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Mega-Development, Scientific Expertise, and the Remaking of Indonesia's Degraded Peatlands

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Geography

by

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ABSTRACT OF THE DISSERTATION

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and the Remaking of Indonesia's Degraded Peatlands

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Though an analysis of the Ex-Mega Rice Project site—a one million hectare degraded tropical peat swamp in Indonesia's Central Kalimantan province on the island of Borneo—this dissertation asks how and why degraded tropical landscapes become valuable. Some of political ecology's foundational questions address discourses, agents, and institutions that contribute to and enable environmental resource degradation. This dissertation proceeds with degradation as its starting point to explore how this site has enabled certain actors to claim value from degradation while reducing value for others. Using qualitative methods, this research analyzes conjunctures of development, science, and value in and through this degraded landscape. I begin with an historical account of how the Mega Rice Project was planned and executed, despite warnings from scientists that it would be an ecological disaster. I then explore the seemingly paradoxical economic, cultural-scientific, and political values of degraded tropical landscapes, and of wastelands generally, within global discourses of planetary climate change. In a departure from traditional conservation research in the natural and social sciences, I also broaden notions of what value and values are inscribed on and in landscapes without high biodiversity, agricultural fertility, and/or aren't obviously economically profitable. As the Indonesian state and

transnational capital seeks to re-develop land classified as degraded, questions of how degraded environments might be refashioned are very much in play. Furthermore, Central Kalimantan—and the EMRP site in particular—has been the place of generative scientific knowledge about tropical peat soils as a global carbon threat since the late 1990s. I thus draw conceptually and methodologically from science and technology studies investigate how and why this scientific trajectory was located here and what implications that holds for future capital accumulation and livelihood strategies in this and similar sites.

The thesis of Jennifer Elaine Goldstein is approved.

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Table of Contents

List of Abbreviations

AMDAL	*Analisis Mengenai Dampak Lingkungan* (environmental impact assessment)
BAPPEDA	*Badan Perencana Pembangunan Daerah* (District-level planning and development agency)
BAPPENAS	*Badan Perencana Pembangunan Nasional* (National-level planning and development agency)
BOS	Borneo Orangutan Survival organization
BP-REDD	*Badan Pengelola REDD+* (Indonesian national REDD+ agency; disbanded in 2015)
CARE	Cooperative for Assistance and Relief Everywhere (international humanitarian agency)
CCBS	Climate Community Biodiversity Standard
CDM	Clean Development Mechanism
CIFOR	Center for International Forestry Research (Bogor, Indonesia)
CIMTROP	Center for International Cooperation of Sustainable Management of Tropical Peatland
CKPP	Central Kalimantan Peatland Project
COP	United Nations Convention of the Parties (annual climate change negotiation)
DNPI	*Dewan Nasional Perubahan Iklim* (Indonesian National Council on Climate Change)
Ex-MRP	Ex-Mega Rice Project (used to refer to Mega Rice Project area post-1999)
FFI	Flora and Fauna International
HGU	*Hak Guna Usaha* (Land Cultivation Rights)
HL	*Hutan Lindung* (Protection Forest)
HP	*Hutan Produksi Tetap* (Permanent Production Forest)
HPH	*Hak Pengusahaan Hutan* (Forest Use Rights)

HPK	*Hutan Produksi Konversi* (Convertible Production Forest)
HTI	*Hutan Tanaman Industri* (Industrial tree plantation)
IAFCP	Indonesia-Australia Forest Climate Partnership
ICCC	Indonesia Climate Change Center (non-profit organization based in Jakarta, partially funded by US Forest Service)
IMF	International Monetary Fund
INCAS	Indonesian National Carbon Accounting System
IPCC	International Panel on Climate Change
KFCP	Kalimantan Forest and Climate Partnership
LiDAR	Light and radar: remote sensing method that uses light in the form of lasers to measure distances to the Earth
MoF	Ministry of Forestry of Republic of Indonesia
MRP	Mega Rice Project
MRV	Measure, Report, Verify (sometimes referred to as Monitor, Report, Verify)
NASA	United States National Atmosphere and Space Agency
PLG	*Proyek Lahan Gambut* (Peatland Project; commonly used in Indonesian)
REDD+	Reducing Emissions from Deforestation and Degradation (United Nations program)
UNFCCC	United Nations Framework Convention on Climate Change
UNORCID	United Nations Office for REDD+ Coordination in Indonesia
UNPAR	University of Palangkaraya
USFS	United States Forest Service
USGS	United States Geological Survey
WALHI	*Wahana Lingkungan Hidup Indonesia* (Indonesian Forum for the Environment)
WI	Wetlands International

WWF	World Wildlife Foundation
VCS	Verified Carbon Standard

List of Figures

Photos by author unless otherwise indicated

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Vita/Biographical Sketch

Jennifer E. Goldstein holds a B.A. in History and Theory of Architecture from Barnard College, Columbia University and an M.A. in Geography from the University of California, Los Angeles. Her scholarly work has been published in *Food and Foodways, Environment and Society: Advances in Research*, and *Environment and Planning A.* In addition to conducting research in Indonesia, she has also completed fieldwork in Rwanda and Japan. Beginning in January 2016, she will be a postdoctoral research fellow at the Atkinson Center for a Sustainable Future at Cornell University, based in the Science and Technology Studies Department.

Chapter 1: Borneo's Scorched Earth

In November 2014, at the very end of Borneo's traditionally dry season—fire season—a friend and I were driving on a dirt road through an area of cleared peatland in Central Kalimantan province commonly referred to as the ex-Mega Rice Project. The site is networked with drainage canals of varying sizes; lines of identical oil palms, each a single story tall, extended into the distance. Sheets of rain were falling so violently that the windshield wipers couldn't clear the water fast enough. The car slowed to navigate over and around puddles that had turned into craters. Though visibility was murky, along the edge of a canal to our left I could make out thick plumes billowing up from the ground as forcefully as the rain was falling. There were no flames, just white smoke un-dampened by the downpour. Tropical peatland degradation is an unusual phenomenon and it sometimes looks like this: smoke in the rain.

Prior to drainage, tropical peat forests are swamps inundated with water that appears reddish-black on the surface. Peat is a soil layer ranging from half a meter to over 20 meters deep, made up of partially decomposed vegetation matter, such as tree roots, leaves, and trunks. When peat is waterlogged, the carbon it contains remains stable as stored biomass. But if the soil dries out, as it does through intentional drainage and forest clearing, the stored carbon is released into the atmosphere as carbon dioxide through two biophysical mechanisms: fire and oxidation.[1] Fires in tropical peatlands are like smoldering fields of charcoal, often flame-less but leaving fields blanketed with white, acrid smelling smoke. The fire eats through the soil itself, releasing thousands of years of accumulated carbon in a matter of months. Such fires can only be extinguished by prolonged rains that raise the water table enough to flood the soil. Even when it

[1] Peatland burning and oxidation also releases other greenhouse gases, including methane and ozone, and particulates. For the purposes of this discussion, I emphasize carbon dioxide here.

is not burning, dry peat undergoes continuous microbial oxidation, which also emits carbon dioxide into the atmosphere, albeit at a slower rate than burning.

In late 1997 and into 1998,[2] enormous peat fires sent plumes of grayish-white smoke across Indonesia's Sumatra and Kalimantan, and a noxious yellow-gray haze settled over Singapore, Malaysia, and Thailand for weeks at a time. Though anthropogenic forest fire has been part of the Sumatra and Kalimantan landscapes for centuries, if not thousands of years (Barber and Schweithelm 2000; Page, Rieley, and Banks 2011), general consensus among scientists, government officials, and local land users alike was that these fires were unprecedented in their magnitude and extent. By the time the flames dissipated in mid-1998, an estimated ten million hectares had burned in Kalimantan and Sumatra, affecting the health of millions across Southeast Asia and costing roughly $10 billion in lost economic activity (Barber and Schweithelm 2000; Harwell 2000; Aiken 2004).

Haze from smoldering fires in Central Kalimantan province on the Indonesian portion of Borneo[3] drew particular ire. Here, a one million hectare area of peat forest had been cleared and hundreds of miles of drainage canals dug for the Mega Rice Project[4] (MRP) in 1996, President Suharto's[5] attempt at re-engineering peatland hydrology to turn the province into the country's rice supplier. But little rice ever grew in the project site and the endeavor ended abruptly in 1998 as President Suharto resigned, the Asian financial crisis sent Indonesia's economy spiraling into

[2] The fires burned most severely from late August into November of 1997, died down during an abnormally short rainy season in December 1997 and January 1998, and picked up again from February to April 1998.
[3] Three countries are located on the island of Borneo: Indonesia (West, South, Central, East, and North Kalimantan provinces), Malaysia (Sarawak and Sabah provinces), and the Sultanate of Brunei.
[4] The area is referred to as the "Mega Rice Project" (MRP) prior to 1999, when the project was officially stopped by the government, and the "Ex-Mega Rice Project" (Ex-MRP) thereafter.
[5] Like many Indonesians, President Suharto went by only one name.

inflation, and one of the most severe El Niño cycles on record caused severe drought across the region.

The Mega Rice Project has since been called the biggest environmental disaster in Indonesia's history. Though the Mega Rice Project site was not the only part of Indonesia burning in 1997-98, researchers later determined that 32 percent of the Mega Rice Project site, which is itself 90 percent peatland, had burned during the year's fires. This was the largest concentration of peatland combustion in Indonesia. Furthermore, extrapolating from data obtained from the MRP site, scientists determined that Indonesia's 1997-98 peat fires released the equivalent of between 13 and 40 percent of *global* average annual carbon dioxide emissions from fossil fuels into the atmosphere (Page et al. 2002). The planetary atmosphere has been well-established as a dominant trope for thinking about environmental problems (Taylor and Buttel 1992; Demeritt 2001). The fires' far-reaching effects, inextricably bound up in the failed Mega Rice Project itself, revealed not only that the ecological dimensions of land degradation are global in scale but so too are the socio-political consequences.

What can the failure of the MRP and the subsequent peat fires in Kalimantan teach us about the political ecological dynamics of land degradation in relation to development and carbon emissions? In contrast to studies of the causes of failed state-led development projects, I take the sites of failure as the starting point to ask how degraded tropical peatland ecosystems become scientifically, politically, and economically valuable. I argue that the degraded landscape has become valuable within several, intertwined global circuits that attempt to extract new forms of value from the degraded landscape: the biophysical circulation of carbon through the planetary system, the circulation of scientific knowledge about peatlands' carbon emissions, and the circulation of capital through re-development schemes. By tracing these circuits, I show how these projects to render degraded land valuable catalyze new forms of development and conservation[6] through regimes of scientific knowledge. Yet scientific knowledge does not act unidirectionally *on* peatland management strategies: it is, as I also argue, produced *through* conservation and development projects themselves. In doing so, I show how science—its knowledge practices, products, and politics—is used to create new forms of economic value in degraded peatlands, whose potential for profitability is perceived to be untapped or in decline.

Images of 'degraded' land conjure up places that are barren, deserted, and uninhabited. But though the Mega Rice Project left behind a vast expanse of scrub brush and smoldering soil, this site has hardly been abandoned. The heavily—yet heterogeneously—degraded peat swamp is currently a nexus of competing, overlapping, concurrent land use and land investment practices. In the years since the project ended, the area has attracted attention from governments around the world, transnational corporations, financiers, non-governmental organizations, and activists all seeking to claim new value from, and re-inscribe their values on, the landscape. Meanwhile, the site's indigenous and migrant inhabitants search for ways to continue to live in a deteriorating environment. Many (though certainly not all) of the policies and practices that have attempted to render the degraded peatlands in the former Mega Rice Project site valuable are underpinned by scientific knowledge and uncertainty about the peatlands' emissions.

I advance these claims in three parts. In chapter 3, I trace the scientific value of the MRP site—and Indonesia's peatlands more generally—to the scientific *episteme*, or dominant expertise-based narrative, that emerged in the wake of the MRP disaster, which connected peat degradation to carbon emissions. The circulation of this knowledge then leads to attempts to

[6] "Conservation" and "development" in tropical ecosystems has traditionally been framed as an oppositional binary. Yet directives to rehabilitate the degraded peatlands in order to reduce global carbon emissions challenge this binary in many ways.

rehabilitate the area as a means to reducing the carbon emissions, which generates what I call new "scientific infrastructure." Such infrastructure is leveraged at national and international scales, reworking Indonesia's position in international climate change debates, with consequences for national, and local, policy. Furthermore, local inhabitants are enrolled as both producers of scientific knowledge that reinforces the *episteme*, and as threats to the planetary atmosphere, as discussed in chapter 4. Alongside such rehabilitation efforts, parts of the MRP site have become attractive to oil palm companies, despite the fact that oil palm cultivation has become a climate change risk within mainstream scientific consensus, as I explore in chapter 5. Yet claims of oil palm's suitability for degraded peatlands is also underpinned by alternate Ex-MRPscientific knowledge, or what I call "divergent expertise," which counters mainstream scientific consensus in order to sway policy in favor of large-scale agricultural development, or "land grabs" that have become increasingly prevalent across tropical countries. The damage left in the Mega Rice Project's wake and subsequent efforts to rehabilitate and re-develop the land thus reveals the limits and possibilities of science for making the subterranean legible, and to thus make 'ruined' landscapes valuable in new ways.

