu/ba.html.

[9] See, http://sipongi.menlhk.go.id/

5.3 Results

Major peatland wildfires have been linked with El Niño[10] events. This study found that policy and governance of recovery strategies for post-peatland wildfire in Indonesia transformed due to an increased understanding of material vulnerability. We divided this section into three categories: post-disaster governance after 1982, after 1997, and after 2015. The post-1982 section provided a background on the political vulnerability that caused the 1997 wildfires.

5.3.1 Post-1982 Wildfires: A Cycle of Vulnerability

Beginning in the 1970s, the government of Indonesia (GoI) started to create political vulnerabilities that put pressure on peatland ecosystems. The GoI began allowing peat utilisation for industrial forest plantations and logging concessions in Sumatra and Kalimantan (Havard 2009). Timber concessionaires practised selective logging, focusing on the largest and most valuable trees. They also dug canals to transport the logs out of the islands' interior, which often became permanent drains (Jauhiainen et al. 2012; Singer 2009). Given the growth of the industry, the GoI initiated the transmigration policy for relocating people to live and work near peatland ecosystems. In South Sumatra, transmigration to peatlands began in the late 1970s (Martin and Winarno 2010). There, new villages were made near peatlands to support industrial workers in (Martin and Winarno 2010). As both companies and communities started to gain revenues from peat utilisation, many began to realise the economic value of peatlands. This phenomenon increased unsustainable natural resource exploitation by both, which led to peat degradation and increased fire risks.

Peat degradation contributed to peatland wildfires occurring from 1982 to 1983 (Singer 2009). There were some policy adjustments to address the fires. For instance, through the issuance of Presidential Decree No. 32 Year 1990 regarding protection areas, one of which was peatlands deeper than 3 m and located in upstream locations. However, this regulation is not considered a serious policy for post-disaster governance (Page et al. 2002). The lack of reliable data on peatlands has led to the continuous issuance of business permits in deep peat forests. Therefore, fires occurred repeatedly in 1994 (Singer 2009). The GoI did not conduct post-disaster governance afterwards, but instead expanded natural resource exploitation in 1996 through the Mega Rice Project (MRP) that covered a one million-hectare peatland in Central Kalimantan, along with the transmigration programme to support the project (Putra 2010). It continuously threatened peat stability and made them more susceptible to fire.

When the major El Niño hit the region in 1997, the degraded peat ecosystems in Indonesia became prone to fire (Page et al. 2002). As a result, widespread fires

[10] El Niño is an abnormal weather pattern caused by the warming of the Pacific Ocean near the equator; it causes a prolonged dry season in Indonesia.

occurred throughout 1.4 million-ha forested peatlands of Indonesia (Tacconi 2003). Approximately, 0.519 Gt of carbon was released into the atmosphere in 1997 due to the burning of peat and vegetation in Indonesia (Barber and Schweithelm 2000; Page et al. 2002). This figure is equivalent to 13–40% of the mean annual global carbon emissions from fossil fuels and contributed greatly to the largest annual increase in atmospheric CO_2 concentration since recording began in 1957 (Page et al. 2002). The 1997 wildfires and its haze negatively impacted not only the global atmosphere, but also biodiversity and human health (Barber and Schweithelm 2000; Tan-Soo and Pattanayak 2016). The haze contributed to lung and respiratory disorders affecting thousands of people. Economically, losses associated with fire costs are estimated to be approximately USD 1.62–4.5 billion (Barber and Schweithelm 2000; Tacconi 2003).

Scholars have linked the fires of 1997 to forest and land-use policies and practices that allowed timber and agribusiness firms to set fires intentionally to cheaply clear land. This political vulnerability occurred in the period of President Suharto/New Order[11] (Barber and Schweithelm 2000). The lack of significant political understanding of vulnerability is also marked by the lack of study about peatland degradation during this period. The high degree of political vulnerability remained from the 1970s to the 1990s, during which it contributed to create material vulnerability on-the-ground.

5.3.2 Post-1997 Wildfires: Conflicting Policies

After the 1997 fires, there was a high degree of knowledge uncertainty among policymakers regarding the causes of the fires, and no comprehensive assessment was conducted to determine the post-disaster governance strategy. Most of the GoI's responses to the disaster were perceived as weak, uncoordinated, and defensive, except for the Ministry of Environment's monitoring and public information efforts and its forthright identification of the role of big business in starting many of the fires on peatlands. Due partly to international pressures regarding the haze problem, the Ministry of Environment (KLH) announced that the 1997 fires were largely due to land clearance activities using fires and that El Niño was only an additional contributing factor. Furthermore, the KLH named oil palm and timber plantation companies the major culprits, using overlays of NOAA[12] hot spot maps and plantation concession maps. The KLH's response contrasted that of the rest of the GoI and the business, which traditionally blamed forest fires on small-scale shifting cultivators (Barber and Schweithelm 2000).

The debate that occurred regarding the cause of fires somewhat increased the understanding of stakeholders about material vulnerability from peatland wildfires.

---

[11] See, https://www.indonesia-investments.com/culture/politics/suharto-new-order/item180.

[12] Satellites from the US National Oceanic and Atmospheric Administration monitor the earth's dynamics.

The reformist government of President Abdurrahman Wahid stopped the MRP and proposed the “KAKAB project” as a conservation project for the ex-MRP area (Barber and Schweithelm 2000). Nevertheless, the GoI did not materialise the KAKAB project due to the unstable political situation, but instead continued other proposals to conduct massive land-use conversion. For example, the Mamberamo megaproject in Papua (Barber and Schweithelm 2000).

5.3.2.1 Rise of (Fragmented) Policy Instruments

In the immediate years following 1997, the dominant (risk) perception among government stakeholders was that slash-and-burn farming practices triggered peatland fires. As a risk management strategy for peat fires, the GoI issued two regulations: Presidential Decree No. 80/1999 about General Guidelines for Planning and Managing the ex-MRP area in Central Kalimantan, and Government Regulation/PP No. 4/2001 to ban burning practices on farms and plantations. The latter regulated criteria for peatland degradation. Additionally, the GoI established national parks on peatland, such as in Central Kalimantan, whose primary aim is to conserve native peatland species (Mirmanto et al. 2000).

The change in political regimes opened a window of opportunities for non-state actors and universities to become involved in post-peatland wildfire governance. After the 1997 fires, civil society organisations stepped up efforts to study peat vulnerability and to restore peatland, trying to reduce peat vulnerability. Risk assessment by non-government organisations (NGOs) and academics around this time found that the driver of peatland degradation was the absence of proper water management and burning-land clearing practices, which led to dry peatlands and make it susceptible to fire (Kartodihardjo et al. 2018).

The prominent involvement of NGOs in peatland conservation began in 2001. Wetlands International Indonesia (WII), in partnership with local NGOs and supported by local governments, started peatland restoration projects in Jambi, South Sumatra, and Central Kalimantan. They introduced community-based peatland management to restore burned peatland (Noor 2007). The projects’ activities consisted of the construction of canal blocking/backfilling, revegetation using native species, promoting alternative livelihoods around peatland, and mainstreaming village policies to be aligned with the objective of sustainable peatland management. Challenges abounded in the project. One of these challenges is social acceptance. For example, in Central Kalimantan, communities made a new canal for local transportation next to the canal blocking. It reduced the function of canal blocking to rewet peatland, as the new canal allowed drainage.

In 2004, WII and other NGOs proposed a national strategy for sustainable peatland management. After almost four years of lobbying, the KLH (Ministry of Environment) agreed to issue such a national strategy in 2007. The issued document provided conceptual guidelines for sustainable peatland management in Indonesia. In the same year, the KLH established a new sub-directorate (echelon IV-level) for peatland management under the General Directorate of Environmental Degradation Management (PPKL—*Pengendalian Pencemaran dan Kerusakan Lingkungan*). However, the lack of robust data and strong legal/regulatory support, as well as limited (authority) resources by the sub-directorate, restricted the implementation of sustainable peatland management strategies.

Efforts at various levels provided the push for the GoI to follow-up on the KAKAB project and Presidential Decree No. 80/1999 regarding the MRP. It resulted in Presidential Instruction No. 2/2007 to make Bappenas (Ministry of National Development Planning), Kemenkokesra (Ministry of Coordinator of Economy and General Welfare), and other ministries from various sectors (including the KLH) begin the planning of restoration projects for 1-million-hectare degraded peatland in the location of the ex-MRP project. However, the project met many challenges in implementation and was eventually stopped in 2011 due to knowledge uncertainty (lack of techno-scientific knowledge about peatland restoration by the government) and institutional uncertainty (absence of cooperation mechanisms among governmental bodies and support from related stakeholders) (van der Meer and Ibie 2009).

At the local level, there were some bright spots in the government's effort to achieve sustainable peatland management. For example, Balitbang LHK Palembang—a research institute under the KLH (now KLHK)—conducted a revegetation project in Kedaton Village, OKI regency, South Sumatra, in 2010. The project utilised native peat trees such as *jelutung, ramin,* and *meranti*. With international funding support, this project[13] restored more than 10 ha of peatland in five years (Bastoni 2019; Budiman et al. 2020a, b, c).

From 2001 to 2010, there were few regulations and fragmented restoration projects as post-disaster governance for peatland wildfires in 1997 and the 2000s. Restoration activities were adopted and developed further by a company in Kalimantan and other NGOs, such as WWF and Earth Innovation (Earth Innovation, n.d.; Purnawan et al., n.d.; Rossita et al. 2018). Knowledge transfer for adaptive learning occurred due to personnel rotation and networks across institutions.

