01

Health and Haze

A SCIENCE-DRIVEN POLICY APPROACH TO SOUTHEAST ASIA'S ANNUAL OCCURRENCE

This anthology is a project of the Planetary Health Alliance (planetaryhealthalliance.org). The Planetary Health Alliance is a consortium of over 200 partners from around the world committed to understanding and addressing the human health impacts of global environmental change.

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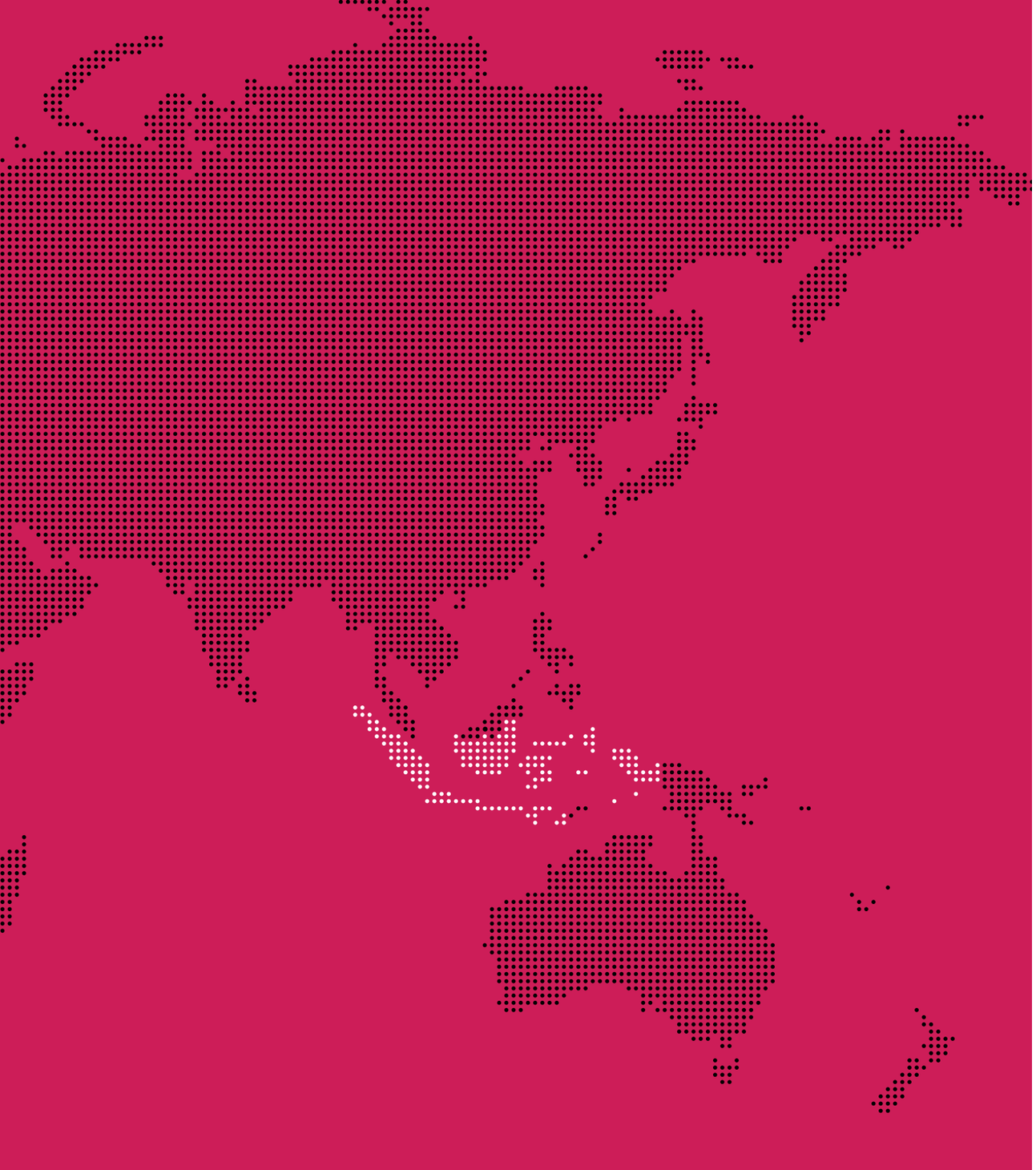


Executive Summary

Themes from this case study are explored in greater detail in the land use section of chapter 4 and the non-communicable disease chapter 7 as well as the discussion of air pollution in the energy chapter 12 of ↘ Planetary Health: Protecting Nature to Protect Ourselves.

Learning Objectives

After examining this case, students should be able to:

① Analyze the underlying driving forces of haze events.

② Appraise the short- and long-term health effects of haze events.

③ Explain the importance of multidisciplinary and multi-sectoral actions when facing planetary health challenges, specifically haze events prevention and peatland restoration.

④ Evaluate how determinants of health frameworks can guide problem analysis and the solution design process.

⑤ Apply principles of good governance, equity, and evidence-informed policy in the face of planetary health challenges.

This case study explores how an anthropogenic haze episode in September and October 2015 contributed to 100,300 excess premature cardiopulmonary disease-related deaths in Southeast Asia, with a focus on Indonesia, Singapore, and Malaysia. It will look at how historical and present-day land use and land cover change (LULCC) practices on peatland areas altered ecosystems and influenced the vulnerability and severity of the 2015 event.

The case study will also outline how the Indonesian government has addressed this issue: with the creation of new policies and the establishment of a government agency to manage and restore peatlands. Collaborating with groups across the country, as well as with international researchers, that government agency is using a multi-tiered approach to address the complex drivers that contribute to peatland fires. Included in that approach is the use of a new tool that allows policymakers to link land use scenarios, associated fire emissions, and long-term health consequences into the foreseeable future.

This case study is based on interviews conducted in Jakarta and communities across Central Kalimantan in August 2018.

On this humid day in August 2018, the *Badan Restorasi Gambut* (BRG) office in Central Jakarta is buzzing with activity. If the BRG (the Peatland Restoration Agency in English), had a busy season, this would be it. August is the mid-way point in Indonesia's dry season, a period that stretches from June to October each year. With those months comes a history of haze—the dense air pollution that drifts over much of Indonesia and other Southeast Asian countries as a result of smoldering, human-caused peatland fires.

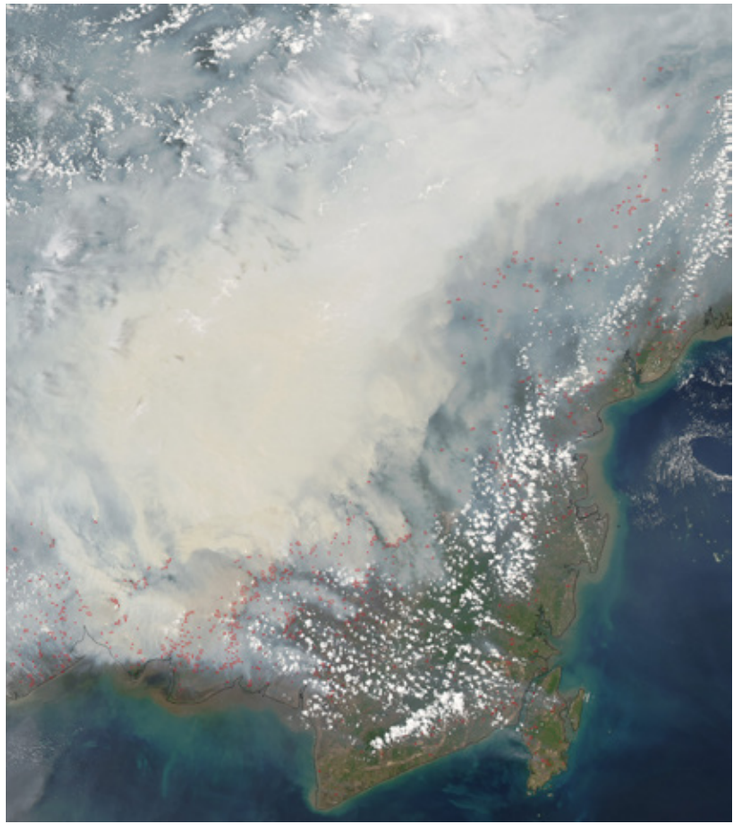
BRG's mission is to reduce haze by facilitating the restoration of more than 20,000 square kilometers of peatland. They also coordinate the sustainable management of those ecosystems with many levels of government, organizations, and communities across Indonesia.