1. Political Ecology of the Mega Rice Project

The Mega Rice Project is to many inside and beyond Indonesia a caricature of centralized state-led agricultural development, a historical example of failed planning. Yet the social and ecological degradation wrought by the Mega Rice Project is an ongoing contemporary process, making the site a compelling place in which to investigate the relationship between scientific practices, re-development, and new forms of value. Three historical and geographic particularities of the MRP make these relationships especially visible. First, rapid peatland drainage in this site inspired scientists to look closely at the relationship between peatland drainage and subsequent fire on carbon emissions in ways that would ultimately link the peatlands to the global politics of climate change. Second, the time period over which the Mega Rice Project and subsequent land use practices occurred is revealing. The project ended with the fall of President Suharto's authoritarian government, while efforts to "clean up the mess" have coincided with Indonesia's transition to decentralized democracy and related efforts by the Indonesian state to gain economic and environmental legitimacy on an international stage. Third, in part because the overall story of the Mega Rice Project is well-known, but also because of its sheer size[7] and ecological and social heterogeneity, the area has drawn attention from an extensive range of actors—governmental, financial, scientific, activist—interested in rehabilitating and/or re-developing the land. As a result, this landscape has become a site on which these different interests and attempts at valuing and re-valuing the land come into contact and shape the ways that both the MRP and tropical peatlands are valued and understood.

Conflict over peatland rehabilitation provides an instructive example. Because of the magnitude of carbon emissions attributed to Indonesia's degraded peatlands, some scientists have cast large-scale agricultural development in tropical peatlands as a threat to the planetary atmosphere.[8] Drawing on this expert knowledge, many actors in international science and policy circles believe that without extensive human intervention to rehabilitate landscape hydrology in sites like the former Mega Rice Project (Ex-MRP), peatlands will continue to oxidize and remain

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[7] Depending on which part of the MRP site is being referred to, total size ranges from one million to 1.7 million hectares. One hectare is 2.47 acres.

[8] As I describe in chapter three, the first publication in a major science journal to argue this was "The Amount of Carbon Released from Peat and Forest Fires in Indonesia during 1997," published in *Nature* by Page, S. et al. Other more recent published papers providing evidence for the significant role of Indonesia's degraded peatlands in the global carbon cycle includes but is not limited to: Carlson et al. 2012; Frolking et al. 2011; Gaveau et al. 2014; Hirano et al. 2012; Hergoulac'h and Verchot 2013; Hooijer et al. 2010; and Page et al. 2011.

flammable. Yet rehabilitation, especially through carbon offset-based mechanisms, is not a universally accepted solution. While reducing deforestation remains a prerogative of governments, companies[9], and environmental organizations, tropical peatland degradation incorporates a new set of challenges, politics, and institutions that make it difficult to enact traditional ecosystem conservation programs. In a practical sense, it is nearly impossible to walk on or otherwise access drained and burned peat without falling through the surface. Additionally, there are competing claims to expand agricultural production onto degraded peatlands in Indonesia. Portions of the Ex-MRP site have attracted transnational capital through oil palm development over the past decade, as companies and the state seek degraded, empty, or "sleeping"[10] land for industrial agriculture.

In this context, debates over Indonesia's peatlands extend well beyond national borders. Since Blaikie and Brookfield's 1987 *Land Degradation and Society* shifted the focus from individual actors to the structural causes of land degradation, political ecologists have connected losses of ecosystem function in forests, farms, and fields to national policies, international trade agreements, and neoliberal markets (Hecht and Cockburn 1990; Fairhead and Leach 1996; Peluso and Watts 2001; Davis 2005). Environmental degradation, in other words, has never been an isolated, localized phenomenon. Yet Indonesia's peatland burning and oxidation reveals dynamic impacts of agrarian change on *global* atmospheric processes, contributing to a sense of planetary climate crisis (Fairbairn et al. 2014). The ways in which knowledge of these impacts, in turn, shapes processes of land re-use and re-valuation, though unevenly so. At local and

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[9] Several of the largest transnational oil palm and pulpwood corporations, such as Asia Pulp and Paper, operating in Indonesia have recently enacted "zero deforestation" policies. The efficacy of such policies is obviously complex and beyond the scope of this research.
[10] Land that has not yet been developed for economic purposes is often referred to as *lahan tidur*, or sleeping land, in Indonesian.

regional scales, dangerous particulates from peat fires penetrate human bodies and cross political borders, also raising questions of what conservation and development looks like in rural areas attracting international concern. Finally, as capital continues to rework rural lands that have been left in ruins, questions of what ecological "repair" is in such places— for what ends and by whom—are very much in play. This research thus reveals the politics underlying future trajectories for the remaking of degraded landscapes and the ways in which scientific knowledge is mobilized to shape those futures.

2. Twentieth Century Indonesian Development

Modern Indonesia became an independent nation-state in 1945, after winning independence from the Dutch, under which it had served as a colony for over 300 years.[11] Sukarno, who had led the campaign for independence, was appointed the country's first president. He maintained authoritarian rule for 20 years, balancing the country's military and Communist party interests. In 1965, an anti-Communist revolt led by General Suharto half a million suspected Communists across the country. A weakened President Sukarno was finally overthrown in 1967 and Suharto was appointed as President, beginning the country's "New Order" era. The New Order became synonymous with President Suharto's 33-year reign over an authoritarian, highly centralized government. His administration was vehemently anti-Communist and thus was supported by the United States during much of its rule.

President Suharto became known as Indonesia's "Father of Development" through his commitment to maintaining political order through economic development. As I discuss briefly

[11] It is currently the fourth largest country in the world by population and the largest Muslim country.

in chapter two, New Order economic development was, like most mid-20th century modernization trajectories, associated with large-scale infrastructure projects, increased agricultural yields, and expanded industrialization in Java, Indonesia's most populous island. President Suharto achieved steady economic growth in part through an oligarchic power structure in which Suharto family members and military leaders partook in crony capitalism. After a series of violent student-led protests and the Asian financial crisis, which severely depreciated the Indonesian rupiah (Rp), President Suharto resigned in May 1998. Vice President B.J. Habibie was appointed President until 1999; the country's first direct democratic elections were held in 2004.[12] In an effort to undo and prevent the extensive state corruption of the New Order, legislation was enacted to shift decision-making and spending power to the district level, creating what is now a highly decentralized democracy.

The Mega Rice Project was, in many ways, a spectacular culmination of Indonesia's developmental ideologies during the New Order. Components of the MRP had been executed in various forms and places throughout the country in preceding decades, including peat swamp conversion for agriculture, transmigration programs that relocated Javanese and Balinese peasants to the 'outer islands,'[13] and large-scale infrastructure construction. Thus, the MRP was not a new or particularly surprising plan for Suharto's government. What was unprecedented was the scale of the project: over one million hectares of peat forest was planned for conversion to wet-rice cultivation versus earlier transmigrant agricultural projects that averaged around 10,000 hectares.

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[12] Susilo Bambang Yudhoyono was twice elected President, in 2004 and 2009. Joko Widodo was elected President in 2014.
[13] Indonesia's "Outer Islands" are all of those beyond Java and Bali, including Sumatra, Kalimantan, Sulawesi, and Papua.

Central Kalimantan province was a particularly suitable location in which to execute many of Suharto's development aims through the Mega Rice Project (figure 1). One, the province has historically had one of the lowest population densities in Indonesia, which made it attractive for developers as previously described, but is the third largest province by size. Two, unlike many of the farther flung outer islands, Central Kalimantan's capital city, Palangkaraya, is only one hour by plane from Jakarta. The project was also adjacent to Banjarmasin, the capital of South Kalimantan province and a major trading port. Central Kalimantan's southern coastline borders the Java Sea, which is a waterway used to transport goods between Java and Kalimantan. Historically, Central and South Kalimantan were one province ruled by the Muslim Sultanate of Banjar.[14] While the Banjar people—inhabitants of Banjarmasin—are of Muslim Malay descent, inhabitants of the lowland forest areas of Kalimantan are predominantly indigenous people, called Dayak.[15]

Both the Banjar and Dayak people inhabiting Central and South Kalimantan cultivated rice long before the arrival of the Mega Rice Project. Though they didn't attempt to grow rice in deep peat soils for reasons I describe below, both groups had devised methods to adapt rice cultivation to shallow peat swamps. The Banjar groups constructed small canals called *handil* perpendicular to rivers.[16] Alongside the *handil* they cultivated food crops, including rice, which were irrigated by riverine tidal flows. These fields were never more than a kilometer or two from a major river, so the riverine tides provided nutrients and flushed out soil acidity. This method of rice cultivation is called *padi ladang*, or unirrigated rice. Dayaks, whose villages were

[14] In 1957, the province split into South Kalimantan (which included Banjarmasin) and Central Kalimantan, which encompassed indigenous Dayak-inhabited lowland peat forests, in order to grant indigenous groups more autonomy.
[15] Most of the Dayak groups in the lowland forests and living along rivers are Muslim, while most of the upland Dayak groups are Christian.
[16] Each *handil* functioned as a single social unit comprised of several families.

historically farther up river than the Banjar settlements, also adopted the *handil* method of crop cultivation (Ramonteu, Gutierrez, and Levang 2000). Dayaks have incorporated additional species of rice into this cultivation system, generally referred to as *padi gunung*, or mountain rice, as its origins can be traced to the highland areas of Central Kalimantan. It was in part because of the prevalence of this type of Banjar and Dayak agriculture in the shallow peat swamps around Banjarmasin that Javanese officials believed the area *writ large* would be suitable for large-scale rice production.

3. Tropical Peatland Ecology

Analyzing the disputes that have emerged over carbon emissions, rehabilitation interventions, and agricultural development in Indonesia's peatlands requires a basic grasp of tropical peat ecosystems and what happens when they become degraded. Peat is incompletely decomposed vegetation material that has accumulated in environments that lack oxygen. This surface material is at least 30 centimeters deep, but up to 20 meters deep in some places. Peat deposits are found in boreal, temperate, and tropical zones around the world. Tropical peat differs from peat found in colder climates only with respect to the type of vegetation found in the peat layer and the rate at which the peat layer has accumulated, which relates to temperature. Tropical peatlands comprise 9 percent of the global peatland area, and 14 percent of the global peat carbon stock. Indonesia has approximately 50 percent of the world's tropical peat forests, spread across low-lying coastal areas on the islands of Sumatra, Kalimantan (Indonesian Borneo), and Papua (figure 2) (Wahyunto and Suryadiputra 2008). Other tropical peatlands are found in Central America, the Caribbean, the Western Amazon, and southern Africa (Page, Rieley, and Banks 2011). Radiocarbon dating of Indonesia's peatlands shows that peat formation occurred between the late Pleistocene and the late Holocene geologic periods.[17] Peat found closer to Indonesia's coastlines is geologically younger, formed between 3,500 and 6,000 years ago, than inland and sub-coastal peat. Sub-coastal and inland peat in Central and West Kalimantan formed between 40,000 and 7,000 years ago (Neuzil 1995).

In Indonesia, peat forms up to 100 kilometers from coastlines and river deltas at low altitudes, between sea level and about 50 meters above sea level. Peat closer to rivers and coastlines is shallower than inland peat. When viewed aerially, these wetlands appear to be completely flat, with a consistently level tree canopy (figure 3). Beneath the surface, however, peat soils have a complex geomorphological structure that belies the low elevation, flat terrain. Sub-coastal and inland peat forms a dome structure between two rivers, with peat depths of 20 meters or more found near the mid-point between the rivers and gradually shallower peat near the rivers (figure 4) {Hooijer:2010tc}. Under historically normal weather conditions, intact tropical peat soil is entirely waterlogged. Nearly all of Indonesia's peat forests are ombrogenous, meaning they receive water exclusively from rain rather than from mountain runoff or rivers. This makes for relatively nutrient-poor, and highly acidic, soil. During wet seasons, the water table rises up to several meters above the soil surface, creating swamp conditions. Trees shoot up from standing black-ish water pooled on the forest floor, roots grow upwards through water to reach oxygen. Throughout most intact peat swamp forests, the forest floor is highly uneven with hummocks, large above-ground root tangles, and interconnected pools of water.

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[17] The Pleistocene geological epoch lasted from roughly 2.5 million to 11,700 years ago, spanning several glacial periods. The Holocene epoch began about 11,700 years ago and continues to the present, discussions of a contemporary transition to the "Anthropocene" era notwithstanding.