5.3.2.2 Peatland Conversion to Palm Oil Plantation

While limited amounts of peatlands were restored, and conserved, more peatlands were converted into palm oil plantations in other areas from the early 2000s to

[13] The project area survived the 2015 wildfires disaster due to routine monitoring in the area. As a result, it became a role model for peatland restoration in Indonesia. In 2016, this post-disaster governance effort in Kedaton continued when the Peatland Restoration Agency (BRG) provided funding to Balitbang to extend the restoration area to 20 ha. In 2019, results from revegetation were clearly seen: the height of the trees reached more than 9 m, hence contributing to carbon emission reduction. The project is being replicated in adjacent areas in Kayuagung in partnership with communities and other stakeholders. Supported by stronger law enforcement on peatland protection after 2015, the number of peatland wildfires in Kayuagung has been reduced, highlighting successful post-disaster governance that led to the mitigation of the risk of future disasters (Budiman et al. 2020).

2009 (Goldstein 2016). The palm oil industries began to exploit peatlands due to the depletion of large lands on mineral soil. Business permits to palm oil companies remained issued by the Ministry of Agriculture and local governments, including in protected peat areas. The issuance of business permits in protected area contradicts Presidential Decree No. 32/1990 regarding the protection of deep peatland. This conflicting policy occurred partly due to incomplete data on peat depth and weak law enforcement. By the early 2000s, approximately 6% (or ~880,000 ha) of tropical peatlands in Kalimantan[14] and Sumatra had been converted to oil palm plantations, resulting in the loss of more than ~145 million Mg of biomass carbon (aboveground and belowground) and a significant decline in biodiversity annually (Koh et al. 2011).

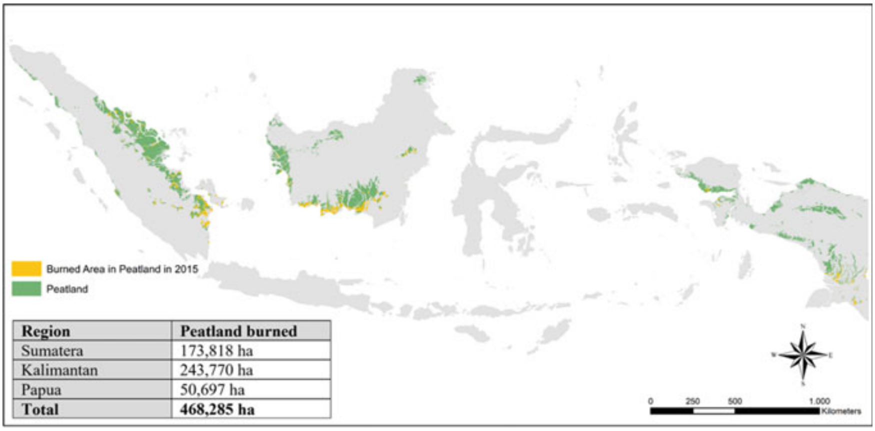
At that time, most of the palm oil industries had limited detailed knowledge about sustainable plantation techniques on peatland. The communities near the palm oil plantations followed suit. Smallholders began converting peatland into palm oil plantations (Nurhidayati et al. 2016) via land clearing, drainage, and canal construction. This major expansion by the large and small palm oil actors throughout the first decade of the twenty-first century brought episodic wildfires in some locations from 2006 to 2008 (Tan et al. 2009).

As a response to recurring disasters on peatland due to land-use changes, NGOs demanded stronger regulation regarding peatland management. Additionally, in the late 2000s, climate advocacy by the international community also often mentioned peat degradation as one of the major sources of global carbon emissions (Van der Werf et al. 2009). In response to public concern, the GoI issued three policies: (1) The Minister of Agriculture Decree No. 14/2009 about the Guidance for the Utilisation of Peatland for Oil Palm Cultivation, (2) the National Act 32/2009 that officially disallowed peatland clearing using fires while taking local customary practices into account,[15] and (3) a moratorium on issuing business permits in peatland and primary forest in 2011. The latter policy aimed to reduce the issuance of business permits on new industrial concessions on peat deeper than three metres. The moratorium policy took two years to release the indicative map in 2013 (Enrici and Hubacek 2016; KLHK 2019). In the meantime, approximately 5–10 million hectares of peatlands in Indonesia were estimated to have been degraded and utilised by industries and communities (Koh et al. 2011; Sumarga et al. 2016).

From 2012 to 2013, fires were found on oil palm concessions in peatlands in Sumatra and Kalimantan; there were thousands of hotspots, particularly in concessions without certifications for sustainability (Cattau et al. 2016; Lake et al. 2016). The occurrence of fires led to more persistent advocacy by NGOs and eventually forced the GoI to establish the first specific regulation on peatland ecosystem management, i.e. Government Regulation (PP) No. 71/2014 on the Protection and Management of the Peatland Ecosystems, which is widely considered a drastic policy measure for sustainable peatland management. Among others, the regulation introduced the concept of the peatland hydrological unit/KHG as a landscape approach that covers

[14] This includes Peninsular Malaysia.

[15] This regulation implies that, in practice, only small-scale and controlled burning of peatlands is allowed for only customary communities, mainly for agricultural purposes.



Region	Peatland burned
Sumatera	173,818 ha
Kalimantan	243,770 ha
Papua	50,697 ha
Total	**468,285 ha**

Fig. 5.2 Burned peatland in Indonesia in 2015. *Source* Burned area products from University of Maryland,[16] and peatland map from Indonesia's Ministry of Agriculture

multiple villages or sub-districts and multiple area functions (protection, cultivation, and concession). The regulation became the basis for the newly established KLHK (merger of the KLH with the Ministry of Forestry) to work with other stakeholders to perform risk assessment and compile peatland data that was previously scattered in the hands of NGOs, academics, and the Ministry of Agriculture.

However, PP No. 71/2014 arrived at the beginning of the 2015 El Niño, which triggered devastating fires that burned approximately 468,285 to 618,574 ha. of peatlands across the country (LAPAN 2015; UMD 2020). Figure 5.2 shows the extent of peatland burning in Sumatra, Kalimantan, and Papua, which brought major environmental and socio-economic impacts both regionally and globally (UMD 2020). A mean emission rate of 0.16–0.22 Gt C was recorded from the 2015 peatland fires (Huijnen et al. 2016; UMD 2020). Daily emissions during the peak of the fires surpassed the average daily emissions from the entire USA (Huijnen et al. 2016). Financial losses were estimated at approximately USD 16.1 billion (Purnomo et al. 2017). These disaster impacts were more severe than the higher number of fires in 1997 because there had been land-use change and an increased population surrounding the peatland ecosystem.

The GoI argued that the 2015 fires were caused by several factors: slash-and-burn practices by the community and some industries, a lack of law enforcement due to limited resources, and a low level of compliance by the target group of the policy. The risk perception towards peatland hence became systemic, as it intertwined socio-economic drivers, policy, and governance factors.

In short, the cycle of vulnerability to post-disaster governance continued during the period after the 1997 wildfires. The rise of (fragmented) risk management efforts in the early 2000s was not aligned with the increase in business permits for palm oil

[16] See, http://modis-fire.umd.edu/ba.html.

plantations on peatland. This association suggests a different degree (compared to the post-1982 period) of political vulnerability where the intensity of vulnerability in the governance cycle decreased as political processes (issuance of regulations) and policy instruments (restoration projects) contributed to elevating stakeholders' awareness and action towards disaster risk management on peatlands. Such fragmented post-disaster policy and governance contributed to reducing the extent of burned peatland from 1.4 million ha in 1997 to 468,285 ha in 2015.

In this period, the National Disaster Management Agency (BNPB) did not do much to support peatland restoration, as the institution had just started the paradigm of disaster mitigation[17] in 2007. Previously, BNPB had focused more on disaster handling and emergency responses (BNPB 2010).

5.3.3 Post-2015 Wildfires: Protection of Peatland (Ecosystem)

The 2015 fires taught Indonesian stakeholders much about systemic drivers and pressures to peatland degradation, which resulted in an increased awareness about peat restoration. The GoI formally institutionalised peatland restoration efforts by establishing the Peatland Restoration Agency (BRG) and upgraded the Sub-directorate (echelon IV level) of Peatland Management in KLHK into the Directorate of Peatland Degradation Control (echelon III level). This change at the institutional level indicates elevated priority by the GoI towards disaster risk reduction on peatlands. BRG and KLHK were given a mandate to facilitate local stakeholders in restoring 2.67 million hectares (ha) of peatland across seven priority provinces,[18] particularly on previously burned peat and protected peat, from 2016 until 2020. The president divided the responsibility of peatland restoration between BRG and KLHK based on the function of the area: BRG is responsible for facilitating restoration in 892,248 ha non-forest areas,[19] while KLHK must urge concession holders to restore peatland in 1,784,353 ha production forest[20] areas. In addition, KLHK also conducts community-based peatland restoration in non-priority provinces (KLHK 2019).

The increased understanding of systemic vulnerability in peatland influenced the selection of BRG leaders by the GoI. BRG leaders included NGOs' experts who have been working on peatland restoration since the 2000s. As leaders with clear authority, the experts institutionalised their restoration strategy into the formal approach for

[17] Disaster mitigation measures are those that eliminate or reduce the impacts and risks of hazards through proactive measures taken before an emergency or disaster occurs.

[18] Riau, Jambi, South Sumatra, Central Kalimantan, West Kalimantan, South Kalimantan, and Papua.