Today, that mission is still a work in progress. A newspaper headline announces the number of hot spot fire areas in Central Kalimantan, one of Indonesia's most fire-prone provinces. Along the capital city's notoriously traffic clogged streets, every other person riding an *ojek* motorbike taxi has their face covered by a mask. While caused by vehicle pollution rather than peatland fires, today's hazy scene is a small glimpse into what thousands in the country face year-after-year. In both cases, face masks offer inadequate protection.

A family riding a motorcycle through the thick air and smoke from peat fires in October 2015. Outside Palangka Raya, Central Kalimantan. Photo by Aulia Erlangga, CIFOR; cifor.org

Hanging in the BRG office is a photo of President Joko Widodo, Indonesia's leader since 2014. President Jokowi, as he's commonly referred, established the BRG as his first presidential decree of 2016, and the agency is overseen by his office. Its establishment was a bold statement marking the political seriousness with which the issue is now regarded—and the international pressure that urged its creation.

In 2015, that international pressure was intense. Photos of Indonesia's red-and-yellow tinged skies captured headlines worldwide. "Southeast Asia, Choking on Haze, Struggles for a Solution," proclaimed *The New York Times*. "Indonesia's fires labelled a 'crime against humanity' as 500,000 suffer," declared *The Guardian*. Images captured by NASA satellites show a dense cloud of smoke blanketing the region during September and October 2015,[1] the period in which 68% of all active fires were detected.[2]



Dense clouds of smoke seen over the island of Borneo in September 2015. Photo via NASA Earth Observatory.

What is striking about these satellite images is that the smoke hangs heaviest not over the burning areas, but those regions downwind in Indonesia and, to a lesser extent, in neighboring countries. In Malaysia, Members of Parliament called for the government to adopt regulations that could be used to take legal action against companies responsible for creating the haze[3] —similar regulations had already been passed in Singapore. Indonesia's environmental crisis was the plight of the region and the talk of the world.

This was the media and political climate that surrounded President Jokowi in December 2015 as he attended the United Nations Climate Change Conference, COP21, in Paris. The fires of the previous three months were finally being extinguished by monsoon season downpours, but not before they had scorched through 26,000 square kilometers of Indonesian land. The cause had already been identified: human-triggered fires set as an inexpensive way to clear land for agriculture. A 2015 World Bank report laid out the short-term impacts of the event: the haze had forced weeks of school closures, grounded airplanes, and caused thousands to fall sick across the region.[4] Early estimates placed the initial economic cost of that year's haze at US $16 billion[i] —twice the amount that it took the country to clean-up the devastating 2004 tsunami.[5] This estimate does not account for the long-term health costs of sustained haze exposure nor the loss of biodiversity and ecosystem services.

"The creation of BRG was the response of the president to stop and prevent fire, haze, and further peatland degradation. It was also because of the international concerns to the republic," says Pak Budi Wardhana, the agency's Deputy Head of Planning and Coordination. "During the Paris COP21 [in December 2015], the President made a commitment to the international community that Indonesia will take every measure, and will set up an agency that focuses on peatland restoration. That was the seed of establishing the BRG."

The need for peatland restoration became more apparent the following year. Research published by Harvard and Columbia University researchers linked the haze exposure in September and October 2015 to 100,300 excess deaths in Indonesia and neighboring countries of Malaysia and Singapore.[6][ii] That research was conducted by a multidisciplinary group of scientists, medical professionals, and policymakers who called themselves The SMOKE Team.

[i] A detailed breakdown of this estimate is included in the full World Bank report (see above). It includes losses of US $399 million in the tourism sector, US $372 million in the transportation sector (including shipping), and US $151 million in immediate health costs. Overall, the costs represented 1.9% of Indonesia's 2015 Gross Domestic Product.

[ii] How are excess deaths calculated? Why is this measure useful? ↘ Learn more here

Pak Budi is the Deputy Head of Planning and Coordination with Badan Restorasi Gambut (BRG), Indonesia's Peatland Restoration Agency. That agency was created in response to 2015's transboundary haze event.

Using their diverse backgrounds, the team more recently combined fire emissions inventories, satellite monitoring, chemical transport models, and epidemiological data. The result was a framework to determine which peatland areas should be prioritized for management in order to prevent the greatest number of downwind health effects in the future. Another takeaway was that preventing haze-related deaths demanded more than a reactionary response. The team concluded that an effective long-term solution would require shifts in land use management in order to target the root cause of the haze.

This long-term view of prevention and mitigation resonates with the BRG. "The World Bank study only covered five months of the disaster. It wasn't really looking into the long-term effect of the health problems," says Pak Budi of the 2015 report. "Those health effects will add more cost to the government, so with [the SMOKE Team's studies] we can provide the government with a compelling argument that the sustainable management of peatlands is much more important, rather than just restoring it."

Addressing the causes of the 2015 haze event demanded Indonesia take a dive into its long history of fires. While the public health toll of the 2015 dry season was the first to be carefully quantified, similar episodes have been occurring for decades.

The waterlogged appearance of a healthy peatland forest in Central Kalimantan. Photo by Nanang Sujana, CIFOR; cifor.org

Southeast Asia and a History of Haze

With a land area of 1.9 million square kilometers, the Republic of Indonesia is the largest country in Southeast Asia. It's the fourth most populous country in the world, and its 264 million inhabitants live across a sprawling archipelago of more than 17,000 islands.

Seasonal haze is an annual problem in Indonesia and across the region, although severity varies from year to year. So common is the issue that it's looked at as an inevitable event expected every year around the dry season. The past two decades alone have provided plenty of cause for concern, with severe fires in 1997-98, 2006, and 2013 making headlines long before the events that transpired in 2015. Fire activity has historically been most severe on the islands of Sumatra and Kalimantan, the Indonesian portion of Borneo island. Fires that burned through the Indonesian and Malaysian Borneo in 1982-83 remain the largest on record, with 50,000 square kilometers scorched.[7][iii] Primary, logged, and secondary forests contributed to more than half of the total area burned in these years.[8]

[iii] Roughly the size of Costa Rica, or Alabama. As reference, the Amazon fires of 2019 burned around 10,000 square kilometers

Experts say the government response to these fires has historically been underwhelming. "When the cases happen then the government is very busy and concerned about this situation, but after the haze passes then it's business as usual," says Dr. Budi Haryanto, an environmental epidemiologist at the University of Indonesia's Research Center for Climate Change. "The Indonesian government was in denial when the [2015 SMOKE Team] study came out, but for me, I believed it because I have been looking at the health findings associated with haze and air pollutants for many years."

While the miniscule particles that cause haze can be generated by coal burning factory emissions, traffic pollution, and road dust, the haze events that so frequently occur in Southeast Asia are produced by vast, human-triggered fires. What made the 2015 fires so harmful to public health was not only that a large area burned—but the length of time that the fires smoldered, and the material that was set ablaze: peat.

Peatlands: The World's Carbon Bank

Peatlands are a wetland ecosystem created when trees and other organic matter have partially decomposed in a water-logged, oxygen-poor environment.[iv] The result is a thick layer of wet, organic material, ranging from half a meter to 20 meters in depth.[9] Having existed on our planet for around 360 million years, the oldest peatlands store carbon captured thousands of years ago.[10] ↘ *Watch: An introduction to peatland ecosystems video from the BRG*

[iv] Are there peatlands in your country of origin? Are they protected or sustainably managed? What policies surround these ecosystems in your country?