Though almost no primary peat forests are left in Indonesia today, peat forests were historically biodiverse[18] and a major primate habitat.[19] In intact peat forests (including secondary forests) forest structure and tree species composition is highly correlated with peat depth, nutrient availability, and waterlogging. Shallow peat close to rivers and coasts, where there is more drainage and nutrient cycling, has more diverse forest composition. Tree species found in inland peat forests are typically shorter, thinner, and short living.[20] However, in Central Kalimantan's peat inland forests, the sequence of forest structure change has been found to transition from riverine forest within one kilometer of rivers, to mixed/marginal peat swamp forest one to three kilometers from the rivers with tall trees (up to 35 meters), to low pole forest 3 to 11 kilometers from the rivers (tree height up to 25 meters), to tall interior forest more than 12 kilometers from the river (tree height up to 45 meters). Throughout Kalimantan's riverine peat forests where villages are located, extensive burning and cutting trees has significantly altered forest structure. Few canopy trees (taller than 25 meters) are left in these areas, and sedge and pandan species[21] have replaced trees, especially along waterways (Shepherd, Rieley, and Page 1997).[22]

Peatlands are part of the global carbon cycle through processes of accumulation, which sequesters carbon dioxide from the atmosphere, and degradation through microbial oxidation and fire, which releases carbon dioxide back into the atmosphere. Because boreal and temperate peat

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[18] Peat swamp forests are not, however, as biodiverse as other lowland rain forests in Borneo, such as dipterocarp forests.
[19] Orangutans, gibbons, and various monkey species still live in intact peat forests in Central Kalimantan. Some of these forest areas have protected status for the purposes of wildlife conservation (e.g. SeEx-MRPbangau National Forest). Remnant forest patches in the Ex-Mega Rice Project are also home to small orangutan populations (Cattau, Husson, and Cheyne 2015).
[20] This is a common to lowland peat forests across Borneo and peninsular Malaysia.
[21] In the Cyperaceae and Pandanaceae families, respectively.
[22] A list of trees still commonly found in the Ex-MRP site, see appendix.

deposits did not begin to form until roughly 7,000 years ago, tropical peatlands were involved in the global carbon cycle far earlier than non-tropical peat. Through dead and decomposing biomass—an assemblage of trees trunks, roots, and leaves— peat soils sequester and store extremely large amounts of carbon. Though scientists' estimates vary, recent estimates calculate that peat soils contain roughly 7,000 tons of carbon per hectare below the surface alone, while humid tropical forests on non-peat soils contain between 400 and 700 tons of carbon per hectare in above-ground and below-ground biomass combined (Frolking et al. 2011). Peat soils globally contain roughly 30 percent of total terrestrial carbon stock (Page, Rieley, and Banks 2011). Other recent tabulations have calculated that Indonesia's peatlands alone contain approximately 65 percent of the global carbon stock found in tropical peat soils and nearly 20 percent of peat soil carbon when temperate, boreal, and subarctic peat is included (Hirano et al. 2012).

Undisturbed peat forests are typically submerged in standing water for most of the year. Even during long dry seasons the water table is presumed to be no lower than 50cm below the surface, making sub-surface fires extremely rare in these conditions.[23] Under these hydrological conditions, the soil's carbon remains locked up beneath the surface. In areas where the soils have been intentionally drained, however, the water table can be as low as 100cm below the surface, which increases fire risk and stimulates microbial (aerobic) oxidation, thereby emitting greenhouse gasses (Page et al. 2002; Jauhiainen et al. 2008). Oxidation of dry peat soil is a largely invisible process, though it causes subsidence and compaction of the upper layers of soil. Through oxidation and subsequent compaction, drained peat soil disappears into the atmosphere at a rate of up to half a meter per year even if fire does not occur. Peat fire, meanwhile, has become an annual event in parts of Indonesia. These subterranean fires don't produce visible

[23] Prolonged drought associated with the El Niño Southern Oscillation is presumed to be exacerbating peat fires in recent decades. The largest fires have occurred during El Niño years in 1982, 1997, and 2015.

flames and thus can burn somewhat undetected. Along with carbon dioxide, they release large amounts of particulate matter and aerosols suspended in the white smoke, which is prone to drift far from the fires' origin (figure 5). These smoldering peat fires produce larger amounts of greenhouse gasses and particulate matter than flaming wood fires. From a fire-fighting perspective, a fire is usually considered extinguished if it is no longer producing visible flames. But subterranean peat fires can only be extinguished by prolonged, deeply penetrating rain that sufficiently raises the subsurface water table (Page et al. 2009). Causes and rates of carbon dioxide emissions from peatland oxidation and burning are not simple facts. They are rather, as I argue in this dissertation, the subject of highly contentious debates with political and ecological consequences and surrounded by a lot of scientific uncertainty. I discuss this with regards to national and international development, and agricultural re-development policy, in chapters 4 and 5.

Some of same characteristics that enable the formation of tropical peat forests also position this land well for development initiatives. Indonesia's peatlands have coastal access along relatively calm seas and are intersected by myriad navigable rivers, allowing for easy transport and export ports. Indigenous Dayak people, along with migrants from the coastal city of Banjarmasin, have practiced swidden cultivation in shallow peat along the edges of rivers for hundreds of years. They have also cut small canal passageways, called *tatas*, into the forest to collect timber and other forest products. Smallholders, particularly indigenous Dayak farmers, have long known that agriculture is better suited to the shallow peat soils (of depths ranging from half a meter to roughly three meters). Various species of rice, cassava, vegetables, rubber, and fruit trees can be adapted to the biophysical conditions of shallow peat soils. Cultivating the deeper peat soils is far more difficult for smallholders. As mentioned above, the deepest peat is most often found at the mid-points between two rivers, making this land more challenging to access from river villages. Very low nutrient content and high acidity also demand inputs to raise the pH level, whether through fire ash or chemical fertilizer. As a result, much of the peat forests situated on the deepest peat soils, reaching up to 10 or 12 meters deep before hitting mineral soil, have been altered through decades of selective, illegal logging rather than agricultural cultivation.[24] Both legal and illegal selectively logged, as opposed to clear-cut, peat forests are often designated as "degraded" because of their loss of tree canopy. As a result, NGOs and governments have justified subsuming degraded forests into development regimes on the basis that they aren't suitable for conservation or other ecosystem protections (Hall 2011). Similarly, areas left fallow by peatland swidden cultivators can be classified as idle or under-utilized despite their use by rural inhabitants as part of larger agricultural landscapes or for non-timber forest product collection (Robbins 2001; Nalepa and Bauer 2012; Eilenberg 2014; McMichael 2014).

Additionally, population densities have always been lower in Kalimantan's lowland forests than in Java and Bali, where intensive paddy rice agriculture, or *sawah*,[25] predominates (Geertz 1963). Thus, the peatlands have often been further characterized by Javanese government officials as marginal or idle land because they lack both the intensive irrigated agriculture of Java and Bali and the richly valuable timber species found throughout Indonesia's humid forests rooted in mineral soils (Dove 1985). As further described in chapter two, coastal peat forests of Indonesia were targeted for transmigration projects throughout the 20th century because of their relative accessibility and because they were perceived to be uninhabited. Today,

[24] Timber companies during the Suharto era primarily extracted *Calophyllum sclerophyllum*, *Cratoxylum glaucum*, *Dactylocladus stenostachys*, *Gonystylus bancanus*, *Shorea balangeran*, and *S. teysmanniana* from the marginal peat forests one to three kilometers from rivers (Shepherd et al. 1997).
[25] *Sawah* also means rice in the husk.

the perception persists among Javanese and other elites that Kalimantan's peat forests have few inhabitants, and few land conflicts. This makes this land further attractive to developers for both agribusiness and conservation projects. Thus in many ways, Indonesia's peatlands fall into dual categories that have enabled "land grab" dynamics elsewhere: land perceived to be marginal "wasteland" while simultaneously having biophysical characteristics and existing infrastructure to make it relatively accessible for development (Nalepa and Bauer 2012; Baka 2014).

4. Knowledge Regimes and Land Development

For the past 15 years, scholars have drawn on James Scott's *Seeing Like a State* (1999) to analyze how states manage—or rather, *fail* to manage—environments and populations through processes of legibility, simplification, and standardization (Ferguson 2005; Sivaramakrishnan 2005). Scott argued that state-led schemes to "improve the human condition" fail because government technocrats ignore "local" knowledges in the implementation of such schemes. In offering a critique of Scott, Tania Li (2005) asserted that "postmodern" states—alongside actors such as NGOs, scientists, and various global consultants—actually incorporate or appropriate local knowledge as they see fit. Other scholars have echoed this approach, arguing that states, to various degrees, organize, concentrate, and disseminate local knowledge about environments. They also combine local knowledge with state-created technocratic knowledge (Akhil Gupta 1998; Mitchell 2002).

However, throughout these analyses of relations between states and environmental knowledge practices, the knowledge in question remains *local*. Whether grounded in understanding of irrigation systems, agricultural techniques, or forestry management practices, the knowledge regimes that the state interacts with (or fails to interact with) is a knowledge tied to specific locations, most often framed at the village level. Though Trevor Birkenholtz asserts that knowledge practices enacted by local-level government officials can be “global” if such technocrats acquire knowledge abroad (2008) or import practices from elsewhere as with colonial administrators (Mitchell 2002), the environmental knowledge in question nevertheless focuses on knowledge practices developed and enacted in specific, largely rural, places, by peasants or other rural actors who have a stake in safeguarding their own expertise. Justifiably, many of these accounts of how local knowledge operates within or against state-led schemes is an attempt to counter privileged or elite knowledge, particularly that which originates in the Global North and has been applied in the Global South (Timothy Forsyth 1996; Zimmerer 1996; Fairhead and Scoones 2005).

In my analysis, I look at how knowledge flows in the opposite direction: how do state and non-state actors at various scales appropriate, react to, or contest *global* knowledge? Such global knowledge practices and products might be, as I expand on below, a composite of knowledge scaled up from local places, or they might be something fundamentally different. I also contend that such global knowledge is then reworked at local scales, or currently in the case of the Ex-Mega Rice Project, in the degraded peat swamp itself. Regardless, the ways in which particular sites contribute to global environmental knowledge, such as that related to climate change, is a shift away from privileging local environmental expertise within studies of socio-environmental relations. Ultimately, I ask how the politics of knowledge—mostly scientific but also expertise as practiced by non-scientists—enables new forms of economic value in landscapes classified as degraded. To begin to answer this question, I situate this analysis within three complimentary conversations: an emergent geography of science, the knowledge politics of land grabbing, and new valuations of degraded land.

A conceptual framework around the notion of "knowledge regimes" draws together the ways in which scientific understanding of a particular problem is materially related to action on the ground through political order. Rebecca Lave (2015) defines scientific regimes as the relations between scientists and economic, political, and military elites at particular historical conjunctures. Building on this, a knowledge regime frames the ways in which scientific actors (both trained experts and those expected to carry out scientific practices) are organized around a particular scientific paradigm, the ways in which this impacts scientific practices, and how the politics of those practices impact the environment. As such, a knowledge regime offers a way to understand how power is operating between actors with a stake in producing, contesting, or silencing scientific knowledge, without over-reliance on normative explanations of capital accumulation as the impetus for action.

Positioning Global Science within Human Geography

Understanding of how global knowledge is produced is underpinned by questions of "how and why people come to conceptualize the world in global terms" (Miller 2000, 47; see also Hulme 2010). The ways in which knowledge is made in particular places figures closely in this. Yet it is not immediately clear if 'global' refers to an aggregation of knowledge made in local places or if it is something fundamentally different, more akin to "globally systemic change" (Hulme 2010, 563). Forsyth (2003) argues that global environmental problems can actually be reflective of local approaches and practices (167) because they are defined by located societies and networks with their own socio-political values. Sheila Jasanoff (2010) also suggests that global environmental problems and their associated transboundary movements of molecules and people can help dismantle “rigidly place-based justifications for caring about others” (246). This suggests a scaling up and out of responses to such problems, but it also requires understanding how such global environmental problems come to be seen as problems, and to whom. Attention to spatial relationships of power in making global knowledge—and in making knowledge global—while paying attention to cultural differences in the process, is similarly necessary.

Critical analyses of the production of scientific knowledge mark a relatively recent turn within political ecology research (Goldman, Nadasdy, and Turner 2011; Lave 2012; Fleming 2014). While political-economic and ecological phenomena have long been in tension within the discipline, and not always attended to equally (P. Walker 2005; Turner 2015), Tim Forsyth suggests that explanations of biophysical events and processes, as well as analysis of the political implications of biophysical events, should be a core part of political ecology, yet rarely are (T Forsyth 2003). Political ecologists have partially responded to this gap by deploying concepts from Science and Technology Studies, such as hybridity (Swyngedouw 1999), to advance understanding of socio-environmental relations. Critical analyses of the production of biophysical knowledge also have been central to a Science and Technology Studies (STS)-inflected political ecology (Duvall 2011; Lave 2012).

Scholars advancing ‘critical physical geography’ propose intertwining biophysical and human geography at a foundational level in order to better understand the production of environmental knowledge. Combining knowledge of a subfield of physical science with attention to power dynamics and socio-historical relations of scientific practice can, critical physical geography proponents hope, move geographical research towards more balanced understanding of both the ‘political’ and the ‘ecological’ (P. Walker 2005; Lave, Barron, and Carey 2014).

Some critics of this approach — as both a research methodology and a theoretical framework— argue that this does not sufficiently address ways that physical geographers can fundamentally approach their work with a more critical eye. They suggest this approach may simply replicate longstanding calls in political ecology for more biophysical science yet still from a human geography-centric starting point (Tadaki et al. 2014). While urging a move towards a more critical physical geography from *inside* physical geography is commendable, it still leaves open the question of how to adequately address the ecological and the political within one frame, especially when the researcher isn't necessarily trained in biophysical scientific methods.[26] As Matt Turner argues, this type of engagement can actually take many forms, though the products of this are likely not up to the research standards of biophysical scientists, as critical physical geography aims for. The value of such engagements, he explains, instead "lies in the degree of socio-ecological integration made possible by documenting ecological response in particular geographic and historical contexts where ecological research is often lacking" (2015, 6).