[19] Local governments are expected to contribute to support the funding of the restoration.

[20] Production forest areas consist of industrial forest plantations and palm oil plantations. For palm oil plantations, KLHK must collaborate with the Directorate General of Plantation at the Ministry of Agriculture (Kementan) to facilitate restoration. Kementan is the national authority that is responsible for data on palm oil concessions.

peatland restoration. The approach included soil rewetting, revegetation, revitalisation of the livelihood of local people, and “Peat Care Villages” (*Desa Peduli Gambut)* as a strategy for risk communication and institutional building at the local level. These activities involved a wide range of institutional networks that included various actors across sectors and different levels.

5.3.3.1 Governance Arrangement and Risk Assessment

In 2016, the GoI made a revision to PP No. 71/2014 and replaced it with PP No. 57/2016. One significant change is the addition of policy measures to prevent peat ecosystem destruction, which includes: (1) evaluation and audit of peat-based use permits, (2) early warning system[21] development, and (3) institutional strengthening (capacity building for forest management units and the involvement of fire-care communities in peat management, among others).

This regulation has become the guideline for the GoI in collecting, assessing, and analysing relevant (risk) information for peatland restoration. Then, in early 2017, the GoI compiled indicative maps for restoration planning based on remote sensing analysis and released a contingency plan for restoration. This plan was presented to authorities at the provincial level to be the guideline for restoration implementation, but it received unfavourable responses. For example, stakeholders in Riau and South Sumatra argued that some information in the maps was wrong (Kartodihardjo et al. 2018), and it hampered the field implementation of peat restoration in some cases. Another barrier was the absence of local regulation to support (the funding of) peat restoration. At the end of 2017, the BRG achieved only less than 5% of its annual target,[22] while KLHK did not provide an annual implementation report (PRIMS 2020).

Learning from past mistakes, in 2018, BRG revised the governance strategy for restoration by increasing the degree of involvement of provincial stakeholders in restoration planning and budget management. The BRG changed its financing scheme from direct assignment, which was the only budget transfer[23] in 2017, to the addition of co-administration funds for the restoration in 2018. This change increased the provincial governments’ involvement in restoration projects. Further, it affected the risk assessment strategies for restoration planning. Along with their provincial counterparts, BRG started to conduct rapid assessment to verify the contingency plan and to have yearly restoration planning (RTT/*Rencana tindak tahunan*)[24]

---

[21] See, http://sipalaga.brg.go.id/

[22] In 2017, BRG planned to conduct/facilitate 59,308 rewetting activities and 541,804 ha revegetation. However, the implementation was only 7847 rewetting, 0 ha revegetation, and 93 livelihood areas.

[23] The transfer occurred from BRG to provincial governments.

[24] This restoration plan is more detailed and includes ground-truthing, socio-economic surveys, and a stakeholder forum for risk evaluation in its method.

in four provinces[25] (BRG 2019a). In South Sumatra, for example, BRG worked with the NGOs consortium to compose detailed restoration planning in 14 peatland hydrological units.[26] Such a document presents a more integrated plan for landscape restoration activities per peat hydrological unit.

However, the RTT document could not be fully utilised by local agencies because of the absence of national regulatory[27] support for risk assessment and evaluation for restoration planning at that time. To try to solve this issue, some provincial governments issued local regulations for peatland protection in 2018.

Meanwhile, the KLHK went through separate arrangements in facilitating concession holders to include restoration in their business plan. This fragmented governance arrangement caused overlapping restoration plans in the peatland hydrological unit (Budiman 2020; Januar 2020). Neither the contingency plan nor the RTT was integrated with the restoration plan by concession holders. Fortunately, BRG has a responsibility to supervise concession holders' restoration plans. Until the end of 2019, BRG's record shows that they had supervised restoration plans in 242,260 ha concession areas (16 companies) out of a 1.7 m-ha target (Helindro 2019). Furthermore, ideally, all restoration plans should be integrated with the disaster management plan (RPB) in the National Disaster Management Agency (BNPB) and its subnational agencies to optimise the risk assessment of peatland wildfires. However, this did not occur until the end of 2019.

Despite the above-mentioned issues, restoration planning brought an advantage for the failed restoration project of the ex-MRP area (see Sect. 3.2.1). The planning guide helped the implementation of restoration in the area, under the partnership between BRG, the Ministry of Public Works, and the Riverfront local agency.

5.3.3.2 Measures of Risk Management

The governance arrangement of restoration above led to the existence of three different planning documents: the contingency plan, the rapid assessment, and the restoration plan by concession holders. It often confused local stakeholders to utilise them as guidelines for implementation. Integration of those planning documents requires intensive coordination, but the absence of protocols for coordination made it difficult for provincial stakeholders to collaborate in implementing peatland restoration. Additionally, there were also institutional (ego) issues between the BRG, provincial governments, and the KLHK that hampered the coordination. Consequently, some restoration implementation was not based on the single proper planning document (Kompas 2020).

[25] Jambi, South Sumatra, West Kalimantan, and Central Kalimantan.

[26] Peatland hydrological unit is unit area for peatland use and planning, located between two water bodies in peatland landscape.

[27] The Decree of Minister of Environment and Forestry about Guidelines for National and Regional Planning of Management and Protection of the Peatland Ecosystem was not ready until the end of 2019.

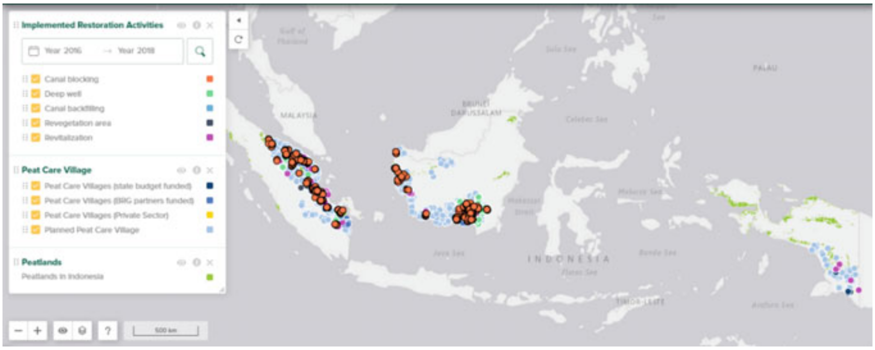


Fig. 5.3 Implementation of peatland restoration in non-concession areas. *Source* BRG (2019)

Hence, each stakeholder tended to work in fragments to translate different planning documents into their own restoration responsibilities. In the concession area, the process of including restoration plans[28] in business plans requires a long bureaucracy to be approved by the KLHK. In the meantime, some concession holders continued unofficial restoration activities with local police. As a result, the restoration implementation was not integrated within a peatland hydrological unit, as BRG, KLHK, and their partners tend to work in separated arrangement. This mode of governance impacted the output and outcome of restoration programmes in general.

Outside the restoration programme, the GoI implemented a moratorium that prohibited the issuance of new permits to clear primary and peat forests; this prohibition became permanent in 2019. Since 2016, the moratorium has been shored up by peat protection regulations that have helped slow the loss of forest cover and reduced fires (Arumingtyas 2019). This policy attempts to address the economic driver from concession holders to degrade peatland. However, the enforcement of this policy is still an issue. Some industrial forest plantations are still expanding their business on peatland (Eco-Business 2019b). In addition, there is still another conflicting policy in Kementan for replanting palm oil partly in peatlands (Nugraha 2020) (Fig. 5.3).

The above-mentioned political vulnerabilities in planning have consequences to the quantity and quality of restoration output. In early 2019, quantitatively, the BRG record shows that they performed restoration activities[29] (3377 canal blocking, 5525 deep wells, 33 canal backfilling, 19 ha revegetation, 213 units of livelihood support, and peat care programmes in 262 villages) in 49 peatland hydrological units in the seven priority provinces (Antara 2019b; Post 2018; PRIMS 2020). Most of these activities were in the Central Kalimantan Province (Kurniawan 2017). South Sumatra and Riau were able to meet approximately 10% of the target and South Kalimantan, West Kalimantan, Jambi, and Papua were able to meet less than 5% of the target (PRIMS 2019), due to issues with peat data and personnel capacity (MI

[28] By the end of 2019, 523,112 ha of restoration plans were supervised by BRG.

[29] From these activities, BRG claimed to restore 697,000 ha of peatland. However, there is uncertainty in this calculation of accounting potential restored areas from the intervention/activities.

2019a,2019b). Despite these percentages, this achievement shows better progress in post-disaster governance compared to the post-1997 period.

Qualitatively, many restoration activities conducted were still far from the ideal implementation. A recent study found that restoration activities in two sub-districts in South Sumatra occurred in non-peat areas (Budiman 2020). For rewetting activities, approximately 10% of canal blocking infrastructure on peatland was found to be broken and did not follow regulated standards (Budiman 2020). The same issues were found for deep well infrastructure supported by the National Disaster Management Authority (BNPB and BPBD) (antaranews.com 2019a); maintenance was not completed due to budget issues (Ane 2019). The lack of revegetation activities also influenced the effectiveness of rewetting infrastructures (Bastoni 2019; Giesen and MacDonald 2018). In addition, many livelihood supports were delivered to the wrong target group[30] (Budiman et al. 2020a,b,c; Daeli 2020).