Despite covering just 3% of the Earth's surface,[11] peatlands store more carbon than all other ecosystems combined.[v] The majority is stored in tropical peatlands, most of which are found in Indonesia and Southeast Asia.[12]

[v] What other ecosystems store large amount of carbon compared to their total surface? ↘ Find out here

Peatlands store carbon through a process called carbon sequestration. Rather than allowing decaying vegetation to release carbon into the atmosphere, peatlands contain and hold this carbon over the long-term, reducing the amount of carbon dioxide (CO^2) circulating in the atmosphere. The release of CO^2 into the atmosphere is the main contributor to climate change. This can happen from the combustion of fossil fuels, and also through the burning of carbon rich ecosystems such as peatlands.[vi]

[vi] Which countries emit more net total carbon dioxide and other greenhouse gases? How about per capita emissions? What is surprising about this data? ↘ Find out more here

The Issues Beyond Burning

Burning peatlands emit large amounts of carbon dioxide (CO2). But even non-burning peatlands emit CO2 through a process called oxidation. Peatland oxidation happens when dried peatland is exposed to the sun, releasing the carbon that's been previously sequestered in the form of CO2.

Oxidation will continue unless peatlands are rewetted to ground surface level, says Marcel Silvius, a peatlands expert with the Global Green Growth Institute in Indonesia. Current regulation classifies peatlands as rewetted when the water table sits no more than 40 centimeters below ground surface level.

Paired with the issue of oxidation is the risk that comes when peatlands subside—organic matter that had been previously propped up by natural water levels sinks once that water has been drained. Peatland subsidence is a significant issue in the Netherlands, Silvius' home country, where water has been pumped from the peatlands for several centuries to allow for continued agricultural development. "Half of the Netherlands lies below sea level as a result of the oxidation of peatlands over the centuries," says Silvius. In 2016, the country's Environmental Assessment Agency found that the continued subsidence of peatlands in the Netherlands will cost taxpayers between €1.7 billion and €5.2 billion from the date of publishing until 2050.[13]

"In the Netherlands, dykes have been built along the coast and the rivers, and we let farmers continue their unsustainable business even though it costs society huge amounts of money," expands Silvius. "[One hundred thousand square kilometers] of peatland in Indonesia is going to face the same problem and subside. In the Netherlands, the rate of subsidence is 1-2 centimeters a year. It happens much faster in tropical locations, at a rate of 3-6 centimeters annually." The long-term risk, Silvius says, is when the ground level subsides to sea-water level: "Indonesia would have to build thousands of kilometers of coastal and river dykes to prevent flooding and keep that land arable and livable. It's an issue of huge financial, economic, and social proportions."

An area of peatland near the Trans-Kalimantan Highway in Central Kalimantan—this area was scorched during the 2015 fires.

While providing valuable ecosystem services like carbon sequestration, water storage and regulation, habitat for biodiversity, and nutrient cycling,[14] tropical peatlands have experienced decades of land use and land cover change (LULCC). This is especially true in Sumatra, Kalimantan,[vii] and Papua, the three Indonesian islands with the greatest peatland area.[15] Human activity on Indonesia's peatlands began in the 1980s, with extensive land conversion by large-scale concessions and small-holder farmers leading to deforestation[viii] and peatland degradation. Between 1990 and 2015, Sumatra, Borneo, and Peninsular Malaysia experienced a 47% decline in peat swamp forest area.[ix] There was a growing demand for arable land and the flat topography of peatlands made them an easy target for production.[16] As of 2015, industrial plantations and small-holder farms cover half of all former peatland areas in Sumatra, Borneo, and Peninsular Malaysia.[17]

[vii] Kalimantan is the name for the Indonesian portion of Borneo island. Borneo is shared by three countries, including Malaysia (an area known as the Malaysian Borneo) and Brunei.

[viii] Another case study in this anthology focuses on deforestation and illegal logging in Kalimantan, with a focus on the lowland rainforest around Gunung Palung National Park in West Kalimantan.

[ix] Peatlands that have not been drained and deforested.

Water-logged peatlands must be drained in order to be used for farming—an act that dramatically increases the land's susceptibility to fire.[18] Draining is most easily done by digging a series of deep canals beneath the peatland. Once drained, remaining peatland vegetation is cleared by setting fires—the fastest and most cost effective way to prepare land for new growth. This method is referred to as slash and burn agriculture. The ash cover that settles after burning provides a nutrient-rich layer for new crops which offers short-term benefits for farmers.[19] Those nutrients, however, are short-lasting, and slash and burn agriculture leads to detrimental long-term effects, including soil degradation, loss of habitat, soil erosion, water contamination, and, in the case of peatlands, deadly haze. Slash and burn is the traditional method used by Indonesian farmers annually to prepare their land for the approaching rainy season. While these slash and burn fires are deliberate and their area planned, blazes can sometimes burn out of control, and "escape fires" create damage on neighboring land.[x]

[x] Is slash and burn used in your country? Are there sustainable ways of doing slash and burn? Why or why not? Are there policies in your country in this regard?

In their natural state, peatlands are moist and non-flammable. Once drained, however, they become tinderboxes of organic material. Fires that spread from slash and burn sites to areas of surrounding dried peat become virtually impossible to extinguish. As they burn, centuries worth of CO_2 and other greenhouse gas emissions are released into the atmosphere—10 times more CO_2 than the amount released by forest fires.[20] The depth of peatlands means that while fire crews can tame surface-level fires, the thick carpet beneath can continue to smolder for weeks until monsoon rains finally dampen the blaze. The effect is eerie: tracts of land where you see no fire, only the huge clouds of smoke that billow from within.

The contrast between an area of burnt peatland (left) and regrown peatland (right). Though a valuable carbon bank, peatlands are often perceived as wasted space and are cleared and drained to make way for more "productive" activities.

This was the scene in much of Indonesia during the 2015 haze event.

In Gohong Village, Central Kalimantan province, village secretary Pak Anang Sogito remembers not being able to see beyond two meters. If he had been able to see, he would have witnessed devastation—village records say the 2015 fires burned through more than 150 square kilometers of land. "We lost our sources of food and our economy was totally damaged. The income decreased for all of the villagers," Pak Anang says.

At the time, the residents of Gohong Village took the only action they could: they attempted to extinguish the fires using traditional methods. Those methods involved isolating fire areas by digging four-meter-deep wells into the ground to limit their spread, just as firefighters may clear cut part of a forest to prevent the growth of a wildfire. This method worked to contain some blazes, but many more times the depth of peat meant fires would spread unseen beneath the surface. "We all fought until we reached our limit, using big cans of water to make the peatland wet," Pak Anang describes. "But it didn't solve the problem because it was just the top of the peatland that was wet."

Gohong Village is located in Pulang Pisau, a priority area for the BRG. More than half of the region is peatland, and the regency was particularly affected by the 2015 fires. Draining of the peatlands in this area began in the 1980s when the government constructed the 3,900-kilometer Trans-Kalimantan Highway that runs across the island. The drainage canals that were built created transportation channels allowing villagers to reach once inaccessible parts of the island. As a result of this practicality, more canals were made, further drying peatlands. "At first it helped us reach new land, but after a lot of canals were built it affected us, especially during the long dry season," Pak Anang explains.

At a global scale, atmospheric scientists knew 2015 would be a problem. "Everyone who was paying attention to fires knew it was going to be a bad year by late July, August," says Dr. Shannon Koplitz, an atmospheric scientist on The SMOKE Team. For one thing, 2015's dry season followed a similar pattern to previous fire years. "We were watching that El Niño index creep up, and a positive Indian Ocean dipole index creep up, too. You could see it a mile away, and it became more of a question of what people on the ground were supposed to do with that information," says Koplitz. Both meteorological phenomena are associated with reduced dry season precipitation and exacerbate the risk of drought in landscapes that have become highly flammable because of human alteration.

When Meteorological Systems Meet

Two meteorological systems played a role in creating the ideal setting for 2015's haze events: the coupling of the El Niño Southern Oscillation (ENSO) phenomena and a positive Indian Ocean dipole.
El Niño conditions* occur in the Pacific Ocean basin, and mean less rain on the western side of the basin, including in Indonesia. The El Niño phenomenon in 2015 was the strongest on record since 1997.[21] These dry conditions increase the flammability of landscapes as plants lose their leaves and lower their moisture content.[22]

The Indian Ocean dipole operates in the ocean basin of the same name. Like the Pacific Ocean, the Indian Ocean has a variance in temperature, with warmer sea surface temperatures around Indonesia typically leading to more precipitation. A positive Indian Ocean dipole, like the one in 2015, brings less precipitation.