Geography of science offers one possible route forward. Taking a cue from historians of science, geographers of science have interrogated how science is produced by individual actors in places as well as across time periods (see also Barnes 2001; Livingstone 2003). As Powell (2007) describes, a strength of analyzing the physical surroundings influencing scientific practice is that it ascribes meaning to scientists and non-scientists through social mediation. Yet most geography of science literature, a particularly small subfield within human geography, leans more closely to STS than to critical human geography. While it offers strong interrogation of how knowledge production is spatialized, it nevertheless avoids political economic concerns most of the time. Questions of land and resource access are quietly sidestepped, as are concerns

[26] I offer this as a point of self-critique as well.

with the Global South, broadly speaking. Forsyth (T Forsyth 2003) called for more research on the power relations and political maneuvers behind many well-known scientific issues, though without invoking geography of science outright. A more critical geography of science, then, brings politics and power relations to the forefront of research on how scientific knowledge is produced in specific locations.

Interrogating scale and scalar relations through a geography of science is one way in which to theorize how and why knowledge is made global and how global knowledge is made. Geographers of science are well-positioned to assess ecological change—and especially the *knowledge* of that change—within and across scalar registers. While STS scholars have long taken this approach with fields of science other than ecology, Latour-ian influenced STS and proximate research has, as noted above, typically overlooked field-based sciences. Attention to scalar politics, similarly, hasn't figured in most STS-based research. Environmental change at a global register, meanwhile, has only recently been given attention in political ecology, given the discipline's longstanding commitments to socio-environmental relations at local scales (Peet, Watts, and Robbins 2011). Of course, global processes are often implicit in political ecological research and to a lesser extent, scalar politics are made explicit (Neumann 2008; Rangan and Kull 2009). What Brown and Purcell (2005) call the "scalar trap" in political ecology is a presumption that local actors and organizations are more effective at creating environmentally sustainable solutions, social justice outcomes, and democratic outcomes than actors at other scales. Brown and Purcell argue that for most political ecologists, the "global" or larger scale has become synonymous with political economic processes, while culture and ecology unfolds at "local" or smaller scales.

For most geographers of science and STS scholars, knowledge travels between *local* places, but not necessarily across scales. As Goldman and Turner (Goldman, Nadasdy, and Turner 2011) point out, a 'crisis mentality' in environmental research—particularly with respect to global climate change—can enable the transfer of knowledge developed in one place to somewhere else. But prior to the emergence of thinking about the environment and/or climate as a unified, global whole (Miller 2000), ideas about how to best use Indonesia's peatlands were shaped by national and colonial political-economic dynamics as the country transitioned from authoritarian, centralized rule to a decentralized democracy. Knowledge about peat ecology also jumped from one Indonesian island to another, as certain actors presumed wetland development on one island would be successful on others, irrespective of ecological difference. Analogous application of knowledge also occurs across scales, as scientific claims are scaled up or down between places. Such claims might also simply move between locations or ecosystems perceived to be analogous. This is one way in which to analyze the circulation of scientific knowledge: how ideas are applied across places, in addition to shared and understood within communities of actors.

So, what can a geography of science contribute towards an understanding of how peatlands are made legible, or illegible? How does scientific carbon forestry depend on this legibility? Drawing on Thomas Kuhn,[27] Shapin (1998) argued that "We need to understand not only how knowledge is made in specific places but also how transactions occur between places" (6). But although science is produced locally, knowledge claims deemed true enough or produced by the right actors can circulate widely—becoming consensus—despite the fact that

[27] Thomas Kuhn (1970) first upended belief in a universality of science, showing that science was conceptually heterogeneous and also the result of diverse methodologies rooted in places, that actors practicing science were influenced by their surroundings and inter-personal relations.

truth is presumed to be universal, not geographically located or place-dependent. As Powell (2007) argued, "The place of knowledge is fully imbricated within networks of power relations, and in perceptions of the validity and legitimacy of that knowledge" (312). Yet place, for many STS scholars and many practicing scientists, no longer "adds credibility to scientific claims, but only because those places of inquiry have been carefully designed and built to be identical" (Gieryn 2002, 127). The standardization of most research laboratory settings ensures that scientific claims are transferable across places, and that those claims can remain true everywhere.

Finally, a geography of science can help us understand how certain research sites become privileged within the scientific community, as this process is rarely made explicit. Most research in STS has held onto the notion that epistemic scientific claims were produced in laboratories with controlled variables, not physically difficult outdoor spaces like tropical swamps. But for political ecologists and for geographers of science, the field site—not the laboratory—is more often the place where the production, circulation, and application of knowledge coalesce. We need to interrogate how these field sites are selected and how they are maintained. Few Science & Technology Studies or other scholars have ventured into the physical fields in which the ecological sciences conduct research to understand how these scientific practices change the environment in which they are working (Lowe 2006; Hennessy 2014). The practices of scientists and other actors conducting research in 'messy' places, such as tropical swamps, remain under-explored as a result. This is the case even within political ecology, which contends to study politics as they are enacted through the environment (Goldman, Nadasdy, and Turner 2011). Many questions thus remain about the relationships between scientists, non-expert actors trained to conduct science, and the material field that they study (in which they also work). How, for instance, do scientific practices as they are enacted in the field reconfigure power relations among actors at the local scale, or between local actors and actors at other scales? Star and Griesemer (1989) argue that new research methods and procedures are research goals in themselves, as a means to building new scientific institutions, which function as centers of authority and credibility. Scientific practices and the ways in which those practices alter a material environment then become less significant for the data that they produce and more for the ways in which they advance new institutions and ultimately underpin development.

Land Grabbing and the Knowledge Politics of Land Suitability

The recent emergence of transnational land deals, or "land grabs," has prominently shaped contemporary socio-ecological relations in degraded tropical landscapes. Global land grabbing has become shorthand for recent, rapid, and large-scale land investments for agricultural commodity production (De Schutter 2011; Borras and Franco 2012). National and transnational land acquisitions have indeed occurred prior to this contemporary moment. But McMichael (2014) argues that a particular crisis-motivated juncture of food, fuel, and climate shapes current mechanisms of large-scale land control, especially as corporations, investment firms, and wealthier countries seek land throughout the Global South[28] (Peluso and Lund 2011). Particularly in tropical countries, climate change narratives justify biofuel crop expansion by promoting oil palm and other biofuels as fossil fuel alternatives, even though the vast majority of

[28] In addition to historically 'developed' countries appropriating land in 'developing' countries, other transnational relations are also emerging around land grabs. For instance, China, Saudi Arabia and the Emirates have become a major player in land deals throughout Africa, while Malaysia seeks land in Indonesia, even though Malaysia is generally considered a "developing" country. Clearly, the regional geopolitical dynamics are as important in shaping land deals in tropical countries as traditional international dynamics (see chapter 5).

oil palm is consumed as food, not biofuel (Borras and Franco 2012; Nalepa and Bauer 2012). Furthermore, climate change mitigation strategies can justify large-scale land acquisitions if expanded food or biofuel crop production in a particular location enables high-carbon value forest conservation elsewhere (Perfecto, Vandermeer, and Wright 2009; Hecht 2010; McMichael 2014).

But these drivers of land grabbing, while critical to analyze, don't in themselves explain the complexity of socio-ecological responses—and crises—that ensue when land is consolidated and acquired by corporate and transnational actors. Several scholars have analyzed the uneven socio-political outcomes of recent land grabbing dynamics. These land deals have generally been detrimental to smallholders and other rural inhabitants, though inconsistently so (Li 2011; Fairhead, Leach, and Scoones 2012; Hall 2012). Less attention, however, has been paid to the ways in which land grabbing generates socio-ecological crises at multiple scales, which in turn catalyze or alter further land grabbing mechanisms and outcomes (Dauvergne and Neville 2010; Nalepa and Bauer 2012). Few studies, however, have articulated how certain lands and ecologies are managed through land grabbing, and how that environmental management is underpinned by knowledge claims of land's suitability for consolidation and development.

While emergent agricultural development paradigms are explained as a response to anticipated environmental change, as with biofuels and carbon offsets, it is still unclear how land grabbing is simultaneously a response, and contributor, to global ecologies through land acquisition itself. Clearly, large-scale land-use change impacts the environment at multiple scales. Lazarus (2014) argues that land grabs cause unprecedented biophysical change (Paoli et al. 2011; Wicke et al. 2011) but that the physical sciences have not yet shifted their attention to the biophysical dynamics of land acquisitions and conversions. But as forested land is continuously converted into mono-crop agricultural plantations, many experts have in fact scrutinized the biophysical consequences of these land use changes, if not explicitly within the political-economic contexts of land grabbing (P. Edwards 2010; Ziegler et al. 2012; Hergoualc'h and Verchot 2013). It is of no surprise then that the risks and resiliencies of large-scale land transformations are similarly cast in global terms, such as through carbon emissions threats. As Philip McMichael (2014: 35) asserts, "The dominant development paradigm views management of the future as a planetary operation, an intensified 'global ecology' involving rational planning of planetary environmental spaces." Within this rationale, management of global biophysical systems occurs *through* development, of which land grabbing is increasingly part.[29]

Just as contemporary transnational land deals are better analyzed as a bundle of "institutions, practices, and discourses of territory, sovereignty, authority, and subjects" (Wolford et al. 2013: 194) than as having an essential set of criteria or characteristics, the diverse ecologies that undermine—and are undermined—by land grabbing also need to be assessed. Some scholars have framed land transactions as a *response* to this multi-pronged ecological crisis rather than generative of ecological crisis itself (Borras and Franco, 2010: Fairhead et al, 2012). Moore (2011) urges us to consider global environmental change through intertwining socio-ecological relations, as opposed to through socio-economic *drivers*, as some land grabbing studies have (Zoomers 2010). The traditional tools of political ecology have proven useful in articulating global environmental change through the application of scientific knowledge and the political economies in which those applications are embedded. Goldman and Turner, for example

[29] Recent attention to what Anthony Bebbington (2012) calls "a political ecology of the subsoil" in reference to extractive regimes for oil, natural gas, and minerals has also shown that land grab politics do extend to the subsurface (see also Bebbington and Bury, 2013). A more expansive political ecology of the subterranean, therefore, requires attending to the land grabbing dynamics playing out *in* and *through* the soil itself in ways that complicate perceptions of the subterranean as solely a site of extraction.

(2011: 16), propose political analysis that incorporates “the influences that shape how these claims arrive at the sites of contestation over resource access” and, as a means to doing so, tracing the circulation of environmental knowledge as this knowledge becomes *information* (Forsyth:2003ug, Rocheleau:2007hf}. Taking socio-ecological relations, then, as a point of departure enables us to interrogate how contemporary land deals intervene in biophysical ecologies (and subsequently, in planetary environmental spaces), and how and by whom those relations are conceptualized and circulated.

It is no longer enough for scientists, policymakers, and developers to ask what land *is* suitable for large-scale acquisition and cultivation and can thus be smoothly incorporated into land grabs. Following Li (2014), the question has instead shifted to what land can be *made* suitable and thus attract additional investment. Suitability, for some actors with economic interests in land grabbing, is synonymous with profitability. For others, suitability raises concerns about socio-ecological changes following large-scale agricultural development. What, then, are the politics of considering land suitability: appropriate for what, for whom, and how do we know? One set of actors that has been conspicuously absent from many land grabbing analyses is research scientists, particularly those who interact with biophysical systems *in situ* or remotely (though Scoones et al, 2013 point out the significance of social scientists and policy makers in generating land grabbing knowledges). James Fairhead et al (2012) argue that scientific experts are key actors in circulating knowledge about human-ecological relations, particularly in the context of land appropriation. In considering how political economy shapes the production and circulation of knowledge claims, geographers engaged with Science and Technology Studies (STS) have pointed out that epistemological differences can create divergent understandings of environmental change (Duvall 2011; Goldman, Nadasdy, and Turner 2011;

Lave 2015). For Sarah Whatmore (2009), scientific knowledge is not only used to settle disputes but is mobilized to *produce* disputes that can be leveraged to obscure political relations. Claiming expertise and working within international networks that circulate their claims(Braun 2000; Vandergeest and Peluso 2006), scientists' knowledge is crucial in determining land's potential ecological suitability, or unsuitability, for agricultural development.

The Afterlife of Degraded Tropical Land: New Trajectories for Development[30]

Degraded tropical land is increasingly being considered economically and ecologically valuable (Barlow et al. 2007; Berry et al. 2010; Gingold et al. 2012; Putz et al. 2012). Since the United Nations set the agenda for Reducing Emissions from Deforestation and Degradation (REDD+) in 2007, policymakers and scholars have paid increasing attention to the carbon emissions risk of degraded tropical forests (Murdiyarso et al. 2008). Most of the recent empirical and theoretical literature on REDD+ and forest carbon finance has analyzed emissions reductions from deforestation, while paying less attention to the second "D," degradation (Hosonuma et al. 2012; Mertz et al. 2012). Meanwhile, in a departure from prioritizing conservation of primary forests and biodiversity "hotspots" (Myers et al. 2000), some recent ecological research has begun to consider logged and secondary forests as valuable for biodiversity and thus worthy of protection (Gavin 2004; Lamb, Erskine, and Parrotta 2005; Ashton 2008; Chazdon 2008; D. P. Edwards et al. 2010; Putz et al. 2012). Concurrent with these emerging conservation discourses on degraded tropical forests, increased demand for food and biofuel and assumptions about rising

[30] This sub-section draws upon J. Goldstein (2014) "The Afterlives of Degraded Tropical Forests: What Value for Conservation and Development?" *Environment and Society: Advances in Research* 5 (1): 124-140

land scarcity (McMichael 2014) has positioned degraded land as ideal land for tropical agricultural development (Hall 2011; McCarthy 2012; Nalepa and Bauer 2012; Baka 2013).