Consequently, the above-mentioned policy vulnerabilities in implementation meant that the restoration did not reach a maximum positive impact (Antara 2019a; Eco-Business 2019a). In September 2019, low water table[31] was identified in more than 90% of monitoring points in restoration areas (BRG 2019b; Swails et al. 2019). The 2019 El Niño hence triggered recurrent peat wildfires. Approximately 61% of peat wildfires occurred in restoration target areas (23% in concession areas, 31% in protected and production forests, and 6.1% in non-forest areas), particularly in Riau, South Sumatra, and Central Kalimantan (BRG 2019c; Budiman 2019, 2020; Pantau Gambut 2019), (BRG 2019c; Pantau Gambut 2019). At the end of 2019, approximately 480,178–709,769 ha of peatlands were burned (Fig. 5.4) (KLHK 2020; UMD 2020).

According to BRG, fire only occurred in the top layer of peat, and their data also shows that only 5.6% of fires occurred in a 1–2 km radius from restoration infrastructures (Liputan6 2019; Normile and Pm 2019). This result implies a positive impact of restoration implementation. In Central Kalimantan, FAO research found that the implementation of rewetting activities shows positive deviation from the soil moisture index (PRIMS 2019). However, these impacts occurred only in small areas of peatland in the country. PRIMS (restoration monitoring platform[32]) is currently working to monitor and evaluate the detailed effectiveness of restoration projects (PRIMS 2020).

Physical vulnerability causes social vulnerability. Indeed, the fires caused over 900,000 people to report respiratory health diseases. Further, 12 national airports halted operations and hundreds of schools in Indonesia, Malaysia, and Singapore closed temporarily. Overall, the total damage and economic loss in eight affected provinces throughout June to October 2019 were estimated at USD 5.2 billion (World Bank 2020).

---

[30] The community group does not base its main income on peatland; thus, the right target group (whose main income relies on peatland) still continues to put environmental pressure on peatland.

[31] A high-water table is one of the indicators for the success of peatland restoration. See, https://www.cifor.org/library/6932/

[32] https://prims.brg.go.id/dasbor.

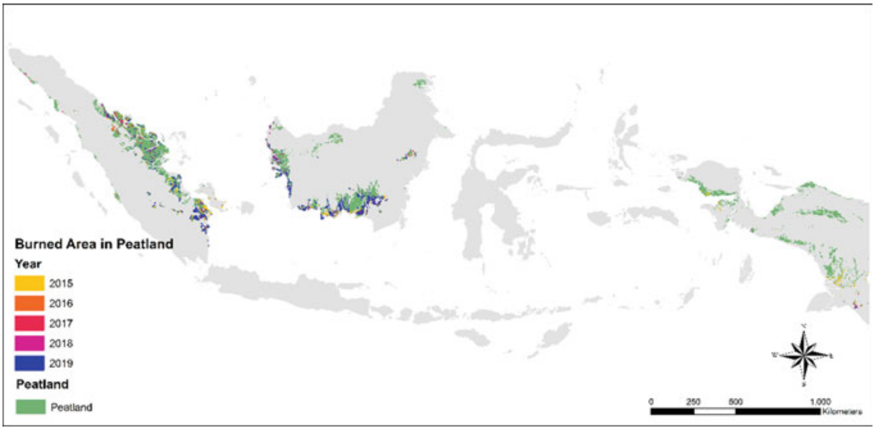


Fig. 5.4 Burned peatland in Indonesia from 2015 to 2019. *Source* Burned Area Products[33] from the University of Maryland (UMD 2020) and peatland map from Indonesia's Ministry of Agriculture

The fires also affected the number of implementations of the 2019 restoration activities. The 2019 implementation decreased by 75% compared to the 2018 implementation (Nugraha 2020). Meanwhile, the KLHK record shows that 2080 concession holders completed restoration based on the 0.4 water table requirement (Kompas 2020). Yet, the fires were still found in concession areas that met the water table standard. Scholars argued that this "standard" is not a scientific standard, but a compromise between the KLHK and plantation owners. Studies show that maintaining peatland groundwater table at a higher level will be more sustainable in the long term (Budiman et al. 2020a,b,c; Evans et al. 2019).

Overall, the national restoration policy since 2016 has made the connection between the political and material situations of peatland appear to be stronger, which affects the intensity of vulnerability in the governance cycle. The ambitious target has resulted in a political push to provide more resources for peatland restoration. The implementation of peatland restoration in seven provinces as post-disaster governance has used three principles within the risk governance framework: improvement in restoration planning is considered a combination of risk assessment and risk evaluation for peatland management, and implementation of the restoration itself is a form of risk management and partial risk communication. The restoration projects have influenced community perceptions towards peatland vulnerability. Restoration implementation is considered adaptation of risk governance principles. In some areas where the restoration activities are well-implemented, the restoration worked as strategies to recover peatland degradation and reduced peatland vulnerability.

[33] This number is the result of an analysis to calculate the area using the World Cylindrical Equal Area projection system.

5.3.3.3 Dealing with Uncertainties

Peatland restoration agendas struggled to deal with multiple uncertainties. The first is knowledge uncertainty about the peatland data and the required duration to achieve the restoration target. The validity and reliability of peat data concern restoration planning and implementation. The absence of ground truthing in the contingency plan caused several restorations to not be implemented on peatlands. The five-year time limit has caused the GoI to struggle to meet the 2.6 million ha restoration target and led the planning and implementation of restoration to not be done properly. Scholars argued that it is not easy to meet the target, while 1 million ha of the target area is concession that requires intensive coordination between private sectors and several government bodies (antaranews.com 2019b; BBC Indonesia, n.d.; Kontan 2019).

The above-mentioned issue relates to the second struggle on strategic uncertainty. The GoI did not prepare a detailed strategy for restoration governance in dealing with multi-stakeholders. For example, determination of the financing scheme for restoration lacked consideration of "rent-seeking" behaviours among stakeholders. Many government bodies are involved in restoration projects due to interest to budget availabilities. Some remain involved despite insufficient personnel capacity in planning and implementing restoration. These issues affect the effectiveness of restoration output and outcome (Sect. 3.3.2). At the village level, although BRG succeeded in approaching the Ministry of Village to issue a regulation that allows the use of village funds[34] for peat restoration (Nugraha 2020), the implementation is still being questioned. This budget could potentially not create a positive outcome for restoration if livelihood supports are not delivered to the right target group (Budiman et al. 2020).

The third is regulatory uncertainties about two main aspects: the ideal peat water table and criteria for determining peat protection zones. Regarding water table, there has been ongoing academic debate on the extent to which the 0.4-m requirement should be deemed a one-size-fits-all criterion for rewetting efforts across all peatland types, since, arguably, it barely impedes the rate of land subsidence and carbon release from peatlands (Budiman et al. 2020a,b,nc; Evans et al. 2019; Sari 2020). In the peat protection zone, the regulatory setting is still somewhat highly influenced by the economic development objective on peatlands. There are differing criteria over areas that can be established as peat protection zones; they are particularly within KLHK decrees (P.10/2019 and P.14/2017) and government regulations (PP.57/2016 and PP.13/2017), whereas such criteria consensus matters for the prioritisation of restoration areas. Eventually, these regulatory uncertainties challenge the overall extent of restoration efforts across peatlands in Indonesia.

The final struggle is institutional uncertainty that is correlated with regulatory uncertainty. Institutions are obliged to follow regulations, and regulation serves as the individual institution's rationale for action. Because of the absence of a clear institutional arrangement between the institutions involved, the restoration agenda currently faces coordination and organisational issues, particularly between BRG and KLHK.

[34] BRG's record shows that 143 villages were allocated 16 billion IDR to support peat restoration.

Meanwhile, this situation has also impacted governance at the local level, where the provincial restoration team (TRGD) has difficulty facilitating local government bodies to cooperate in integrating restoration planning and implementation.

In addition to dealing with issues in the current institutional arrangement, BRG and KLHK still need to complete additional work to integrate peatland restoration into the national master plan of disaster risk management. Currently, the work plan by the deputy on risk assessment, emergency response, and recovery in the National Disaster Risk Management Agency (BNPB) is not yet integrated with the work plan from BRG and KLHK in responding to peatland wildfires. BRG and KLHK focus on facilitating the construction of restoration infrastructure. The BNPB and the local disaster risk management agency (BPBD) should maintain this infrastructure. However, this has not occurred yet.

Failing to deal with these uncertainty issues is considered new political vulnerabilities that could undermine restoration opportunities to improve the management of peatland ecosystems to prevent future wildfires.

5.3.4 Trajectory of the Progress of Post-disaster Governance

From 1982 to 2020, a trajectory of progress has been made by Indonesian stakeholders to improve the post-disaster governance of peatland wildfires (Fig. 5.5). The transformation in each period (post-1982, post-1997, and post-2015) has reduced the degree of vulnerability in the policy and governance process (Table 5.1).

Post-1982, the absence of serious post-disaster governance after the 1982 peat fires caused recurrent fires in 1994 and 1997. In the 2000s, restoration projects in scattered areas across the country started to reduce political vulnerability in disaster management for peatland. This marked a turning point in the understanding of post-disaster governance of peatland wildfires by the GoI, NGOs, and concession holders. However, this risk management approach did not have strong regulation support; hence, the scale of restoration was rather small. Meanwhile, the pressure from palm oil plantations began, and pressure from communities to clear new peatlands could not be reduced (Medrilzam et al. 2014). Law enforcement for government regulation No. 4/2001 banning burning practices was rather weak. These situations show that there was political vulnerability from a disconnection between the initiatives to restore and protect peatland with the issuance of business permits that degraded peatland. As a result, before the 2011 moratorium policy and PP71/2014 had an impact, more than two decades of peatland degradation could not survive the 2015 El Niño. It led to fire activity and smoke pollution in 2015 that showed persistent sensitivity to the El Niño-induced drought (Field et al. 2016).