"When you have both of those systems operating in unison it is a double whammy for drought, and that's what happened in 2015, 2006, and 1997," says Koplitz. Scientists are still actively looking into how the ENSO and dipole systems interact with one another, as well as the effect climate change could have on these systems.

Unlike other places where fires are a natural part of the ecosystem, the ecology and climate of Indonesia rule out meteorological conditions alone as the cause of the 2015 fires. "In the humid tropics like Southeast Asia, fires don't generally occur unless there are people setting them," explains Dr. Ruth DeFries, an environmental geographer at Columbia University. A member of The SMOKE Team, DeFries has worked at the intersection of fire, deforestation, and air quality for the better part of three decades. In 2015, it was the combination of meteorological systems and individual and industrial land use that created the setting for a destructive fire season. By September and October 2015, the height of the year's burning season, the Global Fire Emissions Database[xi] had detected more than 100,000 active fires across Indonesia.[23]

*The Pacific Ocean is where the El Niño Southern Oscillation (ENSO) system occurs. The ENSO controls much of the year-to-year variability in the areas surrounding the Pacific Ocean, including precipitation patterns, winds, and storm systems. The Pacific Ocean basin has a variance in temperature, an in non-El Niño years, the eastern side of the basin is cooler than the western side. This is why the western United States experiences dryer weather, and countries in Southeast Asia experience more rain. During an El Niño system, that gradient in ocean temperature lessens, leading to less precipitation on the western side of the basin.

[xi] Check out real time data on global fire emissions ↘ here. What can you conclude from this map?

[xii] 15.95 mega tons is the U.S. daily average. The United States is the world's largest producer of greenhouse gas emissions.

[xiii] What is a GHG equivalency? Why is it useful? ↘ Explore more here

[xiv] Do you think your actions might be affecting the severity of haze events in Indonesia? Why or why not?

The Health Toll of Haze

The emissions produced by those fires was intense. For a three week stretch, Indonesia's peatland fires produced more daily CO_2 than the average daily emissions of the entire United States.[xii] By the end of the 2015 fire season, 4 teragrams (4 million tons) of emissions had been emitted between July and October.[24] After just a few months, Indonesia's CO_2 emissions were on par with the amount of fossil fuel-attributed emissions generated by countries like Japan and India over the course of an entire year.[25][xiii] More than three quarters of all emissions came from Kalimantan and South Sumatra, the islands most badly burned.[26]

While the impact on the global climate was concerning, more dire still were the serious health effects being faced by millions.[xiv]

It's a beautiful clear day in Palangka Raya, the capital city of Central Kalimantan province. The windows and front door are wide open on Pak Tuberyono's home, a very different sight from 2015. That year, he and his family were trying to make their house as airtight as possible to prevent haze from seeping in. "Where the wind could come in, the haze could also come in," Tuberyono remembers. The average Indonesian home is rarely airtight, and outside air and pollutants can waft in through gaps in floorboards and ventilation slots above windows.

The birth of Tuberyono's third grandchild, Ratu Agnesia, had aligned with the start of 2015's haze season. A healthy baby girl, Ratu Agnesia's life was cut devastatingly short when she developed an acute respiratory tract infection, an ailment the hospital confirms was caused by the haze. "It was very fast. It started with it being hard for her to breathe, then we asked for medicine from the midwife," Tuberyono recalls, staring out the window. "We brought her to the hospital but it wasn't long before she passed away." Ratu Agnesia was just 45-days-old.

Tuberyono and his family weren't the only ones who sought medical help during the 2015 haze. Indonesia-wide data found that the percent of children under five diagnosed with pneumonia during a hospital visit jumped from a baseline that had historically ranged from 23-29% to 63% that year.[27] Global data indicates that children under the age of five and adults over 60 are the groups most impacted by air pollution.[28][xv] Pollution-related mortality disproportionately occurs in low and middle income countries, of which Indonesia is one.[29]

[xv] Why are children most affected by haze?

According to the 2016 research published by The SMOKE Team, the 2015 haze accounted for 91,600 excess deaths in Indonesia. Neighboring countries of Malaysia and Singapore faced 6,500 and 2,200 excess deaths respectively. That's because haze is a transboundary environmental issue,[30] meaning the pollution is so thick and dense that its concentration downwind remains high enough to create health impacts. That includes in densely populated urban centers such as Singapore and Kuala Lumpur, Malaysia.

Ultimately, it was those living in close proximity to the peatland fires who experienced the worst health effects. That includes Pak Tuberyono and his 45-day-old granddaughter, and other people living in Central Kalimantan province. Dr. Mual Bobby had been working as a pulmonologist at RSUD Doris Sylvanus the largest state-run hospital in the province, for six years when the 2015 haze began. During a normal shift he would see around 100 patients, but in 2015 he was treating up to 500 a day. The hospital faced so much demand for treatment that it turned away patients for three weeks in September and October, admitting only those who would receive treatment while sitting on the floor.

Dr. Mual Bobby is a pulmonologist in Palangka Raya, Central Kalimantan. He would see as many as 500 patients a day during the haze events in September and October 2015 — sometimes treating people lying on the ward floor when all the beds were occupied.

"It was especially bad for people with asthma and elderly people with chronic obstructive pulmonary disease (COPD)," says Dr. Bobby. "Every day their lung function decreased, and this happened faster during the haze situation. They were in terrible condition. I was giving them the anti-inflammatory medication [for asthma and COPD] and oxygen but that didn't change their condition."

Like homes, hospital buildings in tropical climates are rarely airtight. Open architecture allows for natural ventilation, but in 2015 it meant the haze could drift in and hang above the wards where patients were being treated in the beds below.

It was a similar scene in the local *puskesmas* clinics, the community-health units that provide first-response primary care for outlying urban areas and rural villages in Indonesia. "We started from 8 a.m. and would usually end at 10:30 a.m., because our vision would be blurred if we worked earlier or later in the morning. I remember that breathing made us weak," says Dr. Yulitha Christiana, who worked in a *puskesmas* location at the edge of Palangka Raya. Dr. Christiana also saw patients in her home clinic. "Here I had oxygen available for patients. I blocked the door with a wet towel, but it

could still not free us from the haze," she recalls, adding that it was virtually impossible to find oxygen canisters in September and October. They were sold out across the city.

So bad was the haze that Stefani Koseanto and her mother left their home in Palangaka Raya for Jakarta. Prior to leaving, Koseanto had been going through a morning ritual: waking up in a day dark as night and posting photos on her Facebook page. Those photos included screenshots of the city's Pollutant Standards Index (PSI) and the color of the sky outside her window, shades that shifted from a sepia yellow to an alarming red. On many days the PSI was higher than 2,000. A healthy figure is 0-50, with anything beyond 301 considered hazardous.

Koseanto has asthma, and had been taking five times the normal dosage from her inhaler. Her father, a doctor in the city, eventually suggested she evacuate. "The air was so thick in my room. I used an air purifier but it didn't help," she said. Despite growing up in Palangka Raya, Koseanto had never seen haze so bad. "In the past it was white smoke, it wasn't a yellow and red sky, and it would only stay for a few days," Koseanto recalled.

For Pak Tuberyono and his ailing granddaughter, the scale of the haze made evacuation seem fruitless. "The smoke was all over the province and in the next province—where would we go? All the peatland was burning," he says. Turns out the question was moot. Tuberyono and his family wouldn't have been able to afford to leave even if they had wanted to.