Practically and discursively, land degradation is largely associated with depreciating value rather than a complete destruction of value. But of what value for future accumulation are degraded tropical lands that have lost ecological function and thus are presumably generating little value in biological or financial terms? While the relationship between capitalist extraction of natural resources and environmental degradation is well documented, there is less certainty regarding how capital encounters post-extraction environments and circulates through non-linear trajectories of value creation. Following Blaikie and Brookfield's foundational *Land Degradation and Society* (1987), a generation of scholars has shown how narratives of environmental degradation justify land and resource appropriation (Peluso 1991; Batterbury and Bebbington 1999; S. Jones 2008). Political ecologists and proximate scholars have also asked incisive questions about the causes and consequences of environmental degradation, as well as the social construction of degradation narratives (Zimmerer 1993; Timothy Forsyth 1996; Kull 2000; Davis 2005; Fairhead and Leach 2014; Kolås 2014). Yet Blaike and Brookfield didn't show explicitly how environmental degradation accompanies a loss or gain in land value, economic or otherwise. While they considered a loss of land capability through degradation in reference to how the land was able to provide services for people, Blaike and Brookfield determined that "value" was too challenging a concept to analyze in relation to land and consciously set it aside (1987, 6; also see Robertson and Wainwright 2013).

The growing body of literature on ecosystem services valuation is one of the few academic conversations that has engaged directly with the economic value of nature (Daily 1995; Costanza et al. 1997; Costanza 2003). Payment-for-ecosystem-services schemes involve market mechanisms set up to pay landowners or users to maintain ecological functions such as water and soil quality (McAfee 1999; 2003; Robertson 2006; Sullivan 2012). Scholars critiquing payment for ecosystem services rightfully assert that these schemes push nature deeper into market exchanges that emphasize price value at the expense of other values (Sullivan 2013, 3). Ecosystem service valuation as it stands is also limited by its conceptual framing of landscapes that can be ecologically simplified and parceled (Norgaard 2010) and have documentable conservation potential. Gomez-Baggethun and Ruiz-Pérez (2011) emphasize that ecosystem service valuation has enabled a shift in assuming nature's benefits as having use value to conceptualizing the same benefits as having exchange value with the objective of countering ecosystem decline for both social benefit and financial profit. Robertson and Wainwright (2013) are similarly critical of scholars who assume an ecosystem's value is self-evident (e.g. Daily 1997). This presumption also closes off the possibility of value through diminished ecosystem services: most literature on nature's commodification assumes an ecosystem as something *a priori* worth conserving for its existing functional services (R. Walker 1973; Daily 1995; Costanza 2003; McAfee 2012). Despite potential for re-valuation through restoration or rehabilitation (Robertson 2000), degraded tropical forests generally fall outside the standard conceptual rubric of ecosystem service valuation regimes.

If it is highlighted at all, the relationship between environmental degradation and value in political ecology and proximate disciplines has linked increasing ecological degradation to declining land capability and thus diminishing value to users. Robertson and Wainwright recently argued that the definition of value has become a newly "important point of contestation in the attempt to develop policies that work to define nature as a commodity" (2013, 3). They call for a return to a theory of value in considering environmental change, citing the dearth of political ecology literature engaging with value theory specifically, despite extensive critical research on nature's commodification and ecological encounters with neoliberalism (Castree 2003; Liverman 2004; Robertson 2006; Bakker 2010). Jason Moore (2011) proposes that rather than remaining stuck with stale questions and inevitable answers about capitalism's negative impact *on* nature, we can advance understanding of socio-environmental relations to see capitalism as developing *through* biophysical crises (L. Johnson 2010; McMichael 2014). Through this lens, then, forest degradation is not an exhaustion of resource value or an obstacle to new forms of use and exchange value. It is a productive re-working of economic value.

So how, then, are we to think of degraded forests as valuable? Nascent scholarship on what Scott Kirsch calls "new geographies of waste" is one potentially provocative entry point to tracing degraded forests within "wider circulations of value and values" (Kirsch 2012). Sarah Moore further catalogues the rise of geographies of waste as a lens for understanding environmental politics, (2012, 780), showing usefully how waste can be mobilized as a concept that disrupts socio-spatial norms through its various relations to society (781). Though these studies don't engage with forest ecologies specifically, they how show how things discarded or exhausted of value come to matter, and to whom (Gregson et al. 2010; Gidwani and Reddy 2011; see S. Moore 2012 for full review).

Waste is also a word that acquires political potency, despite involving entities that are initially marginal, residual, unimportant, or unpalatable to society (Gidwani 1992). Geographically marginal land, whether along edges of roads, fields, or forests, on steep hillsides with infertile soils, far from existing centers of production, or with a history of depopulation, has a history of being perceived as economically and politically marginal (Geertz 1963; Bryant, Paniagua, and Kizos 2011; J. Goldstein 2012; Nalepa and Bauer 2012). In colonial India, control over wasteland was central to colonial power over indigenous communities and, significantly for contemporary forest degradation, to scientific control over the environment (Gilmartin 2003). As Whitehead {*Whitehead:2010ut} and Gidwani (2012) point out, calling idle, untapped, or economically unproductive land "wasteland" implies its wasted potential for economic productivity, thereby lending it potential for value. In the shift from perceiving open fields and common lands as common "wastes" to seeing them as "wasted commons" or wasteland during England's enclosure movement, Jesse Goldstein proposes that a qualitatively different kind of land was produced. He observes that *terra economica* is "a landscape of wasted potential" (J. Goldstein 2012, 2) in a capitalist world that constantly seeks new capital through modes of enclosure that necessitate violent erasure.

Historically, English "common wastes" were fields or fallows in which women, children, and the poor without land of their own were free to forage, play, and work (J. Goldstein 2012). Similarly, Gidwani and Reddy (2011) show how scrub land, pastures, and shifting cultivation fallows in India today act as commons for marginalized people, who use them for food and fuel collection. By officially classifying these commons as wasteland, the state hides the ways in which these areas are *already* included in circuits of value and provide crucial resources for the poor and marginalized. Classifying tropical forests as degraded might similarly obscure the ways in which these lands are already incorporated into circuits of value production, whether through selective illegal logging or for other local forest uses. Therein lies a potential contradiction in degraded tropical forests' value. While states and other environmental governing institutions categorize degraded forests as a means to re-appropriation and future economic production, if forest degradation as a category continues to resist definitional unanimity, this accumulation may remain incomplete.

Underpinning some of the literature on the importance of defining and measuring land degradation is an assumption that this land can, and should, be repurposed for much-needed food and fuel production (e.g. Bailis:2011dg}. As Wolford et al. (2013) describe, degraded tropical land is increasingly seen as a solution to the global land crisis, or the diminishing availability of agriculturally productive land. Jennifer Baka (2013) shows how "wasteland governmentality" is integral to the global land grab and is driving state acquisition of perceived wasteland in India for biofuel production, despite this land's ongoing incorporation into common property regimes for local energy crop use. As Nalepa and Bauer argue in reference to marginal land, a category not wholly different from degraded land, developing countries have incentive to encourage the "marginal lands narrative" by promoting this idle, unproductive, or wasted land as a new natural resource available for economic development (2012, page 404). In this context, marginal land as a global-scale land cover category are defined as lands that are potentially arable but have characteristics that make them difficult to cultivate, such as soil contamination, little water availability, or lacking market infrastructure. Throughout the marginal and waste lands narratives are references to the same biophysical characteristics referenced in forest degradation definitions, though without acknowledging the gradient of ecological change ecologists say is implicit to definitions of degraded forests.

In many tropical countries, degraded forests are being re-purposed by state and non-state actors for agricultural development as states and corporate actors seek to re-extract economic value from these post-logged, disturbed, and secondary forests (Sist and Sabogal 1999; Hall 2011; McCarthy, Vel, and Afiff 2012; Nalepa and Bauer 2012). NGO and government rhetoric about the extensive amount and underutilized capacity of land categorized as degraded has drawn attention to degraded land for new agricultural cultivation (Bailis and Baka 2011; Gingold et al. 2012), despite the aforementioned obstacles to detection and measurement. Policies directing development onto degraded land is also partially a response to decades of mounting pressure to protect primary tropical forests by cordoning them off as biodiversity reserves or national parks (Hecht 2010). In Indonesia, for example, recent government and NGO policy has encouraged the conversion of 15 to 20 million hectares of degraded land to oil palm plantations, which will "save" forests with existing biodiversity (Murdiyarso et al. 2008; D. P. Edwards, Koh, and Laurance 2012). These directives have been supported by the Roundtable on Sustainable Palm Oil, the World Resources Institute, and the World Bank, and seek to increase overall agricultural production while protecting the most "valuable" forests for biological conservation and carbon stock preservation (Gingold et al. 2012; Gibbs and Salmon 2015). However, without policy directives or exogenous financial incentive, companies accustomed to profiting from forested land through timber extraction prior to cultivation might resist swapping forested land for degraded land.

While environmental degradation caused by peasants and their farming practices might once have been enough to justify state appropriation and privatization (Robbins 2001), that is no longer a sufficient condition for locating and incorporating degraded land into neoliberal relations (Fairhead, Leach, and Scoones 2012; McMichael 2014). New technologies and elite actors create and identify degradation (Peluso and Lund 2011), while state decentralization makes village leaders complicit in local land dispossession by signing business deals with corporations, as I discuss in chapter 5. This further justifies identifying those rural lands as degraded, with potential for improvement by corporate control. New actors and opportunities emerge in defining and measuring degraded forest land as a natural resource, a pre-condition for commercial value extraction (Nalepa and Bauer 2012, Robertson 2012). But the transfer of degraded forest control should not be assumed as a pre-determination of power. In his historical analysis of the shift from industrial forestry to community forestry in Mexico, Andrew Mathews (2011)shows that the expansion of commercial logging infrastructure into forests enabled a countermovement through which indigenous people realized the financial value of the forests and then successfully asserted resource control.

For degraded tropical land to be incorporated into new circuits of resource extraction and production, is must be abstracted from local, subtle, non-linear ecologies and made into a singular land use classification. As Morgan Robertson explains, “Value, if and when it comes to rest in the social abstraction that stands in for the complicated ecosystem, comes from the success of rendering the ecosystem measurable and comparable with other ecosystems, not from nature itself” (2012, page 394). Making degraded forests commensurable, then, requires precisely the kind of abstraction and measurement that degraded forests have resisted.

Concurrent with discourses on the economic potential of developing degraded forests for agricultural production, there is an opportunity within ecological rhetoric for biodiversity and carbon conservation through forest rehabilitation. But tropical forest rehabilitation relies on definitions of forest degradation that incorporate non-linear ecological dynamics. It also requires a guiding baseline to which the forest can be partially returned (Chazdon et al. 2009). In looking at new forms of land appropriation—what has been dubbed ‘green grabbing’—Fairhead, Leach, and Scoones (2012) propose that there has been a fundamental shift “in the structure of economy-nature relations,” from value of nature for conservation or sustainability of resources to now reflecting the “value of what we might call ‘the economy of repair’” (2012: 242). The economy of repair is embedded within sustainability rhetoric but contends that unsustainable use in one location can be repaired by sustainable use somewhere else. Damage inflicted on nature, therefore, creates opportunities for new economic growth, through ecological repair or improvements. To extract the most value (as profit) from nature, both growth and repair need to be maximized (Fairhead et al. 2012), the possibility of which is rendered clearly in classification of degraded forests.

To make any of this value commensurable, science and policy work in tandem to create definitional and methodological equivalence across spaces. These methodologies link ecosystems to places while simultaneously making them generic abstractions that can then be brought into the realm of commodification (Fairhead et al. 2012, Nalepa and Bauer 2012). For degraded land in one place to be assigned a market value it must quantitatively equal degraded land in another place, however qualitatively different those places might be (Gomez-Baggethun et al. 2011). But as Fairhead et al. (2012) point out, the promise of scientific certainty rather than the actual findings of techno-science to render land degradation a commensurable abstraction may be enough to assert its value (see Ziegler et al. 2012).

Furthermore, as I discuss in chapters 4 and 6, the overriding emphasis on using remote sensing as a method for detecting tropical land degradation encourages measurement of carbon stock as a primary guideline for determining whether a forest is degraded and worth protecting or rehabilitating through REDD+ schemes (Herold et al. 2011; Romijn et al. 2013). In a study of above and below ground carbon stock, researchers found that out of ten land cover categories, logged-over forest had the second highest carbon stock both above and below ground following intact forest. They suggest that logged-over forests, despite their frequent classification as degraded, could be left alone to completely regenerate into secondary forests with additional carbon sequestration capacity. Land with less existing carbon stock could also be "improved" to yield more carbon storage, by converting grasslands to agricultural plantations for example

(Ziegler et al. 2012). Moreover, given that climate change is expected to create unpredictable ecological dynamics causing additional degradation, parsing out natural from anthropogenic causes might present an even larger challenge for REDD+ projects seeking to isolate drivers of forest change and generate financial value.