The impact on material vulnerability reduced from 1997 to 2015 and its degree varied spatially across the country. There were different peatland vulnerabilities and risks in each region. A significant reduction in peatland wildfires occurred in Papua, where there was less peatland conversion to palm oil plantations (Afriyanti et al. 2016; Elisabeth 2018). In Kalimantan, the restoration project of the ex-MRP area

Fig. 5.5 Transformation of post-disaster governance of peatland wildfires in Indonesia

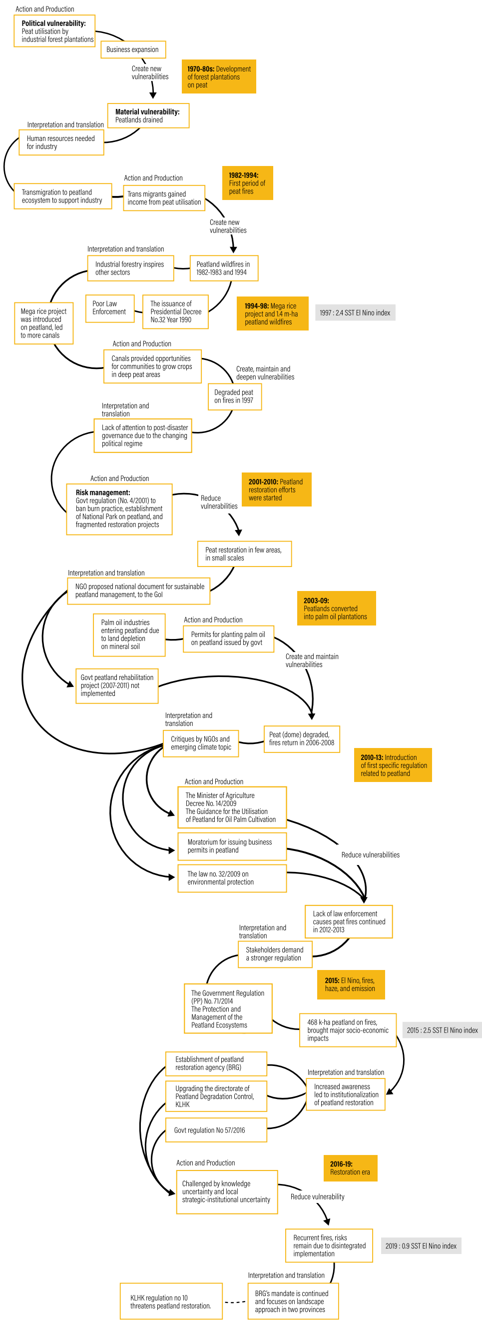


Table 5.1 Contribution of transformation of post-disaster governance to affect peatland wildfires

	Peatlands burned in 1997	Post-disaster governance (2001–2014)	Peatlands burned in 2015	Post-disaster governance (2016–2018)	Peatlands burned in 2019
El Nino index	2.4 SST		2.5 SST[35]		0.9 SST
Total/national	1,458,000 ha	PP No. 4/2001 on ban on burning practices	468,285–618,574 ha	PP 57/2016 on peatland protection	480,178–709,769 ha
		National strategy for sustainable peatland management		Establishment of BRG and Directorate of Peatland degradation control, KLHK	
		Minister of Agriculture Decree No. 14/2009 on cultivation on peatlands		*Permanent prohibition* on new land clearance on peatlands	
		Moratorium for issuing business permits in peatland in 2011			
		PP 71/2014 on peatland protection			

(continued)

[35] SST: The sea surface temperature (Center NCP 2020).

Table 5.1 (continued)

	Peatlands burned in 1997	Post-disaster governance (2001–2014)	Peatlands burned in 2015	Post-disaster governance (2016–2018)	Peatlands burned in 2019
Sumatra	308,000 ha	Restoration in Jambi and South Sumatra	173,818–267,794 ha	Restoration in Aceh, North Sumatra, West Sumatra, Riau, Jambi, and South Sumatra	279,248 ha
				Local regulation on peatland protection	
Kalimantan	750,000 ha	Restoration in Central Kalimantan	243,770–319,386 ha	Restoration in Central, South, East, and West Kalimantan	428,353 ha
Papua	400,000 ha	–	31,214–50,696 ha	Restoration in Papua and West Papua	2169 ha
Total estimated emission	0.519 Gt of C[36]		0.166–0.22 Gt of C		0.232–0.252 Gt of C

Source Authors' analysis

[36] 0.73 Mha peat burned is estimated to release 0.26 Gt C.

helped to save the area from peatland conversion to palm oil plantations. The absence of this kind of project in Sumatra might be the reason why this region experienced the lowest reduction in peatland wildfires among all regions (Table 5.1).

After the 2015 fires, perceptions of post-disaster governance of peatland wildfires changed significantly among the government, academics, and NGOs, followed by reduced overlapping regulations.[37] The moratorium policy and PP71/2014 proceeded faster and resulted in the institutionalisation of the national restoration agenda and permanent prohibition of business permits on peatland. In this period, a new degree of political vulnerability was found in the arrangement of the governance cycle of peatland restoration. The absence of an integrated landscape approach in restoration planning and implementation and institutional issues has caused the restoration policy to not yet have a positive impact, as the many areas of restoration targets still suffer from fires, and this is also due to the 2019 El Niño.

After the 2019 fires, the GoI announced a new commitment to restoring peatland based on a landscape approach: its peatland hydrological unit. The president extended the years of service of BRG to continue focusing restoration on two provinces, Riau and Central Kalimantan, which suffered the most from the 2019 fires.

5.4 Discussion

Two political vulnerabilities are identified in governing restoration as a recovery strategy for the 2015 peatland wildfires. Firstly, political vulnerability is an ambitious target to restore 2.6 million hectares of peatland in seven provinces within five years. This target did not consider degrees of uncertainty in peat restoration. Peatland takes a much longer time to recover from interference or damage than other lands because of its physical characteristics such as soil structure and hydrological function (González et al. 2014; Swindles et al. 2016). The minimum period for microtopographic recovery in restored wetlands was between 10 and 30 years, and the examination of early indications of recovery started 2–3 years after the restoration was carried out (González et al. 2014). To further complicate the process, planning and implementation of restoration must involve a great deal of coordination between government institutions, such as BRG, KLHK, and provincial government bodies. As discussed in the previous sections, this reality has generated institutional challenges on its own.

The focus on meeting the ambitious target often caused the GoI to overlook ideal ways to reduce peatland vulnerability to fires through landscape approaches (kompas.id 2019). The landscape restoration of peatland ecosystems requires a strategy of ecosystem governance. The BRG and KLHK, which should work together with almost a hundred local institutions and concession holders across a five-year

[37] For example, in Central Kalimantan, a few months after the peat fires became uncontrollable in mid-2015, the Gubernatorial Regulation 52/2008 about permit for peat area burning with controlled mechanisms and limited scope was officially cancelled.

span of 2.6 million-hectare peatland ecosystem, have not been adequately equipped to prepare for such a strategy. Secondly, political vulnerability relates to this issue.

The second political vulnerability is the absence of a suitable governance arrangement to support landscape restoration on peatland. The division of responsibility for peatland restoration between KLHK and BRG is based on area/land function. This task division follows the jurisdiction of KLHK in forest and concession areas. This arrangement makes it difficult to govern landscape restoration based on peatland hydrological units. The absence of a strong lead coordinator and a lack of substantial coordination among responsible institutions hamper the synergy of restoration activities by KLHK and BRG within the peatland hydrological unit (Kartodihardjo et al. 2018). Therefore, BRG and KLHK tended to facilitate restoration separately, even though the target area was the same. As a result, the concept of a landscape approach for peatland restoration was not implemented. Landscape restoration of peatland requires strong network governance to address multiple interests from stakeholders within a peatland hydrological unit that consists of multiple administrative regions (villages and sub-districts) and multiple functions of the area (protection, cultivation, and concession). This governance model requires clear division of responsibility and allocation of resources, and coordination mechanisms (Budiman and Smits 2020).

Political vulnerability in this period lays within a sphere of complex governance arrangements for peatland restoration. The absence of the suitable governance arrangement contributed to quantity and quality of restoration implementation. This association affects the effectiveness of the restoration policy. Ineffective restoration implementation made peatlands remain vulnerable to fire.

This study found that the cycle of vulnerability still goes on the policy cycle of disaster risk management on Indonesian peatlands, but to different degrees and intensities. This finding can contribute to detailing the framework for transforming post-disaster governance. The aspect of the transformation of degree of political vulnerability is considered a novelty of this study. This framework could be a transitional pathway for stakeholders to understand more comprehensive sustainable peatland management.[38] Peatland wildfires mainly occurred due to failures in conducting sustainable peatland management. Policy on sustainable natural resource management requires the provision of appropriate incentives, an increase in restrictive access, simpler institution, and appropriate management scales in order to bring better output and outcomes (Ostrom et al. 2012). Further study is required on this topic. One of the frameworks that can be used is the institutional analysis and development (IAD) model (Ostrom 2005; Poteete et al. 2010). The IAD has been adapted to a variety of different contexts and has been applied to various analyses of the occurrence of institutional failures in natural resource management.

[38] Includes consideration of multi-factors beyond policy and governance aspects, such as social acceptance.