The impact haze has on human health and well-being is a growing field of research. A 2016 review of epidemiological studies highlights the role automobile exhaust, haze from burning biomass, and wildfire smoke has in COPD risk and incidence. Both short-term and chronic exposure to haze cause respiratory symptoms, reduce lung function, and lead to the development of COPD.[31] Increased risk depends on a number of factors, including the chemical composition of the haze and the concentration to which people are exposed. In most cases, the fine particulate matter component of haze presents the gravest health concern.[xvi]

[xvi] What is the global burden of disease due to air pollution? Who is more affected? ↘ Read more, and check the status of the air you breathe on the State of Global Air here

A student goes to school wearing a mask to protect him from the smoke that blankets the city of Palangka Raya, Central Kalimantan. October 2015. Photo by Aulia Erlangga, CIFOR; cifor.org

Referred to as PM2.5 because particles are less than 2.5 micrometers (μm) in diameter, you could fit 20 fine particulate matter particles across the width of a single human hair. “PM2.5 in particular is a health concern because it’s so small it can go deep into our lungs,” explains Jonathan Buonocore, a Harvard University-based epidemiologist, environmental health expert, and member of the multidisciplinary SMOKE Team. From there it can cross the lung-blood barrier and get into the bloodstream. Samples taken from the September 2015 peatland fires in Indonesia found that 81.6% of all particulate matter was less than 2.5 μm in size. That size, combined with the chemicals that composed the particulate matter, made the episode particularly harmful to people’s health.[32] According to the WHO, fine particulate matter is the most harmful form of air pollutants, a broad category accounting for the anthropogenic chemicals generated by industry, transportation, and households.[33]

Peatland fires in Indonesia are particularly hazardous, emitting a cocktail of up to 90 chemicals, including toxic gases such as formaldehyde, carbon monoxide, and ammonia.[34] These chemicals are invisible to the naked eye until the fine particulate matter binds together to create haze. Research is currently underway to differentiate the chemicals that come from Indonesia’s peatland fires versus other types of urban air pollution.

Despite the global literature establishing the health impacts of air pollution and haze, local governments still seek ‘local data’—in this case, research gathered and published in Indonesia. To address the desire for local data, UNICEF commissioned a 10-year epidemiological time-series study to look at seasonal spikes in air pollution and health outcomes in the country. Based on data from health facilities and air quality monitoring devices in affected areas, the study demonstrated the impact of haze on respiratory health. It also highlighted the limitations that come with relying on public health data.

“We found that the cases recorded at health centers did not reflect the true caseload or the long-term burden of disease,” says Richard Wecker, a Risk Reduction Specialist in UNICEF Indonesia’s Disaster Management, Climate Change Adaptation & Mitigation portfolio. He says collecting data for the 10-year study was costly time-wise and financially, and that the satellite data and modelling methods used by The SMOKE Team may be more accurate and cost-effective. “However, this information is not always as compelling to stakeholders, so we need a balance,” Wecker says, referring again to the need for local data to show Indonesian policymakers.

In 2015, activists in Palangka Raya, Central Kalimantan put masks on city statues as a symbol of protest against peatland fires. Photo by Aulia Erlangga, CIFOR; cifor.org

Attempted Health Interventions

Various health-focused interventions were implemented with little success during the 2015 haze. "During the peak of the fires, most agencies including the government were helpless to do anything beyond band-aid measures to protect the health of people," says Richard Wecker. "You could not possibly evacuate the tens of millions of people affected by transboundary haze. At that stage harm reduction measures were necessary, but most were not appropriate and offered limited overall coverage."

The first of those harm reduction measures was the distribution of masks. In Palangka Raya, the provincial Ministry of Health also set up airtight, air-conditioned tents where people could seek refuge from the haze. Even government offices became mini hospitals where people could stay in an air conditioned and well-ventilated space. "We also asked cooperation from parents to restrict the outside activities of their children," says Erna Parida Susanti, a midwife at a local *puskesmas*. With school suspended for as much as three weeks, she admits this was a near impossible ask.

Back in Dr. Bobby's office at RSUD Doris Sylvanus hospital in Central Kalimantan, the brightness of the day has been spoiled by conversation of the haze. "I don't want to talk because what happened in 2015 is a kind of trauma for us pulmonologists. We opened our eyes and we could not see in front of us. For three months we had this situation. Maybe if you don't have a healthy mind you could go crazy. Every day I went to the hospital and saw people die."

Midwife Erna Parida Susanty, Dr. Yulitha Christiana, and nurse Nurul Hafizhah were on the frontline of care during the 2015 haze. Employed at a puskesmas, a community health clinic, the three women saw patients throughout the course of the fires.

The Role of Land Use Management

[xvii] What other countries produce palm oil? At what scale? Why has there been a rise in palm oil production globally?
↘ Read more here

The role individuals versus industry play in Indonesia's peatland fires is a contentious topic. On one side is the large oil palm, timber, and logging companies that have shaped the landscape of Southeast Asia for decades. Fly over many Indonesian islands, but especially Kalimantan and Sumatra, and you'll notice the unmistakable patchwork of oil palm plantations: palm trees in orderly grids the size of dozens of city blocks. Trucks carrying the valuable fruit rumble down the highway, precious cargo secured in place by canvas tarps. The commodity is the country's largest agricultural export.[xvii]

In control of large areas and with a vested interest in preparing land for rows of palm trees, oil palm plantations are the most common scapegoat for the destruction of Indonesia's peatlands. However, a study looking at a decade of manmade fire ignitions in Kalimantan between 2000 and 2010 found that only 17 to 19% of man-made fires originated on palm oil concessions.[35] Satellite data showed the majority of fires came from a mosaic of non-forested areas—land composed of small-scale, independent oil palm producers, farmers, and swatches of degraded and drained peatlands. This came as a surprise to Dr. Ruth DeFries of Columbia University, who co-authored the research with other members of The SMOKE Team. "We went into this thinking we would find that the big oil palm concessions are the root cause of the fires and the haze problem. The oil palm industry is what everyone loves to hate. [...] That's lesson number one: challenge your assumptions."

DeFries says this revelation both simplified and complicated the land use scenario. While it shed light on the true source of fires, it meant the haze issue could not be solved by targeting a single player. "To have a policy that targeted big oil palm producers would have been easier because there's less of them, but at the same time more challenging since they're a large industry and they have lobbies and lots of profit at stake," she says. Meanwhile, most of the fires were occurring on a mosaic of degraded land that had thousands of users. It became increasingly apparent that preventing fires required a paradigm shift in how that land was used, protected, and restored. Only once all three were addressed could a group address the root cause of the haze.

It was within this context that The SMOKE Team set out to build a tool to help policymakers prioritize restoration areas that would yield the greatest benefits to human health.

A common scene on roadsides in much of Indonesia. Palm oil is one of the country's largest industries, and individual households often get involved by threshing the fruit from the spiked bunches. Be it rainforest or peatlands, the creation of oil palm plantations is a main driver of land use change in the country.

The SMOKE Policy Tool

While The SMOKE Team's 2016 paper focused on quantifying the public health effects of the 2015 haze, their latest research is forward-looking. Published in July 2019 with BRG's Pak Budi as a co-author, the paper outlines a framework policymakers can use to maximize the health benefits from peatland restoration.

The paper documents the future health outcomes for five land use scenarios. It does this by synthesizing historical data: looking at land use and land cover change, where fires have originated and the resulting smoke traveled, and the public health outcomes. Over the next several decades, a business-as-usual (BAU) land use scenario would lead to an average of 36,000 premature adult deaths each year across Indonesia, Malaysia, and Singapore. Additionally, the model forecasts an average of 1,100 annual deaths of children under the age of five due to acute lower respiratory infections.[36] These figures are averages, and the team acknowledges mortality numbers could range from <100 to 80,000 annual deaths, depending on the year.

The scientific framework outlined in the paper is publicly available through the SMOKE Policy Tool, a free online decision support tool that allows stakeholders to forecast public health effects in a way that would have previously been prohibitive. "For policymakers to run 30 years of five different land use scenarios—that would be a lot of expensive computer hours and would require knowledge of complicated tools," explains Shannon Koplitz of The SMOKE Team.[xviii]

[xviii] ↘ Take a moment to visit the policy tool here and change the different settings to achieve different scenarios.

Policymakers can use the tool to toggle between land use scenarios. That includes a BAU scenario, and others demonstrating what would happen if fires were blocked on all industrial oil palm, wood pulp, and logging concessions; in existing conservation areas; and on BRG priority sites which involve peatlands in both concession and non-concession areas.

Pak Budi of the BRG notes that the areas identified by the SMOKE Policy Tool as having the greatest potential health impact generally align with the agency's priority areas. He says the tool adds two other useful elements: honing in further still on specific priority protection sites, and quantifying the downwind health concerns of possible haze events. The most ideal land use scenario for human health involves the blocking of all fire in peatland areas. In this scenario, mortality from haze exposure decreases by 65% annually in Indonesia, with similar reductions in Malaysia and Singapore (73% and 70% respectively).[37]

The SMOKE Team's tool enables policymakers to better consider public health consequences when making land use decisions. These policy-level approaches are complemented by more community-oriented, grassroots interventions spearheaded by BRG and the Government of Indonesia. With varying levels of success, these bottom-up efforts are an attempt to consider not only the public health outcomes of haze, but also the complex social, economic, and cultural reasons behind why peatlands are burned.