5. Chapter Summaries

I begin by charting the history of the Mega Rice Project in order to show how this site became ecologically degraded through a large-scale centralized development project. Chapter 2 thus lays the groundwork for understanding the relationship between emergent scientific knowledge regimes in the early 21st century, large-scale agrarian development, and how the Indonesian government has sought to extract value from peatlands. It briefly traces the history of peatland development in Indonesia through the 20th century, highlighting how President Suharto's government struggled to use peatlands for transmigration projects. Under Suharto's authoritarian government, scientific knowledge was largely ignored or repressed unless it matched national economic development objectives. This chapter shows how the Mega Rice Project exemplifies this, as the project proceeded despite quiet acknowledgement from scientists that it would likely not work as planned. The chapter then discusses how the Mega Rice Project unfolded on the ground, through to its abrupt end with the fall of Suharto's government in 1999, to show how the project left behind a complex degraded landscape. I also describe how the project left the site with heterogenous land cover and thus different trajectories of land use and livelihood possibilities for the area's inhabitants, with a focus on Dayak and transmigrant communities.

Chapter 3 then turns to the circulation of scientific knowledge about Indonesia's peatland emissions, and how the MRP site became valuable within global understandings of land-based carbon emissions. It traces the initial production of this carbon-driven knowledge regime to the demise of the Mega Rice Project and argue that this understanding served to position Indonesia's peatlands within global political and economic circuits related to climate change as a threat to the planetary atmosphere. It then considers how conservation and rehabilitation projects in the ex-Mega Rice Project (EMRP) site became framed in terms of global carbon offsets as a result of this scientific understanding in the early 21st century. This leads to the development of a Reducing Emissions from Deforestation and Degradation (REDD+) project in the Ex-MRP site. I also consider how peatland rehabilitation is being enacted in the area through canal blocking/damming. This raises questions of whether there is a "nature of repair," or if peatland ecosystems will recover without human intervention.

Chapter 4 assesses some of the mechanisms through which degraded peatlands are being made valuable through the carbon-driven knowledge regime established in chapter 3. The international positioning I argue for in chapter 3 has consequences for Indonesia's domestic climate policy and for the country's land use policies in peatlands. Pivotally, as REDD+ emerged as the dominant mode of terrestrial carbon conservation at the UNFCCC Convention of the Parties (COP) meetings in the mid-2000s, knowledge of tropical peatlands' carbon source capacity rose to the forefront of the international science-policy community. The change then considers how participation in international climate change mitigation programs, such as REDD+, requires financialization of land-based carbon emissions, which in turn requires—and constructs—precision in measuring carbon stock and carbon emissions. In the case of the REDD+ project that occurred in the EMRP site, acquiring precise carbon data in a degraded peat swamp is limited by the physical difficulties of doing science in a swamp. Some places are more difficult to access—physically or bureaucratically—than others, leading to accumulation of data from some places but not others. Though the REDD+ project was only funded from 2010-14, I assert that the REDD+ project is still continuing to build scientific infrastructure through the emergence of the Indonesian National Carbon Accounting System (INCAS). Data on peatland carbon stock from the Ex-MRP site are being leveraged to construct this national system, which the Indonesian government can then use in international climate change debates.

Chapter 5 turns to the ways in which degraded peatland has become a viable site for oil palm cultivation—through land grab dynamics that have also unfolded elsewhere in the tropics—despite known carbon emissions risks. In the Ex-MRP site, I argue that the oil palm companies have been able to acquire land indirectly by taking advantage of the transmigrant-held land structure that was implemented during Mega Rice Project development. Then, in shifting to discussion of how oil palm companies are able to acquire land more broadly across Indonesia, the chapter shows how industry-funded scientific research has created "divergent expertise" regarding the relationship between oil palm and carbon emissions on peatlands. This alternative knowledge regime serves to shift regulatory regimes in favor of oil palm development on peatlands.

As peat fires continue to increase in severity across Indonesia and the Ex-MRP site in particular, Chapter 6 turns back to subterranean peat fires as an ongoing regional problem in Southeast Asia. I argue that while responses to the problem have focused on the causes of peat fires by assigning blame to various actors, peat fire causality is complicated by the biophysical dynamics of the fires themselves and the remote detection technology that is used to determine causality. This highlights the role of uncertainty and the *lack* of knowledge in techno-scientific regimes that are increasingly deployed to remedy environmental problems, such as the peat fires.

Chapter 2: The Mega Rice Project: Peatland Transformation and Degradation

This chapter provides historical background through which to understand how a contiguous area of peatland was transformed through a single centralized state-led development scheme, leading to ongoing degradation today. First, it briefly traces the historical production of scientific knowledge about Indonesia's tropical peat soil prior to the Mega Rice Project in the 1990s. Throughout most of the 20th century, scientists and government officials paid little attention to soil carbon dynamics or to the role that peatlands play in the global carbon cycle. Instead, Indonesian, European, and American institutions commissioned research that responded to energy and agricultural needs. It also shows the ways in which the production of scientific knowledge about Indonesia's peatlands has always been bound up with political economic dynamics, including President Suharto's authoritarian government. I discuss this in order to highlight that there is a history of using 'science' to advance national development plans in the peatlands, despite obvious ecological resistance to turning the land productive for agriculture. Through to the development of the Mega Rice Project, scientific knowledge—or intentional lack thereof—is used to justify large-scale land transformation, drawing this land into broader circuits of value.

This chapter also discusses how the Mega Rice Project was tied to New Order ideology in which President Suharto identified as the "Father of Development." Through this, land value was measured in terms of potential contribution towards meeting Indonesia's domestic food self-sufficiency goals, which had political and economic underpinnings. The Mega Rice Project offered political currency for Suharto and his oligarchic government as the project kept money circulating through his network of cronies. It then describes how the Mega Rice Project unfolded on the ground in 1996-98, drawing on perspectives from informants who were involved with the project or living in the area at the time. In describing the construction and social history of the Mega Rice Project, this chapter shows how such a large landscape became so rapidly degraded through a state-led project that misinterpreted the ecosystem. This sets the stage for new relations between scientific knowledge about peat soil carbon, agrarian development, and conservation in the 21st century, as I develop in subsequent chapters. The transformation of this particular landscape entailed not only clearing trees but constructing drainage canals, which led to ongoing degradation through fire and oxidation that continues today. Finally, I conclude with a brief description of how the project's design affected livelihoods heterogeneously across the site, and led to broad differences in land cover today.

1. Early Peat Soil Science: From Fuel to Food

Early interest in Indonesia's peatlands was driven by a need for coal to power steam ships. From the perspective of the early European colonizers until the early to mid-20th century, tropical peat was valuable both as a possible substitute for coal and as an indication that coal deposits were nearby (i 34).[31] A Dutch explorer is known to have first mentioned tropical peat in the Dutch East Indies in the late 18th century. The first known mention of these tropical peat soils date to a report from 1794 in Riau province on Sumatra, noted by a Dutch colonist writing in 1910 (Wichmann 1910). Nineteenth century visitors to the region mention "well combustible peat" in Riau in the 1860s, looking to fuel the coal-powered steam ships en route back to Europe. A German coal chemist on expedition to Sumatra in 1895 also suggested that lowland peat formations there were "active carbon" deposits (Soepraptohardjo and Driessen 1976).

[31] The colonial interest in peat as a combustible fuel is indicative of broader global climate dynamics, which I have not yet fully explored. This transitions to 21st century interest from former colonial powers in cleaning up the consequences of combustible fossil fuel.

Most of the earliest scientific research in Indonesia's peatlands was conducted by colonial Dutch scientists, who took an interest in peat because the Netherlands was concerned with their own national peatland subsidence in the 1920s. One of the first scientists to comprehensively study vegetation in lowland peat swamps, J.A.R. Anderson, noted that much of the research conducted in the 1920s was concentrated in South Sumatra and Riau provinces, on the east coast of Sumatra (Anderson 1976). Researchers there focused on soil composition in the lowland peat swamps, while largely ignoring vegetation species composition. J.A.R. Anderson (1976) completed more thorough peat vegetation studies, first in Sarawak, Malaysia (on the island of Borneo) and later in West and Central Kalimantan. After his 1976 study he concluded that tree species composition was correlated with peat soil nutrient density, and that tree density was much higher per hectare in Kalimantan than Sumatra. Research that sought to benchmark vegetation composition thus did so with an eye towards agriculture, hypothesizing which areas had soils better suited for wet-rice agriculture. Other European scientists, including several from France, undertook months-long expeditions to catalog peat forest soils and vegetation, with an eye towards economically valuable tree species. This data provided some benchmarking for later researchers to pursue understanding of the broader ecological dynamics *between* the soils and vegetation. But for the most part, Southeast Asian peat swamps were not extensively studied by Western scientists for most of the 20th century.

Furthermore, although they were aware of carbon content in peat elsewhere, few scientists throughout the 20th century researched the carbon content of tropical peat soil within the context of global carbon cycles. Instead, most research on Indonesia's peat soil, echoing that of colonial interests, centered around using peat as an energy source. In 1984, the Indonesian Director General of Land Reforestation and Rehabilitation highlighted the potential for peatland to supply energy throughout Kalimantan, Sumatra, and Sulawesi using Finnish technology. He suggested that South Kalimantan, near Banjarmasin, was an ideal location for a Finnish-led peat-burning factory alongside using peatlands for agriculture and forestry purposes (*Kompas,* 14 Sept 1984). In 1985, the International Peat Society convened their annual symposium in Jogjakarta, Central Java, the first meeting of the group in the tropics. While the society's members hailed from all over the world, much of their prior work had focused on peatlands in colder climates. This 1985 symposium included a field visit to Central Kalimantan to view the recently constructed peat-burning power plant funded by the Finnish government. The Finns had devised a method to harvest, dry, and burn peat cores for power in their own country and were eager to implement it overseas.

The 1980s was also when the United States Geological Survey sent American researchers to Indonesia to look for low-ash coal deposits.[32] Their objective was to understand coal formation so they could better determine what trace elements are contained within it, so coal could be burned more cleanly in the United States. Coal's trace elements, particulates, and ash can solidify when burned, clogging furnaces. Working with Indonesian collaborators, USGS researchers relied on roads in peat swamps built by oil companies to collect field samples in peat swamps. They arranged a trip to the east coast of Sumatra in Riau province, where an Indonesian oil company, KalTech Specific Indonesia, had built roads through a peat dome to drill for oil. The group of researchers was able to use the company roads to conduct a series of transects to

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[32] The USGS scientist I interviewed had initially been skeptical that there were peat deposits in the tropics at all. Like many scientists in the 20th century, she believed that organic matter decomposed in the tropical heat too quickly to form a peat layer. But her boss theorized that because coal formed in the Appalachian Basin (also known as the Appalachian Mountains) when that tectonic plate was on the equator 280 million years ago, then it must be possible for coal to form near the present-day equator. She found J.A.R. Anderson's research on the vegetation found on peat domes in Sarawak, Malaysia, detailing peat domes exceeding 12 meters in depth, and hypothesized—correctly—that there would also be deep peat soils on the west side of Sumatra.

obtain soil cores to measure depth. Some of the cores measured over 13 meters deep, but because the roads were subsiding into the peat, it was too difficult to determine the full extent of peat depth (i 34). The methods the USGS used to analyze carbon content are basically the same as the methods used currently. Soil samples are weighed, dried and heated, and then weighed again to determine how much weight was lost. Samples collected from Sumatra in the 1980s showed over 60 percent carbon content, surprising many scientists who presumed this tropical peat would have the same carbon content as peat in high latitudes, such as in Minnesota and Russia (i 34). In fact, the tropical peat carbon content was much higher.

Turning peatland productive for agriculture

In contrast to Western researchers, most Indonesians were primarily interested in using tropical peat swamps for agricultural expansion. Suharto made agricultural development in peatlands a priority beginning in the 1970s, though agronomists knew that that rice cultivation in peatlands was challenging. In 1974, the Soil Research Institute of Bogor, located near Jakarta, commissioned research on "Indonesian problem soils, among which peat soils hold a prominent place," in collaboration with the Netherlands Technical Assistance Program (Driessen and Suhardjo 1976). These reports bemoan the difficulty in cultivating *sawah*, or irrigated paddy rice in lowland peat swamps. Though cultivating *sawah* rice in these inundated wetlands is a "particularly attractive proposition," wrote two scientists,

> *"the difficulty in maintaining a constant water level on the heterogeneously shrinking and extremely permeable lowland peats could perhaps be overcome by the skilled Indonesian rice farmer and reclamation of the flat and level lowland peat formations has repeatedly been*

attempted, both in Indonesia and Malaysia. So far, the results have been utterly disappointing" (Driessen and Suhardjo 1976: 21).