5.5 Conclusion

Sequences of devastating peatland wildfires in the El Niño years (1982, 1997, 2015, and 2019) forced Indonesia to learn about the material vulnerability of its peatland ecosystems. There has been gradual improvement among a wide range of stakeholders in the understanding of peat ecosystem vulnerability after the 1997 and 2015 fires. This understanding has been transformed into strategies of post-disaster governance. The GoI has issued approximately 90 regulations[39] related to peatland management at different levels. Together with NGOs and concession holders, the GoI has implemented peatland restoration across the country. The implementation of peatland restoration has partly adapted principles of risk governance. This policy change is considered a transformation of the post-disaster governance of peatland wildfires.

However, there is still a lack of understanding about political vulnerability in dealing with multiple uncertainties, such as the complex sphere of governance arrangements in peatland restoration. This lack of understanding influenced output achievement for peatland restoration, which contributed to reducing the efficacy of restoration outcomes in 2019. This situation leaves the risk of failure for restoration to indicate the positive impacts of reducing the number of peat wildfires. All stakeholders are therefore urged to adopt the lessons learned to reduce political vulnerability. A couple of resilient actions are thus required to prepare for the risks posed by future El Niño events.

Firstly, all stakeholders, especially policymakers, need to understand the concept of political vulnerability. Therefore, each policy must be made with robust background research, particularly about its potential risks. Risk management is required for each peatland-related policy.

Secondly, rethinking regarding policy instruments for peatland management is required. In the last three decades, the GoI has utilised dominantly policy instruments in the form of regulation or command and control instruments for peatland management to prevent wildfires. The GoI called this progress a corrective action to deal with uncertainty in environmental problems. These sequences of regulations were issued following the increase in understanding about peat vulnerability. Nonetheless, opposing courses of action in different sectors (i.e. regional spatial planning policy, conversion for oil palm, the use of fire for land opening) still challenged efforts to reduce peat vulnerability, which somewhat led to recurrent fires.

Policy synchronisation is hence required among the peatland regulations (i.e. Presidential Regulation 71/2014 jo. 57/2016), prohibition of business permits on peatland, restoration plans, (peatland) firefighting,[40] and other related policies. The policy synchronisation is essential to harmonise peatland protection and to prevent

[39] Approximately 50 regulations have been issued by the national government, and approximately 40 regulations came from provincial regulations in peat-dominant provinces, such as Central Kalimantan and South Sumatra.

[40] Regional disaster management agency/BPBD created canals on peatland for firefighting transportation routes. This action increased peat degradation and vulnerability to fires.

overlapping criteria in land use planning at multiple governance levels, which otherwise might both result in conflicting peat-related activities and perceptions among stakeholders. Furthermore, alternative policy instruments, such as community-based management, ecotax, or carbon trading, may be needed to incentivise sustainable peatland management. These instruments must be integrated with other forest and land-use policies. Further research is required on this topic.

Thirdly, effective network governance is required to continue efforts to restore peatland ecosystems. It is suggested the adoption of a more comprehensive risk governance model. After the 2019 fires, risk perception among stakeholders (especially policymakers) needs to be investigated. This information is important for preparing a suitable governance arrangement for landscape restoration on peatland hydrological units. This arrangement requires intensive collaboration across sectors and administrative levels.

The governance arrangement must have clear division of responsibility and allocation of resources, and an (in)formal provision of mechanisms for coordination and cooperation among stakeholders, including communities. These elements will steer the complex web of interdependent actors, rules, and values on landscape restoration of peatland ecosystems that involve the following processes: (1) Risk assessment and risk evaluation for planning integrated restoration activities, (2) Restoration implementation as risk management, and (3) Inclusive and participative monitoring and evaluation. Each step needs to be delivered with effective communication efforts that consider the diversity of local sociocultural knowledge/expertise and political context/interest. Further research on the financial aspects of this governance strategy is required.

Such recommendations will generate the best practices of blended recovery–mitigation strategies to deal with peatland wildfires not just in Indonesia, but also in neighbouring countries with tropical peatlands, such as the Philippines and Malaysia, which require risk assessment and restoration on peatlands. These recommendations will contribute to accelerating the AADMER work programme for post-disaster recovery and mitigation plans and tackle transboundary haze in the long run.

Acknowledgements Thanks to the interviewees and WRI Indonesia (especially Septika Sihite, Dede Sulaeman, and Hidayah Hamzah) for supporting this study. This work was supported by the World Resources Institute Indonesia and the Norwegian Ministry of Foreign Affairs (NMFA).

References

Afriyanti D, Kroeze C, Saad A (2016) Indonesia palm oil production without deforestation and peat conversion by 2050. Sci Total Environ 557:562–570

Ane (2019) BRG Terkendala Anggaran Rawat Sumur dan Sekat Kanal Gambut | Ekonomi. https://www.gatra.com/detail/news/447336/ekonomi/brg-terkendala-anggaran-rawat-sumur-dan-sekat-kanal-gambut

Antara (2019a) BRG akui kebakaran terjadi pada lahan gambut intervensi. https://www.antaranews.com/berita/818170/brg-akui-kebakaran-terjadi-pada-lahan-gambut-intervensi

Antara (2019b) BRG: tersisa 400.000 ha gambut yang harus diintervensi. https://www.antaranews.com/berita/788271/brg-tersisa-400000-ha-gambut-yang-harus-diintervensi

antaranews.com (2019a) Badan Restorasi Gambut siapkan operasi pembasahan di Kalbar. Antara News. https://www.antaranews.com/berita/969860/badan-restorasi-gambut-siapkan-operasi-pembasahan-di-kalbar

antaranews.com (2019b) BRG akui tak mudah restorasi 2,7 juta ha gambut. Antara News. https://www.antaranews.com/berita/1047896/brg-akui-tak-mudah-restorasi-27-juta-ha-gambut

Aronson J, Floret C, Le Floc'h E, Ovalle C, Pontanier R (1993) Restoration and rehabilitation of degraded ecosystems in arid and semi-arid lands. I. A view from the south. Restor Ecol 1(1):8–17

Arumingtyas L (2019) Kebijkan Setop Izin di Hutan Primer dan Lahan Gambut Bakal Permanen? Mongabay Environmental News. https://www.mongabay.co.id/2019/05/20/kebijkan-setop-izin-di-hutan-primer-dan-lahan-gambut-bakal-permanen/

ASEAN, Secretariat, ASEAN, & Secretariat (Eds) (2016) AADMER work programme 2016–2020

Bappenas (2019) Long-term development plan for integrated disaster risk management. IRSA.

Barber CV, Schweithelm J (2000) Trial by fire. World Resources Institute, Washington

Bastoni B (2019) Integrated peatland restoration. Peat expert meeting by ZSL Palembang., Palembang

BBC Indonesia P. A. W. B (n.d.) Target restorasi gambut pemerintah "cukup berat." BBC News Indonesia. Retrieved 2 Oct 2019, from https://www.bbc.com/indonesia/berita_indonesia/2016/03/160310_indonesia_restorasi_gambut

Blackham GV, Webb EL, Corlett RT (2014) Natural regeneration in a degraded tropical peatland, Central Kalimantan, Indonesia: Implications for forest restoration. For Ecol Manage 324:8–15

BNPB (2010) Sejarah BNPB. https://bnpb.go.id

Bonn A, Allott T, Evans M, Joosten H, Stoneman R (2016) Peatland restoration and ecosystem services: an introduction. Peatland restoration and ecosystem services: science, policy and practice. Cambridge University Press/British Ecological Society, Cambridge, 1–16

BRG (2019a) Panduan & Publikasi – Badan Restorasi Gambut. https://brg.go.id/publikasi/

BRG (2019b) S.I.P.A.L.A.G.A. http://sipalaga.brg.go.id/

BRG (2019c) Karhutla 2019 Hanguskan 86 Ribu Hektare Lahan Gambut. Republika Online. https://republika.co.id/share/pyr15s370

Budiman I (2019) Mengapa Kebakaran Hutan dan Lahan Masih Sering Terjadi Meski Sudah Restorasi? Halaman 3—*Nationalgeographic.grid.id*. https://nationalgeographic.grid.id/read/131858570/mengapa-kebakaran-hutan-dan-lahan-masih-sering-terjadi-meski-sudah-restorasi?page=3

Budiman I (2020) Risk governance on peatland management in South Sumatra (In press). WRI

Budiman I, Januar R, Daeli W, Hapsari D (2020) Designing the special pilot economic zone on peatlands. J Geografi Lingkungan Tropik 1(1)

Budiman I, Sari EN, Hadi EE, Siahaan H, Januar R, Hapsari RD (2020) Progress of paludiculture projects in supporting peatland ecosystem restoration in Indonesia. Global Ecol Conserv 23, e01084

Budiman I, Sari EN, Januar R, Bastoni B (2020) Can compromised paludiculture manage its trade-offs for peatland restoration? in press

Budiman I, Smits M (2020) How do configuration shifts in fragmented energy governance affect policy output? A case study of changing biogas regimes in Indonesia. Sustainability 12(4):1358. https://doi.org/10.3390/su12041358

Cattau ME, Marlier ME, DeFries R (2016) Effectiveness of roundtable on sustainable palm oil (RSPO) for reducing fires on oil palm concessions in Indonesia from 2012 to 2015. Environ Res Lett 11:10 105007. https://doi.org/10.1088/1748-9326/11/10/105007

Center NCP (2020) NOAA's climate prediction Center. https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