Palm Oil becomes the main source of income for many villagers in Indonesia.

National and Regional Responses to Peatland Management

Experts say it's only recently that the Government of Indonesia started to change its stance towards degraded peatlands—something that was long overdue. "In 2006 Wetlands International came out with a report on peat carbon dioxide which showed huge emissions from peatland degradation in Indonesia and Malaysia. That was not welcome from either government, and the first reaction was to deny the issue and ban discussions on it," says Marcel Silvius, who has been working on the issue of peatland restoration worldwide, first with Wetlands International and now with the Indonesian branch of the Global Green Growth Institute (GGGI). "It took Indonesia several years to acknowledge the problem, and the major fires that have occurred repeatedly contributed to that level of awareness raising," Silvius says in neighboring Malaysia, peatland degradation and its related consequences are still not being seriously discussed by the government.

Pak Budi, BRG's Deputy Head of Planning and Coordination, worked with the World Wildlife Fund before joining the agency. He says policy around peatland restoration didn't exist before 2015, despite the annual effects of peatland fires. Restoration involves restricting the development on a piece of land while also taking active measures to improve its integrity. "Before [2015] it was just a matter of protecting peatlands, monitoring the [fire] hotspots, and responding to those without really taking into account the larger policy," he expands.

The first inkling of policy around peatland restoration came in May 2011 when the central government led by then-President Susilo Bambang Yudhoyono instated a two-year moratorium on issuing new concession licenses on areas of primary forest and peatland. That moratorium has since been extended on three occasions, the latest in May 2017 by President Jokowi.[38] That moratorium will be in place at least until the government has mapped which peatland areas could be appropriate for production, and those which must be conserved.[xix]

[xix] Can you think of some unintended consequences a moratorium like this might have?

In direct response to the 2015 fires, Jokowi also issued a permanent, national zero burning decree for industry and individuals, banning the use of fire to clear peatland areas. Not using fire, and taking the means to prevent and monitor flames proactively, is also one of the criteria oil palm companies must meet to comply with Roundtable on Sustainable Palm Oil (RSPO)[xx] criteria, though standards are voluntary and still permit planting on peatlands.[xxi]

[xx] ↘ Explore the RSPO website, and take a look at some of their criteria for sustainable palm oil production

[xxi] Which countries or regions purchase most of Indonesia's palm oil? ↘ Explore the chart here

Mapping Indonesia's Peatlands

Mapping—or a lack thereof—has presented one of the greatest challenges to peatland protection and restoration in Indonesia, and has fueled historic conflicts around property rights. One of the first tasks of the newly-established BRG was to work with partners such as the World Resources Institute to put together a more comprehensive map of the country's landscapes. The government calls this the One Map Initiative. The map, which will feature peatland area and depth, will become the basis for future restoration planning.

In 2016, Indonesia's Geospatial Information Agency (Badan Informasi Geospasial, or BIG) launched the million dollar Indonesian Peat Prize in order to more comprehensively map the area and depth of the country's peatlands. Two years and 44 teams later, the winners of the Indonesian Peat Prize were announced on World Wetlands Day in February 2018.

Pak Budi says the "breakthrough" moment came in late 2016. That's when the Government of Indonesia updated a previous regulation,[xxii] proactively protecting peatlands by banning the use of peat areas with a depth of more than three meters, even on existing industrial concessions. The regulation also stipulates the water table of peatland areas be no lower than 40 centimeters as a way to prevent the deep smoldering that occurred during the 2015 fires.[xxiii] The World Resources Institute (WRI) notes that primary forest loss on Indonesia's protected peat areas declined by 88% between 2016 and 2017, and attributes part of the change to this updated regulation.[39]

[xxii] The original regulation was Government Regulation ↘ No. 71/2014 Concerning Protection and Management of Peatland Ecosystems

[xxiii] The 40 centimeter figure was determined by Susilo et al (2013) to be the ideal depth as to prevent the risk of peat fires.

The private sector bears the brunt of this updated regulation. More than half of the peatland area prioritized for restoration is industrial concession land. If a company is found to be burning their land or operating on deep peat areas, it can face warnings or civil and criminal sanctions.

Pak Budi admits the private sector reaction to the 2016 regulation was quite negative. "They saw this regulation as adding more complications to the bureaucracy. We made several consultations with forestry and oil palm groups to provide data around which areas were and were not peatland, and provided them with restoration activities," he says of the BRG's attempts to cushion the initial negativity. Since then, two-way communication has been key, and companies can come forward if an area has been mistakenly identified as peat. Each company is responsible for producing a restoration plan, with the BRG planning to verify the

impact of those activities in the coming years. A land-swap plan has also been introduced as a means of compromise with forestry companies that have more than 40% of their land on protected peat areas (those with a depth greater than three meters), though it has received criticism from NGOs and private sector companies alike.[40]

While the private sector thought the 2016 regulation went too far, others felt it was only scratching the surface of what was needed. "The Minister [of Environment and Forestry] stuck her neck out in doing this, so it's a daring step, but it is still not sufficient to address all the peatland degradation related issues," says GGGI's Marcel Silvius of the 40 centimeter regulation. Silvius advocates for full peatland rewetting, which would restore peatlands to near-natural hydrological conditions. That would stop emissions and soil subsidence, reduce fire risk, and offer an environment to grow commercially interesting local species.[xxiv]

[xxiv] What other policies would have to be in place to make this regulation overall successful?

Striking a balance of restoration buy-in from a wide spectrum of partners is necessary for the BRG to achieve its ambitious restoration goals. "One of the reasons a lot of people are interested in this issue is because we all realize restoring [25,000 square kilometers] is a humongous task, and BRG knows it's impossible if they do it alone," says Satrio Wicaksono, the World Resource Institute's former Forest and Landscape Restoration Manager in Indonesia. For its part, WRI is helping BRG map peatland areas in three priority provinces and create restoration action plans. The institute also oversees the upkeep of *Pantau Gambut*, an interactive watchdog tool people can use to hold the BRG accountable to its commitments.[41] "It's been working out quite well. BRG is seen as easier to work with than the Ministry of the Environment and Forestry," Wicaksono says. "If you look at who the people are in BRG, they used to be in NGOs and academia. It's not like they're long-time government bureaucrats, [many of whom can stereotypically] be averse to working with partners."

At a regional level, policies from other Southeast Asian countries have also taken aim at addressing Indonesia's peatland fires. In 2002, the Government of Singapore tabled the ASEAN Agreement on Transboundary Haze. That environmental agreement came in response to large-scale forested peatland fires that occurred in 1997. The Center for International Forestry Research estimates the degradation and deforestation that resulted from those fires cost between $1.62-2.7 billion.[42] "The costs of smoke haze pollution were in the range of $674-799 million, and probably higher because estimates for the economic impacts on Indonesian business activities were not available," says a CIFOR report.[xxv]

[xxv] What are some challenges in the implementation of international legal mechanisms such as this one?

However, the agreement was virtually powerless until 2014 when Indonesia, the largest producer of haze, finally ratified the agreement. That set the stage for the next iteration of the policy, the Transboundary Haze Pollution Act of 2014. Since then, Singapore has levied fines on Indonesian companies in each subsequent year.[xxvi]

[xxvi] The first use of that act was in 2014 when six lawsuits against Indonesian companies were filed. The largest was filed against Indonesian plantation company Sampoerna Agro, at a fine of US $81.62 million.

But as Ruth DeFries and others found in their research, policies and regulations that consider only the actions of large companies failed to address the millions of small-scale farmers using traditional fire methods to clear land—and the economic practicalities of why they were choosing that method. While the national and regional response was important, peatland protection and restoration demanded the involvement of people at every level.

Pak Ardiansyah is a Fire Guard with the Ministry of Environment and Forestry. Along with other members of Gohong Village in Central Kalimantan, he has received firefighting training since 2015.