The Indonesian-Dutch collaboration in the 1970s, carried out through the Soil Research Institute, sought to establish test plots in tidal areas for wet rice cultivation. In addition to the plant physiological obstacles they encountered, researchers cite the numerous physical problems with peat soil that "reduce their agricultural value considerably" (Soepraptohardjo and Driessen 1976: 15). These included rapid subsidence after drainage and vegetation removal; rapid oxidation/decomposition of organic material following drainage; high heat retention at the surface, leading to high temperature variability; and irreversible shrinkage, as the soil loses its capacity to retain water after it's drained (Driessen and Rochimah 1976).

Agronomists from Java were encouraged by observations that the Dayaks and Malays cultivated rice around the coastal city of Banjarmasin in Kalimantan's peat swamps. But agronomists' test plots of rice in peat swamps would produce just one harvest of grain and then die. The cause of the dismal rice crop, they believed, was not the geomorphological structure of the peat swamps nor the inexperienced "Indonesian rice farmer" (by which they were referring to Javanese farmers especially). It was the lack of micronutrients that was inhibiting rice grain formation. Copper, in particular, is necessary for rice grain formation, but researchers suggested that standing water made copper inaccessible to the plant. Others found that copper only inhibited grain formation in the second year of a crop. Several of these researchers note that these problems could be mitigated through "heavy manuring," but the high levels of organic matter in peat soils still posed a hindrance to high yields. In addition to intensive fertilization, successful cultivation would require continuously flushing the soils with non-acidic water from rivers (Driessen and Suhardjo 1976).

In the late 1970s, Dutch consultants were hired to draft a survey ranking coastal peatland's suitability for transmigration projects in Sumatra, Kalimantan, and Irian Jaya (now Papua). The survey was funded by the International Bank for Reconstruction and Development and conducted by consulting firm Euroconsult BV of the Netherlands in collaboration with PT. BIEC International, a firm based in Bandung, Java. The objective of the survey was to classify and rank coastal land's suitability for "large-scale, low-cost transmigration settlements," highlighting areas that could be made suitable for agriculture through water management. The Dutch consultants used Landsat imagery coupled with field visits to map soil types and hydrology features. They determined that peat soil deeper than two meters was unsuitable for transmigration projects. "High priority" land determined to be suitable for development, meanwhile, had uniform soil properties across a contiguous area large enough for 10,000 families to settle (more than 20,000 hectares). Though the consultants acknowledged the difficulty of lowering soil acidity in shallow peat soil, they assured the government that such soils could be made suitable for agriculture through "proper drainage" (NEDECO, Euroconsult, BIEC 1984).

Research on peatlands' suitability for agriculture also began to intersect with plans for relocating labor from Java and Bali to Indonesia's forested lowlands on other islands. As I expand on in a section below, the government was ramping up efforts to develop peatlands through transmigration projects in the 1980s. While officials often acknowledged challenges with peat-based agriculture, however, they assumed that additional research would inevitably lead to better solutions. One ongoing project in West Sumatra, roughly 240 kilometers from Padang, placed 1,000 families on 125,000 hectares of peatland between 1983 and 1984. Agricultural technicians from a Sumatran food crop institute contended that the project was not yet successful because more research was needed on the interaction between crops, peat soil acidity, and soil drainage properties. They were confident, however, that this additional research would show that with more drainage channels and fertilizers, transmigrants would be able to harvest yields of corn, soy, pineapple, coconut, bananas, and other crops that were just as high as on mineral soils (*Kompas*, 19 February 1985). Yet many of these transmigrant projects in lowland areas remained difficult to get off the ground because of poor soils and/or flooding. Some of these projects eventually turned into permanent agricultural settlements, Transmigration projects on irrigated, fertile land in Sumatra and Sulawesi were relatively successful.[33] While lowland tidal irrigation projects in Kalimantan sought to imitate Buginese[34] or Banjarese cultivation systems, the projects too often failed because they were implemented in areas without adequate soil fertility or drainage (i 29).

The MRP wasn't the government's first attempt to settle Javanese transmigrants in Central Kalimantan. *Kompas*, the Indonesian language national newspaper, reported in 1977 that 500 transmigrant families were successfully harvesting cloves in Kuala Kapuas district (*Kompas,* 6 Jan 1977). From 1974 to 1983, 500 hectares located 250 kilometers north of Palangkaraya (northwest of the MRP site) was intended to become irrigated rice paddy. Yet at that project's completion, nearly 10,000 houses constructed for the transmigrants sat unoccupied. A network of dams and irrigation infrastructure had also failed to reach its maximum potential, according to Vice President, Umar Wirahadikusumah, who visited the site in 1987 (*Kompas*, 29 June 1987).[35] Some of those designations became the basis for the earliest transmigrant projects in Central

[33] "Success" in this context is defined as whether or not transmigrants were producing crops for market within five years of placement.
[34] The Buginese are an ethnic group originating in South Sulawesi. They were lowland rice cultivators and also migrated extensively around the Java Sea, settling along other Indonesian coastlines.
[35] He also proposed turning the site area into a center of energy, powered by peat soil, but this also failed to materialize.

Kalimantan. An area of shallow peat soils close to Palangkaraya, on the outskirts of what was to become the Mega Rice Project, had been settled through transmigration in the early 1980s. The Javanese who settled into those villages had access to city markets for their vegetable and fruit production, and were able to encourage soil maturation by applying lime and fertilizer from livestock. These villages are still occupied by transmigrants, who supply the large urban markets in Palangkaraya.[36]

2. Motivations for the Mega Rice Project

True to its name, the Mega Rice Project[37] (MRP) was a key piece of President Suharto's plan to turn Central Kalimantan into a major rice producing region. Indonesians have been the largest per capita rice consumers in the world for the past several decades (Mohanty 2013). Bolstering domestic food supply to keep up with rising demand was part of President Suharto's development calculus throughout the New Order era. He attempted to control the country's food supply by opening new lands in the "outer islands"[38] to both establish centers of rice surplus and redistribute Javanese and Balinese rice producers throughout the country through transmigration schemes. The long-running transmigration program coupled labor migration with an opening up

[36] A European scientist who consulted for the Ministry of Transmigration in the late 1980s described seeing transmigration settlements near Palangkaraya: *"It was quite surprising to see how these guys survived. The first time I saw [the settlement], I said to get them out. There is nothing you can do there. But they didn't want to listen. They burned peat, made holes, had kitchen ashes, put it in holes, and planted vegetables. And these vegetables grew! It was very expensive. The office workers in Palangkaraya had nothing to eat, but they had money. So every week the transmigrants brought vegetables to the city and got money, and with the money they bought fertilizer. After a while they turned the whole area into productive agriculture."* (i 29)

[37] In Indonesia, the Mega Rice Project is most commonly referred to as *Proyek Lahan Gambut* (Peatland Project), or PLG for short. It is sometimes also referred to as *Proyek Sawah Sejuta Hektar* (Million Hectare Rice Paddy Project).

[38] "Outer islands" refers to all of the islands beyond Java and Bali, including Kalimantan and Sumatra.

of "empty," unproductive land that the government believed was not contributing to Indonesia's national economy.

Yet many of these agricultural development schemes ran aground when they encountered different ecologies than Javanese officials were used to. Javanese and Balinese systems of rice production relied on intensive wet-rice (irrigated) systems called *sawah* while unirrigated rice, called swidden (or *padi ladang* in Indonesia), was more common in the outer islands (Padoch 1985). As Michael Dove has argued, Javanese have for centuries believed *sawah* to be more productive, and thus a better model for national agricultural development, than swidden systems that rely on shifting cultivation. This "agro-ecological myth" underpinned the biggest discontinuity between plans for large-scale agricultural schemes and the agro-ecological reality of transforming swidden into *sawah* (Dove 1985). Nevertheless, attempts to subsume swidden systems of cultivation in the outer islands—and their laborers—into centralized Javanese governance continued throughout the 20th century, climaxing with the Mega Rice Project.[39]

By the 1990s, several decades of economic growth had also given the Suharto administration a determined attitude towards large-scale projects that would satisfy New Order development goals—such as opening up new land and distribute agricultural labor—while ensuring a stable domestic food supply. In 1990, Suharto was granted an award by the United Nations Food and Agriculture Organization (FAO) for reaching rice self-sufficiency in Indonesia. Rice production rates in Indonesia were already starting to decline at the time of the award, however, while population growth was increasing. Rice paddies in Java, long the

[39] Attempts to convert swamps into rice fields are, of course, not limited to Indonesia (Carney 1996). Yet there have been few other "mega" projects of this type in Southeast Asia. Transforming the Mekong River delta was a similar undertaking to make lowland tidal plain suitable for agriculture but it unfolded over several centuries, not rapidly like the Mega Rice Project (Biggs 2010). Mekong Delta conversion to agriculture has also been largely successful, unlike attempts to convert Indonesia's peat swamps to rice paddies.

heartland of the country's rice production, were being converted to industrial and residential areas. By 1994, Indonesia was relying on rice imports from Thailand. The government's immediate solution was to spatially substitute sparsely populated provinces like Central Kalimantan as an offset for losses of Javanese rice paddy.[40] Rice self-sufficiency means one of two things: that the volume of rice imports equals the volume of exports, or that the volume of rice produced in Indonesia was equal to the amount of rice consumed by the population. The Suharto administration set the latter as their goal, seeking to curtail rice imports entirely. The administration may have also feared that declining rice production would lead to immediate food shortages, causing unrest. "If Indonesia imports too much rice, it would be the same as importing instability," argued the Minister of Agriculture Sjarifudin Baharsjah (*Jakarta Post*, 2 July 1997).

In 1995, Suharto's administration, led by Minister of Agriculture Sjarifudin Baharsjah, declared that Indonesia would regain rice self-sufficiency by 2000, at the end of the subsequent five-year development plan. The Ministry was also hopeful that Indonesia's rice consumption would decrease, despite a rising population. "We can only rely on the middle class to shift their staple diet from rice to other high-calorie foodstuffs, like wheat," stated the head of the Ministry's database, "and to diversify their menus, such as by increasing the intake of protein" (*Jakarta Post*, 21 August 1995). Alongside declining rice production, which in 1994 had fallen to its lowest level in 15 years, government welfare programs had increased rice subsidies for the poor, thereby increasing rice consumption for a large portion of the population. But barring an immediate decline in rice consumption, the Mega Rice Project was meant to assure a steady

[40] Alongside initiatives to increase production, Suharto also urged Indonesians to reduce rice consumption by diversifying their diets. "We have to learn to control what we eat," he declared in a town-hall style meeting in 1995, "If we could change our eating habits, and eat only a third of the 136 kilograms that we each consume a year, that means that we will be able to feed three times the size of our population" (*Jakarta Post*, 1 December 1995). He urged the growing middle class to adopt a diet higher in vegetables, meat, and fish, rather than the large bowl of rice with meat and vegetables on the side, which was typical of most Indonesian diets.

domestic surplus of rice. The Mega Rice Project was also a key part of Suharto's 1996 national budget, which underlined continued economic development through what he called the "Trilogy of Development," including economic growth, equitable distribution, and economic stability. Among the five sectors granted over Rp 2 trillion[41] from the overall budget was irrigation. Irrigation development was almost exclusively earmarked for increasing rice production throughout the country. Suharto specifically named the MRP as the beneficiary of this budget allocation (*Jakarta Post*, 5 January 1996).

But amid the general international push for trade liberalization in the 1990s, why was Indonesia trying to achieve rice "self-sufficiency"? Indonesia's obsession with producing as much rice as the country's population consumes, thereby limiting imports, dated to the years just after WWII and Indonesia's subsequent independence from the Netherlands. Early post-colonial government officials recognized that importing rice required large amounts of foreign currency, which Indonesia was short on during post-war rebuilding. Particularly during the first years of post-colonial Indonesia, President Sukarno's administration worried that rice shortages would lead to dependence on other countries, especially the US, limiting Indonesia's ability to negotiate as an independent nation in international relations (Moon 1998). As Suzanne Moon argues, the Suharto administration was interested in reaching rice self-sufficiency for reasons other than it met economic budgetary objectives. As a newly independent country Suharto, and his predecessor President Sukarno, saw increasing domestic food production as means to reducing Indonesia's dependence on foreign powers.

Furthermore, because rice self-sufficiency was implicit in many of the New Order's development goals through transmigration programs and infrastructure projects, Suharto was

[41] About US$120 billion in 1996 exchange rates.

eager to regain such status, at least on paper. Yet rather than increase production through mechanization, as the United States had been doing for decades, Suharto's administration focused on increasing production through higher yielding rice species,[42] opening up new land, and improving water resources such as irrigation systems. All of these relied on farm labor, primarily through transmigration projects; distributing tractors or other technologies that might have reduced on-farm labor were never part of Suharto's Five Year Development plans (Moon 1998).[43] The Mega Rice Project was thus a logical extension of this decades-long attempted expansion of wet-rice agriculture through the transmigration program. In addition to contributing to the goal of once again obtaining rice self-sufficiency, the project fell in line with the New Order's developmentalist goal of building infrastructure in the outer islands, including transportation and public utilities. This also explains why planning and execution of the MRP was led by the Ministry of Public Works, rather than the Ministries of Agriculture, Finance, or Forestry.

Extracting timber from the MRP's peat forest site was another motivation for the project. But while environmental organizations, such as WALHI, argued at the time that timber was the primary objective of the project, it may have been more complicated than that. One ecologist familiar with the area's history contended that the area had already been cleared through decades

[42] This, of course, coincided with the beginning of the Green Revolution in the 1960s, which supplied Indonesia with "improved" rice species via the International Rice Research Institution (IRRI) in the Philippines.