Daeli W (2020) Land-use change and cultural transformation in indigenous villages in Riau, Indonesia. In: Land and poverty conference 2020—ConfTool Pro—BrowseSessions. https://

www.conftool.com/landandpoverty2020/index.php?page=browseSessions&form_session=1037
Earth Innovation (n.d.) Central Kalimantan. Earth innovation Institute. Retrieved 21 June 2019, from https://earthinnovation.org/our-work/regional-initiatives/indonesia/central-kalimantan/
Eco-Business (2019a) Hazy figures cloud Indonesia's peat restoration as fire season nears. Eco-Business. http://www.eco-business.com/news/hazy-figures-cloud-indonesias-peat-restoration-as-fire-season-nears/
Eco-Business (2019b) Perpetual haze? Sustained pressure on peatlands will mean no end to Indonesia's forest fires, warns report. Eco-Business. http://www.eco-business.com/news/perpetual-haze-sustained-pressure-on-peatlands-will-mean-no-end-to-indonesias-forest-fires-warns-report/
Elisabeth A (2018) Puluhan Ribu Hektar Gambut dan Hutan Alam Papua Lepas untuk Kebun Sawit. Mongabay Environmental News. https://www.mongabay.co.id/2018/09/07/puluhan-ribu-hektar-gambut-dan-hutan-alam-papua-lepas-untuk-kebun-sawit/
Enrici A, Hubacek K (2016) Business as usual in Indonesia: governance factors effecting the acceleration of the deforestation rate after the introduction of REDD+. Energy Ecol Environ 1(4):183–196
Evans CD, Williamson JM, Kacaribu F, Irawan D, Suardiwerianto Y, Hidayat MF, Laurén A, Page SE (2019) Rates and spatial variability of peat subsidence in Acacia plantation and forest landscapes in Sumatra, Indonesia. Geoderma 338:410–421. https://doi.org/10.1016/j.geoderma.2018.12.028
Field RD, van der Werf GR, Fanin T, Fetzer EJ, Fuller R, Jethva H, Levy R, Livesey NJ, Luo M, Torres O, Worden HM (2016) Indonesian fire activity and smoke pollution in 2015 show persistent nonlinear sensitivity to El Niño-induced drought. Proc Natl Acad Sci 113(33):9204–9209. https://doi.org/10.1073/pnas.1524888113
Giesen W, MacDonald EM (2018) Tropical peatland restoration report: the Indonesian case
Giesen W, Sari EN (2018) Tropical Peatland restoration report: The Indonesian case (p. 82 pp.). Berbak green prosperity partnership/Kemitraan Kesejatheraan Hijau (Kehijau Berbak). Millennium challenge account Indonesia. Contract No. 2015/Grant/010. Euroconsult Mott MacDonald in association with Universitas Jambi, Mitra Aksi Foundation, Perkumpulan Gita Buana and Perkumpulan Walestra
Giglio L, Boschetti L, Roy DP, Humber ML, Justice CO (2018) The collection 6 MODIS burned area mapping algorithm and product. Remote Sens Environ 217:72–85. https://doi.org/10.1016/j.rse.2018.08.005
Goldstein JE (2016) Knowing the subterranean: land grabbing, oil palm, and divergent expertise in Indonesia's peat soil. Environ Plann Econ Space 48(4):754–770. https://doi.org/10.1177/0308518X15599787
González E, Rochefort L, Boudreau S, Poulin M (2014) Combining indicator species and key environmental and management factors to predict restoration success of degraded ecosystems. Ecol Ind 46:156–166
Granderson AA (2014) Making sense of climate change risks and responses at the community level: a cultural-political lens. Clim Risk Manag 3:55–64
Havard M (2009) Environmental politics and power in Indonesia. Equinox Pub.
Helindro G (2019) BRG Hanya Supervisi Restorasi Gambut Perkebunan, Kapan Giliran HTI? Betahita. http://betahita.id/2019/11/25/brg-supervisi-restorasi-gambut-di-perusahaan-hti/
Holden J, Wallage ZE, Lane SN, McDonald AT (2011) Water table dynamics in undisturbed, drained and restored blanket peat. J Hydrol 402(1):103–114. https://doi.org/10.1016/j.jhydrol.2011.03.010
Hoscilo A, Page SE, Tansey KJ, Rieley JO (2011) Effect of repeated fires on land-cover change on peatland in southern Central Kalimantan, Indonesia, from 1973 to 2005. Int J Wildland Fire 20(4):578–588
Huijnen V, Wooster MJ, Kaiser JW, Gaveau DL, Flemming J, Parrington M, Inness A, Murdiyarso D, Main B, van Weele M (2016) Fire carbon emissions over maritime southeast Asia in 2015 largest since 1997. Sci Rep 6:26886

Hyde KF (2000) Recognising deductive processes in qualitative research. J Cetacean Res Manag 3(2):82–90

IUCN W (2014) A guide to the restoration opportunities assessment methodology (ROAM): assessing forest landscape restoration opportunities at the national or sub-national level. Road-Test Ed. 125pp.

Januar R (2020) All for one: evaluating multi-stakeholder synergetic condition toward peat ecosystem resilience in Central Kalimantan, Indonesia. https://www.conftool.com/landandpoverty2020/index.php?page=browseSessions&ismobile=true&form_session=772

Jauhiainen J, Hooijer A, Page SE (2012) Carbon dioxide emissions from an Acacia plantation on peatland in Sumatra, Indonesia. Biogeosciences

Kartodihardjo H, Mardiana R, Yulian BE, Soetarto E, Baskoro BC (2018) Analisis dan strategi penguatan kebijakan pengelolaan gambut. Tim PSA IPB

KLHK (2019) Perlindungan dan pengelolaan ekosistem gambut _Di provinsi sumatera selatan

KLHK (2020) Karhutla monitoring system (Map). http://sipongi.menlhk.go.id/home/main

Koh LP, Miettinen J, Liew SC, Ghazoul J (2011) Remotely sensed evidence of tropical peatland conversion to oil palm. Proc Natl Acad Sci 108(12):5127–5132. https://doi.org/10.1073/pnas.1018776108

Kompas (2020) Lambat, Restorasi Lahan Gambut. Kompas.Id. https://kompas.id/baca/nusantara/2020/03/16/lambat-restorasi-lahan-gambut/

kompas.id (2019) Restorasi Berbasis Kesatuan Hidrologis Gambut Dikaji. Kompas.id. https://kompas.id/baca/utama/2019/09/14/brg-mulai-kaji-restorasi-berbasis-khg/

Kontan G (2019) Peneliti sebut perlu waktu lebih dari sedekade untuk melihat hasil restorasi gambut. kontan.co.id. http://nasional.kontan.co.id/news/peneliti-sebut-perlu-waktu-lebih-dari-sedekade-untuk-melihat-hasil-restorasi-gambut

Kurniawan H (2017) Deretan hasil kerja Badan Restorasi Gambut tahun 2017. Merdeka.Com. https://www.merdeka.com/uang/deretan-hasil-kerja-badan-restorasi-gambut-tahun-2017.html

Lake S, Rosenbarger A, Winchester C (2016) Palm risk assessment methodology: prioritizing areas, landscapes, and mills. World Resources Institute, Washington

LAPAN (2015) Luas lahan terbakar 1 Juli-20 Oktober 2015

Liputan6 (2019) Badan Restorasi Gambut: Pelaku Kebakaran Hutan Bakal Terungkap saat Musim Hujan—News Liputan6.com. https://www.liputan6.com/news/read/4062486/badan-restorasi-gambut-pelaku-kebakaran-hutan-bakal-terungkap-saat-musim-hujan

Martin E, Winarno B (2010) Peran Parapihak dalam Pemanfaatan Lahan Gambut; Studi Kasus di Kabupaten Ogan Komering Ilir Sumatera Selatan. Jurnal Analisis Kebijakan Kehutanan 7(2):81–95

Medrilzam M, Dargusch P, Herbohn J, Smith C (2014) The socio-ecological drivers of forest degradation in part of the tropical peatlands of Central Kalimantan, Indonesia. For Int J Forest Res 87(2):335–345. https://doi.org/10.1093/forestry/cpt033

MI, mediaindonesia com (2019a) Pemulihan Ekosistem Gambut Capai 3,8 Juta Hektare. https://mediaindonesia.com/read/detail/213593-pemulihan-ekosistem-gambut-capai-38-juta-hektare

MI, mediaindonesia com (2019b) Ekosistem Gambut di Kalsel Semakin Terancam. https://mediaindonesia.com/read/detail/239974-ekosistem-gambut-di-kalsel-semakin-terancam

Mirmanto E, Polosakan R, Simbolon H (2000) Ekologi hutan gambut ditaman nasional tanjung puting kalimantan tengah. Berita Biologi 5(3):331–338

Noor YR (2007) Pengelolaan lahan gambut berbasis masyarakat di Indonesia. Wetlands International, Indonesia Programme

Normile D, Pm 5:00 (2019) Indonesia's fires are bad, but new measures prevented them from becoming worse. Science|AAAS. https://www.sciencemag.org/news/2019/10/indonesias-fires-are-bad-new-measures-prevented-them-becoming-worse

Nugraha I (2020) Empat Tahun BRG: Daya dan Upaya Pulihkan Gambut Negeri. Mongabay Environmental News. https://www.mongabay.co.id/2020/01/28/empat-tahun-brg-daya-dan-upaya-pulihkan-gambut-negeri/