Community-based Solutions: The BRG's 3 R's

The sun is low in the sky by the time Pak Anang Sogito from Gohong Village reaches his destination: a rickety, four-story fire tower constructed a few meters from the highway. The view from the top is spectacular: green shrubs and small trees sprouting from peatland as far as the eye can see—except in one direction where it reaches the boundary of a rubber tree forest and oil palm plantation, an inescapable reminder of the delicate state of Kalimantan's peatlands.

This peatland is slowly experiencing regrowth after being scorched in 2015. Had this fire tower been standing that year, it too would have burned. An inconspicuous white pipe—picture a simplified fire hydrant—protrudes from the ground at the base of the tower. It's one of 300 pumps found across the hotspot area near Gohong Village, installed since 2015 by the BRG and USAID funded project, *Lestari*. As of mid-2018, the BRG had installed more than 23,000 of these deep water wells across its seven priority provinces.

In heavily peated fire-risk areas like this, pumps sit in a 400 meter by 200 meter grid. They wouldn't offer full coverage if a hotspot were to become a full-blown fire, but Pak Anang says they're a start. Plus its presence means villagers wouldn't need to rely on traditional extinguishing methods: the aforementioned buckets of water thrown fruitlessly over smoldering fires. Expanding local firefighting capacity and community response has been one of the main mitigation efforts introduced since 2015, and is the focus of both the Ministry of the Environment and Forestry's *Manggala Agni* fire brigade and the UN Environment Programme's Gambut project.

The installation of deep well water pipes is one of the BRG's interventions to proactively restore Indonesia's peatlands. The agency has a double mandate: facilitate the restoration of degraded peatlands, and coordinate the sustainable management of those ecosystems. That work is the responsibility of a National Coordination Team, a body consisting of 17 government agencies, 10 ministries, and governors in the seven priority provinces, each of whom play a role in supervising restoration efforts by individuals, communities, and private sector.

Notable are the interventions that make up BRG's community restoration efforts. These interventions take what the agency calls a "3-R" approach. While the national government has focused on several top-down policies regulating peatland use, the BRG is focused more on grassroots activities and behavior change. The goal is to shift perceptions around the usefulness of peatlands, and provide affordable alternatives to traditional land clearing methods using fire.

"We needed to have interventions in activities that were really important to people, and found that economic activities were central," says Dr. Myrna Safitri, the BRG's Deputy of Education, Socialization and Participation. After these activities, people gradually change their perception that peatland restoration is something harmful to their lives. They see it can improve their household."

The first R intervention is rewetting, in order to accelerate the recovery and restoration of the hydrological functions of the peatland. Rewetting efforts include installing grids of deep water wells like the ones in Gohong Village, in addition to supporting community firefighting efforts. It also involves the construction of dams to block the canals historically used to drain peatlands. The goal is for rainwater to eventually re-saturate the dried areas to prevent further oxidation. Rewetting success depends on natural precipitation, but also the education and understanding of people living near those canals. Safitri says some communities resisted the dams at first, particularly because the canals had been used as illegal logging access points.

Sensitizing people about interventions like canal dams is two-fold. "We use language that people easily understand," explains Safitri. "When we talk about what peatland restoration means, we tell people it's like a hospital. We're in the emergency room now where we're facing very serious degradation of peatland ecosystems. If we do nothing it will get worse, and we tell people they will be the first victims. Many children get sick because of the haze, and peoples' agricultural land burns. If our ecosystem can be saved then lives can be saved."

Pak Anang stands next to one of the deep water wells at the edge of Gohong Village.

Pak Charles overlooks a peatland canal constructed on his land. With support and funding from the Peatland Restoration Agency, he and others have built the canal blocking dam that he now stands on.

Canal dams have been constructed in nearly 20,000 locations across Indonesia. Two of them are in Tumbang Nusa Village in Central Kalimantan province. That's where Pak Charles stands squinting in the midday sun, observing a wooden canal block on his property. It was constructed by his farming group, with money and support from the provincial government, who in turn received funding and guidance from the BRG. In addition to rewetting the peatland, when filled with water the blocked canal makes it easier for Pak Charles to reach his property far from the road. "After we make the canal blocking the land surrounding is good for farming," adds Pak Charles.

The canal water is also used by the Ministry of the Environment and Forestry's *Manggala Agni* fire brigade. Even with efforts to rewet peatlands, the project is a work in progress and the ground's dryness is evidently dire. Pak Imade, the Chief of *Manggala Agni* for this district, prods at a piece of wood that has been warped and dehydrated by heat and a lack of peatland saturation. It crumbles easily in his palm, the perfect fire tinder. Each day, Pak Imade's joint squad of army, police, and *Manggala Agni* officials monitor the peatlands around the village. They use two satellite monitoring applications to look for fire hotspots, before investigating in-person. "It wasn't until after 2015 that we started our joint patrol, and to do door-to-door socialization about the new government rule forbidding people to burn their land," explains Pak Imade.

Revegetation is BRG's next "R" intervention. This planting of new tree and shrub species is especially important in peatland areas that were previously burned or degraded. Not only can agroforestry projects provide livelihoods for community members, but the new vegetation can also provide biomass that helps peat form.

Community involvement is key for BRG, especially for the third "R": revitalization. This intervention involves the introduction of alternative livelihood activities conducted without burning. That includes farming peatland-appropriate crops, livestock rearing, creating ecotourism destinations, and social forestry projects. Anything that helps villagers benefit economically from healthy peatlands. Another of BRG's community involvement approaches is to help individuals understand that their actions are part of a bigger picture. Often, that involves inviting a farmer to talk about their activities at an international event. "This helps farmers know what they do in their village is not only impacting their communities, but has a global impact," says Dr. Myrna Safitri with BRG.

An Indigenous Youth-led Movement Addressing the Haze

Emmanuela Shinta is a young Dayak leader from Central Kalimantan, Borneo. She recently spoke at the 2019 planetary health conference hosted by Stanford University. During a panel session on Mobilizing a Planetary Health Movement, Shinta introduced the Youth Act Campaign that she and other Indigenous youth started in 2016 in response to the fires and haze that had been occurring since 1997.

The Youth Act Campaign organized many activities to get young people politically engaged, including creating haze shelters and training them as firefighters to help extinguish peatland fires. "They put all of their energy and time to protect their own people, their family, and our beloved homeland: our beautiful forest which is part of our identity," Shinta said on the panel, recognizing her people as the guardians of the forest.

Shinta is an advocate for bottom-up approaches to land management—this starts, she says, by consulting Indigenous communities who best know the land. "If you want to know how to manage the land and preserve the forest ask the Indigenous communities because they have been doing that for thousands of years," Shinta explained.

Shinta also compels people internationally to take individual action to reduce the large-scale clearing of land: "I would like to urge everyone here to mind your palm oil consumption. There is a lot of suffering behind the products that you consume."

To further emphasize the value of peatlands, BRG has created more than 200 Peat Care Villages across their seven priority provinces. In these villages, the agency supports the creation of farming demonstration plots, farmer groups, and village development plans that integrate peatland restoration. Villagers also receive legal training so they can advocate for their land rights around peatlands and beyond. Land boundary issues remain one of the largest conflicts, both among neighboring villages and with large concession companies.

Safitri says it's never the agency's aim to introduce something completely new, since BRG's mandate and capacity are ultimately limited. "We analyze existing initiatives and see how we can support improvement," she explains.

One example of BRG supporting existing initiatives is in Anjir Kalampan, where village chief, Pak Yanir, has become somewhat of a celebrity for his success growing fire-free crops on peatland. While Pak Yanir had been experimenting with non-burning methods of opening land since 2011, his efforts ramped up following 2015, and with support from BRG. "I considered the haze accident as the

important moment. It became the urgent thing to do," he explains, sitting on the floor of the village office.

Pak Yanir, 52, has lived in Anjir Kalampan his entire life. Over the last decade he has developed a specific technique to grow vegetables in the highly acidic peatland environment. His method involves creating raised rows of soil so plant roots don't reach the acidic groundwater, even during rainy season. Unlike rice paddy fields, a traditional crop in the region that requires the flooding of land, Pak Yanir plants crops with shallow roots such as watermelon, chili, and onions. His method is also entirely organic. Instead of buying expensive pesticides and creating nutrients on the land through burning, Pak Yanir mixes the feces of ducks that have been provided by BRG with decomposing grass. The result is a nutrient-rich manure.

Pak Yanir, a resident of Anjir Kalampan village.

He says it's a misconception that opening land with fire is less expensive, though admits his method does require some start-up resources such as the ducks and the manual labor to create raised garden beds. It took a handful of failures and years of experimentation for Pak Yanir to master this burning-free method but it's one that has today been adopted by the village's farmers. The combination of producing his own manure, carefully selecting his crops, and raising his garden beds has proven productive. Importantly, this method is also affordable for subsistence farmers.

Proposing affordable and culturally acceptable alternatives to clearing land without fire is key for BRG. "At the beginning villagers were reluctant of the no fire rule," confesses Pak Yanir. "They blamed the government for making a rule without any solution, and refused to follow it because they could not afford anything other than burning." Pak Yanir says people eventually came around as the result of training sessions—and the threat of prosecution.

Using demonstration plots and field schools as learning sites, BRG's proposed land clearing methods involve training farmers to manually prepare farmland using machetes and other tools. The slashed organic material is then combined with animal feces and other ingredients and left to decompose for several months. The resulting manure mixture minimizes the need for fires.

However, this method isn't perfect. For one, it's a substantially longer process than lighting a fire and watching it burn, and it's one that can attract pests and diseases. That's what a team from the Centre for International Forestry Research (CIFOR) found when they looked into the effect the government's zero-burning policy had on small farmers in Riau province. In Riau and other provinces across Indonesia, fire has been a part of traditional land clearing methods for generations. "There is a need for flexibility in implementing the policy on the ground," wrote CIFOR Researcher Dede Rohadi in a 2017 opinion piece.[43] "Genuine farmers should be allowed to implement controlled land burning. Traditional community wisdom makes it possible to apply the technique with the guidance of government officials in the field." Rohadi argues that without this needed flexibility smallholder farmers may be forced to abandon their land because the cost of fire-free clearing is higher than what they're able to earn through their harvest.

Restoring Russia's Peatlands

Southeast Asia is not the only region that has experienced the health effects of haze. Like Indonesia, Russia is home to a considerable area of peat—it makes up 8% of the world's largest country. The similarities do not end there. The country's peatlands have also fallen victim to short-term economic gain, particularly in the 1970s and 1980s when peatlands were drained for agriculture, forestry, and use as fuel. These actions were supported by the Soviet state, and Russian engineers also bolstered the draining of peatlands in Indonesia by providing calculations, surveys, and designs. With the fall of the Soviet Union in 1990, hundreds of thousands of square kilometers of drained peatland were abandoned. Similar to in Indonesia, these drained layers of peat provided the ideal kindling for hazy fires, and are located upwind from many large population centers.

In 2010, peat fires smoldering around the Moscow Region contributed to 11,000 premature excess deaths.[44] Resulting from that crisis was a bilateral project between Russia and Germany. Working with the Russian branch of international NGO Wetlands International, as well as a team of lawyers, scientists, sociologists, and engineers, the ongoing project has rewet 950 square kilometers of drained peatland, and is one of the largest peatland ecosystem restoration projects worldwide. About a third of that restoration has occurred using an ecological restoration approach.

The goal of ecological restoration is to not only rewet areas, but also to restore natural ecosystems. In order to do this, natural dams are constructed along the man-made canals formerly used to drain the peat areas. Rainfall remains trapped within the dammed areas, and resaturates the dry peat, leading to the slow restoration of its original water-logged state and biodiversity. With dams created using vegetation native to the area and filled solely by natural rainfall, this form of ecological rewetting has been found to be 10 times cheaper than other rewetting methods.
According to Dr. Tatiana Minayeva, a peatland restoration expert with Wetlands International, a major challenge of the project has been convincing Russian stakeholders of the importance of peatlands. Similar to BRG's work in Indonesia, the approach in Russia recognizes that it's not possible to simply demand people act differently. "The attitude is that peat is an obstacle for your development. Draining it was positive for them. We have learned that you need to have different models and schemes," says Dr. Minayeva.

Those models are different based on each community—as are the barriers faced. Some communities, Dr. Minayeva says, demand proof of profit upfront. Some want direction from the highest level of government, and others want to see how rewetting has benefited nearby villages. The introduction of paludiculture—a form of agriculture that happens atop healthy peatlands—is one of the ways Wetlands International and its partners are hoping to convince Russian partners that there is value to be gained from maintaining peatlands.

While policy changes have not been put into place by the Russian government, this ecological restoration project is an example of what can happen when behavior change, economic benefit, and the health of the planet and humans is combined.

Back in Anjir Kalampan village, one of Pak Yanir's farm helpers, Wasis, proudly recalls a week earlier when he harvested five tons of juicy red, orange, and yellow watermelon—a bounty, he notes, was promptly sold. The watermelon was grown on peatland that had been prepared and fertilized by hand, using the raised bed method explained earlier by Pak Yanir.

Wasis says villagers now look at peatlands differently, including seeing the value of protecting peatlands beyond the purely economic: "They understand that when the peatland burns it affects their health. But education still needs to happen, because ultimately burning remains the easiest way [to clear the land]."

Wasis moved from the populous island of Java to Central Kalimantan in search of agricultural land. What he found was plenty of open peatland—an ecosystem that is typically challenging for growing given its high soil acidity level. The Peatland Restoration Agency works alongside farmers like Wasis, conducting agricultural trainings to demonstrate that it is possible to have a viable livelihood on healthy peatlands.

Institutionalizing Peatland Restoration for the Future

Indonesia has not conclusively shaken its pattern of dry season fires. "There was lower fire incidence in 2016-2017 overall, and we now know that those areas did not burn because of our activities, socialization, education, and stronger law enforcement," confirms BRG's Pak Budi of the progress that has been made, though says the interventions are still too nascent to fully assess their effectiveness. Pak Budi points out that climate-wise, 2016-2017 were drier compared to the previous three years, including 2015. In 2017, NASA satellites detected 1,927 hotspots during the July to October dry season months—a fraction of the 130,000 fire hotspots during the same period in 2015, and a new record low.[45]

However, 2019 saw the return of the transboundary haze crisis. The worst fire and haze season since 2015, nearly 16,000 square kilometers of land burned in Indonesia, particularly on the islands of Sumatra and Borneo.[46] Nazir Foead, head of the BRG, told *Mongabay* the agency's monitoring had detected the overly-dry peatlands in as early as May 2019. He acknowledged the need to re-check the canal blocks and deep wells that had been installed in previous years, but added that "fires are flaring up in areas that seldom burned [in the past] and indeed they weren't monitored."[47] Other BRG officials have pointed to the lack of maintenance budgets for rewetting infrastructure, while certain Indonesian NGOs say the agency isn't being transparent enough about progress being made in peatland restoration.[48]

A suite of solutions for this annual environmental crisis is still underway. The BRG's Pak Budi says it's important to ensure the issue maintains the political support and funding it needs. For that, he stresses the importance of having the agency's work backed by science and public health data. That's one of the reasons he joined The SMOKE Team to co-author their 2019 paper connecting peatland restoration areas with their long-term health benefits. "That paper gives us an argument that regional policy and coordinated work are important, not only to suppress the fires, but to prevent health concerns from happening," Pak Budi says. "We always need more data and studies that the health effect isn't only in the five months of the dry season, but can have a long-term effect, too."[xxvi]

[xxvi] What are other examples in which scientific research has informed policy decision at a large scale?

Peatland forest in Central Kalimantan. Photo by Nanang Sujana, CIFOR; cifor.org

Keeping Track of Who's Who

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Dr. Shannon Koplitz

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Satrio Wicaksono

Forest and Landscape Restoration Manager, World Resources Institute

Pak Yanir

Chief of Anjir Kalampan village and peatland farmer

Pak Charles

Resident of Tumbang Nusa village in Central Kalimantan

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Pak Tuberyono

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Pak Budi Wardhana

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Several preventative measures are being used to reduce the risk of new peatland fires. That includes regular monitoring by a group called Manggala Agni.

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