Nurhidayati N, Hafizianor H, Muhammad M, Fauzi H (2016) Perubahan Sosial Masyarakat Di Perdesaan Hutan Rawa Gambut (Kajian Alih Guna Hutan Rawa Gambut Menjadi Perkebunan Kelapa Sawit di Kecamatan Marabahan Kabupaten Barito Kuala). EnviroScienteae 12(3):256–266

Ostrom E (2005) Self-governance and forest resources. Terracotta reader: a market approach to the environment, 12

Ostrom E, Chang C, Pennington M, Tarko V (2012) The future of the commons—beyond market failure and government regulation (SSRN Scholarly Paper ID 2267381). Social Science Research Network. https://papers.ssrn.com/abstract=2267381

Page SE, Siegert F, Rieley JO, Boehm H-DV, Jaya A, Limin S (2002) The amount of carbon released from peat and forest fires in Indonesia during 1997. Nature 420(6911):61

Pantau Gambut (2019) Asap Riau, Ulah Siapa? |Publikasi. Pantau Gambut. https://www.pantaugambut.id/publikasi/asap-riau-ulah-siapa-

Post TJ (2018) BRG boosts peatland restoration in 2018. The Jakarta Post. https://www.thejakartapost.com/news/2018/12/29/brg-boosts-peatland-restoration-2018.html

Poteete AR, Janssen MA, Ostrom E (2010) Working together: collective action, the commons, and multiple methods in practice. Princeton University Press

PRIMS (2019) Peatland restoration information and monitoring system. Sosialisasi RTT 2019 Sumsel

PRIMS (2020) Restorasi gambut. BRG. http://prims.brg.go.id/dasbor

Purnawan EI, Damanik RDE, Perkasa P (n.d.) Tabat sebagai usaha bersama masyarakat dalam upaya pencegah degradasi lahan gambut di taman nasional sebangau, kalimantan tengah

Purnomo H, Shantiko B, Sitorus S, Gunawan H, Achdiawan R, Kartodihardjo H, Dewayani AA (2017) Fire economy and actor network of forest and land fires in Indonesia. Forest Policy Econ 78:21–31. https://doi.org/10.1016/j.forpol.2017.01.001

Putra EI (2010) Recent peat fire trend in the Mega Rice Project (MRP) area in Central Kalimantan, Indonesia. PhD Thesis

Renn O (2017) Risk governance: coping with uncertainty in a complex world. Routledge

Ritzema H, Limin S, Kusin K, Jauhiainen J, Wösten H (2014) Canal blocking strategies for hydrological restoration of degraded tropical peatlands in Central Kalimantan, Indonesia. CATENA 114:11–20

Ritzema HP, Hassan AMM, Moens RP (1998) A new approach to water management of tropical peatlands: a case study from Malaysia. Irrig Drain Syst 12(2):123–139

Rossita A, Witono A, Darusman T, Lestari DP, Risdiyanto I (2018) Water table depth fluctuations during ENSO phenomenon on different tropical peat swamp forest land covers in Katingan, Indonesia. In: IOP conference series: earth and environmental science, 129, 012001

Sari EN (2020) Gambut Itu Harus Basah: Mongabay.co.id. https://www.mongabay.co.id/2020/01/30/gambut-itu-harus-basah/

Simon GL, Dooling S (2013) Flame and fortune in California: the material and political dimensions of vulnerability. Glob Environ Chang 23(6):1410–1423. https://doi.org/10.1016/j.gloenvcha.2013.08.008

Singer B (2009) Indonesian forest-related policies. A multi-sectoral policies overview of public policies in Indonesia's Forest since
Stoker G (1998) Governance as theory: five propositions. Int Soc Sci J 50(155):17–28. https://doi.org/10.1111/1468-2451.00106
Sumarga E, Hein L, Hooijer A, Vernimmen R (2016) Hydrological and economic effects of oil palm cultivation in Indonesian peatlands. Ecol Soc 21(2)
Swails E, Yang X, Asefi S, Hergoualc'h K, Verchot LV, McRoberts RE, Lawrence D (2019) Linking soil respiration and water table depth in tropical peatlands with remotely sensed changes in water storage from the gravity recovery and climate experiment. CIFOR. https://doi.org/10.1007/s11027-018-9822-z
Swindles GT, Green SM, Brown L, Holden J, Raby CL, Turner TE, Smart R, Peacock M, Baird AJ (2016) Evaluating the use of dominant microbial consumers (*Testate amoebae*) as indicators of blanket peatland restoration. Ecol Ind 69:318–330
Tacconi L (2003) Kebakaran hutan di Indonesia: Penyebab, biaya dan implikasi kebijakan. CIFOR, Bogor, Indonesia
Tan AK-J (2015) The'Haze'Crisis in Southeast Asia: assessing Singapore's transboundary haze pollution act 2014. NUS-Centre for Asian Legal Studies Working Paper, 15/02
Tan KT, Lee KT, Mohamed AR, Bhatia S (2009) Palm oil: addressing issues and towards sustainable development. Renew Sustain Energy Rev 13(2):420–427
Tan-Soo J-S, Pattanayak S (2016) Health irreversibility from early-life exposure to air pollution: evidence from Indonesian longitudinal survey. Working paper, Nicholas School of the Environment, Duke University
Turetsky MR, Benscoter B, Page S, Rein G, van der Werf GR, Watts A (2015) Global vulnerability of peatlands to fire and carbon loss. Nat Geosci 8(1):11–14. https://doi.org/10.1038/ngeo2325
UMD. (2020). *Burned scar on peatlands* [Map]. http://modis-fire.umd.edu/ba.html.
UNISDR (2015) Sendai framework for disaster risk reduction 2015—2030. 37
van der Meer PJ, Ibie BF (2009) Forestry and the EMRP. Project report for master plan for the conservation and development of the ex-mega rice project area in Central Kalimantan. Euroconsult Mott MacDermott
Van der Werf GR, Morton DC, DeFries RS, Olivier JG, Kasibhatla PS, Jackson RB, Collatz GJ, Randerson JT (2009) CO 2 emissions from forest loss. Nat Geosci 2(11):737
Walker WE, Harremoës P, Rotmans J, Van Der Sluijs JP, Van Asselt MB, Janssen P, Krayer von Krauss MP (2003) Defining uncertainty: a conceptual basis for uncertainty management in model-based decision support. Integr Assess 4(1):5–17
World Bank (2020) An economic analysis of the 2019 forest and land fires and haze. http://documents.worldbank.org/curated/en/622281575920970133/pdf/Indonesia-Economic-Quarterly-Investing-in-People.pdf

Ibnu Budiman was a research fellow at World Resources Institute (WRI) and international consulting firms Sustainability and Resilience (Su-re.co) in partnerships with Stockholm Environmental Institute and other research institutions, advising international public authorities, such as EU, ADB, JICA, and UN agencies. He has been working as a researcher and consultant in the field of environmental management and sustainable development, and works on themes of climate actions, renewable energy, agriculture, and land use. Ibnu holds master degree (M.Sc.) majoring in environmental sciences from Wageningen University, and is currently a Ph.D. candidate at the same university.

Rizky Januar is currently a research analyst at the World Resources Institute (WRI); where he has been leading and contributing on various research projects, including: peatland restoration; social forestry and deforestation; coastal ecosystem management and accounting; and economic analysis and planning; as well as environment and sustainable development. Prior to joining WRI, he joined the Innovation and Competitiveness advisory team at the Ministry of Education and Culture

of Indonesia. Rizky holds an M.Sc. in Engineering and Policy Analysis from Delft University of Technology, with a thesis on system dynamics modelling on food-energy-water nexus in The Netherlands.

Desti Ayunda is currently GIS Assistant in in the World Resources Institute (WRI) Indonesia under Peatland Restoration Information and Monitoring System (PRIMS) project. She holds B.Sc. on Geodesy and Geomatics Engineering from Bandung Institute of Technology (ITB). Her undergraduate thesis focused on L-Band SAR data utilization to identify peatland. Prior joining WRI Indonesia, she worked as Spatial Data Analyst in Ministry of Marine Affairs and Fisheries where she involved in coastal disaster mitigation program, particularly coastal abrasion.

Satrio Wicaksono is currently works as Forest and Land Use Governance Expert at European Forest Institute's EU REDD Facility. Previously, Satrio worked on forest and ocean issues at World Resources Institute (WRI) Indonesia, where he managed projects and conducted research on forest and landscape restoration, social forestry, and sustainable ocean and coastal ecosystems. Satrio received a PhD in Climate Science from Institute for the Environment and Society at Brown University, Rhode Island, USA. He holds master degree from Wesleyan University in Connecticut, USA, majoring in earth and environmental sciences; and concentrate in environmental and international relations.

Eli N. N. Sari Eli is currently work as Peatland Restoration Technical Expert and conducting research on peatland issues towards sustainable peatland management, particularly in Southeast Asia. She has 15 years of working experience in peatland-related issue policies, peatland-related climate change mitigation and adaptation, liaising with the international and Indonesian scientific community and catalysing research effort to address the policy needs. She obtained her master's degree from the Faculty of Agriculture at Hokkaido University, Japan, and received her Ph.D. degree from the Graduate School of Environmental Science at Hokkaido University.

Dean Affandi holds a Ph.D. in Human Geography from Monash University where he did his thesis on indigenous group claim for control and access over forestlands in Indonesia. He is responsible in overseeing research activities across programs in WRI Indonesia. His research interest is on political ecology that studies the nexus between the state, environment, and society. He specializes in understanding the role of indigenous people and local communities in managing natural resources, and their impacts to nature in general. Other than his work in WRI, he is also actively teaching in the University of Indonesia on the Faculty of Social and Political Sciences.