[43] During the early years of the Cold War, Indonesian requests for mechanized equipment from the US were rebuffed, as the US sought to train large numbers of Indonesians through agricultural extension programs rather than hand over tractors to the government, which they feared would spur large-scale government-owned farms, bringing Indonesia one step closer to Communism. Instead, they implemented agricultural extension programs in to order to train peasants to maintain private farms. This took the form of hierarchical farm management, Taylor-esque daily record keeping and maintenance forms, and installing Americans or American-trained Filipinos as contract managers. The US also supported Indonesian efforts to improve rice yields through modified seed after the International Rice Research Institute was established in 1960 (Moon 1998).

of timber commercial extraction, so the notion that one million hectares of forest was felled by the project was not entirely accurate (i 21). Several companies had HPH timber concessions (*Hak Pengusahaan Hutan*, a commercial forestry concession permit) in the area leading up to the MRP, including PT Mengkatip and PT Djayanti Djaya (i 44). These companies spent 25 years operating in several thousand hectares of what was to become the MRP in areas specified by the Ministry of Forestry. Timber extraction under the HPH system was closely managed by national regulations. The companies were allowed to cut only five species of trees, all of which had to be over a certain diameter in size. Many inhabitants of Mantangai and other nearby villages worked for the companies directly.[44] The concession permits were up in the late 1990s, however, which made for convenient timing for the government to let the concessions expire in the area slated for MRP development.[45]

Many inhabitants of nearby villages claimed that *ramin*—[46]the most valuable species found in the peat forest—was long gone by the time the MRP construction began, so it is not clear that there was valuable timber was remaining for the government to extract.[47] While companies operating in timber concessions were seeing declining returns from the peat forest

[44] Local groups were also hired by the companies to construct *tatas* canals to facilitate log extraction. Villagers—almost exclusively Dayak at this point—were freely permitted to collect rattan, *gemur*, and other plants from the concession areas, as well as hunt and fish. In the peat forest, this included *ramin*, a valuable hardwood species that was common in peat ecosystems.

[45] Bob Hasan, the notorious timber mogul and close affiliate of President Suharto, had connections to the Barito Group, which was running timber concessions in the MRP area. This company was owned by Prayogo Pangestu, also an affiliate of Bob Hasan (Robison and Hadiz 2004). One possible motivation for the project's canal system was to open up land deeper into the HPH concession areas, where there was thought to be more valuable timber species, such as *ramin*, which had all but been depleted from easily accessible areas near the rivers (i 53).

[46] See appendix for tree species names.

[47] One Mantangai resident who had worked for the timber companies described to me that the companies' HPH permits expired in 1997, at which point several government officials delivered a map of the former concession areas to the *kepala desa* (village head) of Mantangai, establishing the blocks of the MRP. A clear line on the map from east to west designated Block E, which was to be protected as conservation forest, from Block A, which was cleared immediately.

and faced a ban on raw log exports beginning in 1980 (Robison and Hadiz 2004), the emerging pulpwood industry saw opportunity. During the 1980-90s, Indonesia's timber industry was transitioning to pulp and paper exports, away from hardwoods that could be made into furniture (Dauvergne 1997). The Suharto family and close associates had constructed sawmills in Java for timber processing in the early 1990s, broadening the range of tree species that could be processed into plywood or paper. These plywood mills, ready to consume tons of forest materials, were facing timber shortages by the mid-90s. Ministry of Forestry Djamaludin Suryohadikusumo opened new forest concessions in Irian Jaya (now Papua) to increase pulpwood supply. Getting timber from the eastern-most part of Indonesia to the sawmills, which were mostly in Sumatra and Java, was a challenge, however. Both the Minister and President Suharto acknowledged that the MRP would provide a windfall of timber, an estimated six million cubic meters of wood by 1998. The Indonesian Network for Forest Conservation (SKEPHI) was worried about the timber shortage causing extensive illegal logging, not only by locals but by government officials and members of the military assisting in timber extraction in undesignated areas. Their coordinator, S. Indro Tjahjono, argued that domestic timber availability couldn't keep pace with an "'irrational growth'" of pulp and paper companies. Furthermore, he explained, "'SKEPHI is afraid that this year, the need for timber will become a justification for unnecessary forest conversions and this may cause an oversupply of certain plantation commodities such as oil palms'[48]" (*Jakarta Post,* 8 January 1997). Forest conversion in the MRP area thus helped reduce pulpwood shortfalls, while allowing government officials to justify the project in other ways as well.

[48] A harbinger of land use priorities to come or already underway, perhaps.

Finally, in the age of New Order crony capitalism, it was clear that the MRP was going to be a lucrative opportunity for many political-business and military leaders. Though state monopolies in public utilities and infrastructure were ending in the early 1990s, political-business leaders (often members of the Suharto family) were beginning to channel foreign investment and state bank loans into mega projects. These public-private projects absorbed an estimated US$80 billion in the early 1990s, much of which was then fanned out into smaller contracts and monopolies in rent-seeking industries. The forestry sector was one such industry, of course, but state and military gate-keepers directed mega project funding into small niche industries, such as soy milling and the collection of bird's nests (Robison and Hadiz 2004). For the Mega Rice Project, Suharto had the Ministry of Public Works channel financing from the other ministries involved—primarily Agriculture and Transmigration— and onto a network of contractors and subcontractors.[49] Personal and business associates of the Suharto family received lucrative contracts through the MRP for everything from housing construction to limestone provisioning to Japanese machinery imports. This was part of the oligarchic capitalist system in which the Suharto family and close associates acted as gate-keepers across nearly every sector by controlling even small contracts.

3. Studying the Swamp, Silencing Science

Scientific knowledge was mobilized differently—or not at all—under Suharto than under subsequent governments. Retrospectively, the Mega Rice Project was believed to be full of engineering mishaps and a scientific folly, having disregarded 'local' knowledge about the site's

[49] The Minister of Public Works was later convicted by the Habibie administration for embezzlement of MRP funds, but died of an apparent heart attack before he could serve prison time. (*Jakarta Post*, 20 December 1999)

ecology (i 58, 63, 69). But scientific knowledge, as Robert Proctor argues (2008), does not necessarily proceed linearly from ignorance to enlightenment, a process he refers to as agnotology. Ignorance itself can also be productive in supporting certain ideologies, or in this case and as I argue in chapter 5, different land uses.

Ironically, a majority of ecological research conducted in the MRP site immediately prior to the project's arrival was facilitated by the logging concessions granted by Suharto's government. A coalition of British and Indonesian scientists began working there in the early 1990s.[50] Because ecological research on tropical peat forests was not funded at the time by the United Kingdom (or, for that matter, by the Indonesian government), the researchers had little money with which to build the infrastructure necessary to access the swamps. Instead, in collaboration with Indonesian scientists and students from the University of Palangkaraya (UNPAR), the researchers exploited the access set up by the numerous logging concessions operating in the area. Working with UNPAR, the team of British and Indonesians researchers secured permission from a logging company to access a concession forest in the soon-to-be MRP area on the company's railway, which was constructed perpendicular to the river, straight into the deepest part of the peat dome. Hitching rides on the unpredictable logging carts and staying overnight in huts borrowed from the company, the researchers were able to collect plant and water samples to draw conclusions about soil nutrient dynamics and biodiversity. Their research did not engage with peat carbon content or emissions capacity, as there was little evidence of oxidation or fire in the area prior to large-scale intentional drainage.

[50] One European scientist who worked in the lowland peat swamps in the 90s said that he had prodded many Indonesian scientists to show him "the real peat forest" but that they only led him to transmigrant agricultural areas located on shallow peat. What he called "the real peat forest" Indonesians considered dangerous and too difficult to work in. He finally found some sympathetic colleagues at the University of Palangkaraya, who encouraged him to venture into the nearby intact peat forest (i 23).

In September of 1995, researchers from the Universities of Nottingham and Leicester, scientists from UNPAR, members of the Indonesian Peat Association, and local government officials convened the "International Symposium on Biodiversity, Environmental Importance and Sustainability of Tropical Peat and Peatlands" in Palangkaraya, Central Kalimantan.[51] The symposium was a turning point for considering the role of tropical peatlands as part of the global carbon cycle. The Icelandic president of the International Peat Society attended the symposium, stating in his introductory remarks that "so far, we have paid too little attention to tropical peatlands, although a sizable proportion of the world's peat resources are located in a belt around the equator and to the south of it" (Rieley and Page 1997). Djamaludin Suryohadikusumo, State Minister of Forestry, also addressed the gathering. In his remarks, he acknowledged that peat forests must be managed wisely for agriculture, and wildlife habitats maintained. He concluded that "It is very possible that changes in peatlands will lead to subsequent changes in the balance of the system of input and output of certain gases and, consequently, speed up global warming" (Rieley and Page 1997: 6). He went on to reiterate that Indonesia was "committed to recovery from global disorder" and is "fully aware that the tropical forests in this country, including the peat swamp forests, are the lungs of the world" (6). Although it is likely that Djamaludin was aware of the plans for the Mega Rice Project, the Ministry of Forestry had yet to endorse the plans as it required taking land from the state forest concession and might have subtly been opposing the project.[52] Moreover, many symposium participants were aware that the Mega Rice

[51] The meeting was attended by nearly all of the world's top tropical peat experts, though this was less than 50 people in total. Papers presented included topics such as "Effect of logging on the small mammal populations in peat swamp forest, Central Kalimantan," and "Development of peat mining in Indonesia with a context of ecologically sustainable principles," along with numerous studies on peat swamps' hydraulic properties, tree species diversity, and suitability for agriculture.

[52] The American USGS scientist presented a paper on the rate of carbon accumulation in peat deposits in Indonesia, drawing on data collected from peat samples using carbon-14 dating. She explained that the research she shared at symposium was a major turning point for her thinking about peat deposits as not only about carbon accumulation. "I was telling my boss that it's not just accumulation of coal this peat can tell you

Project was coming to the area, but could not discuss it because of fear of retaliation by the government. "At the conference we knew it was coming, but we couldn't speak about it. You'd get locked up. That's the way it was," said one British scientist in attendance (i 23). Several Indonesian agronomists spoke in hushed terms about their skepticism of the project's feasibility. In keeping with Javanese cultural convention and the tense political climate, they criticized the project in only vague, indirect terms.

In the last years of the New Order, the Suharto government didn't just ignore scientific research on environmental impact, they actively suppressed it. Voices of Indonesian scientists who might have spoken publicly against the project did not get past President Suharto's insulated team of advisors, who maintained only that the MRP would generate a lot of profit (i 19). "People were quiet," explained an Indonesian scientist, "because of the government system at the time… if the top said something, everybody followed like a rope" (i 69). All government officials, from Jakarta's top officials to the national ministries to the province-level officials, followed presidential directives under Suharto. Foreigners, such as the scientists who had conducted research in the peat swamps, were not privy to government meetings and rarely had opportunity to speak directly against the plans. Those who were aware of the plans, meanwhile, kept quiet for fear of getting kicked out of the country.[53]

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about, it's part of a big carbon cycle on the surface of the Earth today, which is very much tied to climate and climate change," she said (i 34). Shortly after the symposium, the USGS pulled the plug on coal research and switched her area of study to oil shale.

[53] In December of 1995, Kapuas BAPPEDA, the district-level government planning organization, organized a meeting in Palangkaraya to discuss the Mega Rice Project plans. They invited Suwido Limin, a scientist at UNPAR, as a "local expert" (his critical emphasis). He said that just prior to the meeting, offices in Jakarta had faxed the plans for the project to his house in Palangkaraya because the local BAPPEDA office didn't have a fax machine. He was shocked to see pages and pages of plans falling onto his floor that stipulated large canal construction in the area where he had been conducting research since the late 1980s. At the meeting, he protested these plans to the local government officials because it was "neglecting to acknowledge local knowledge" (i 69). Drawing on the data he and the team from the UK had collected several years prior, he argued that canal construction from river to river would "break the ecosystem." His opposition to the project led people at the meeting to call him a Communist, he recalled, as anyone opposing the government's plans

4. Planning for a Million Hectares of Rice

Despite earlier attempts at cultivating peatland through rice-based transmigrant projects, the MRP was inspired most directly by a peatland agricultural project in Sumatra. A Chinese Singapore-based agribusiness company, PT Sambu, had claimed success in growing 20,000 hectares of coconut palms, pineapples, and some rice commercially in the peatlands of southeastern Sumatra, off the coast of Jambi province, relying on an elaborate network of dikes and canals to control tidal flooding. However, Sumatra has much shallower peat soils than Central Kalimantan and so the ecosystems were not analogous. The businessmen talked Suharto and a small group of his advisors into planning intensive wet-rice cultivation in Kalimantan based on the fact that they had cultivated peatlands elsewhere for commercial production. Peat soils in the MRP area would turn out to be much deeper than in Sumatra. Kalimantan's soils are also geologically younger, containing more un-decomposed coarse material such as tree roots and stumps close to the surface, making it difficult to prepare fields for crops.[54] Though many scientists were aware of these differences, any details regarding the lack of ecological feasibility or misguided transfer of agricultural technology was seemingly—intentionally—lost on officials overseeing plans for the Mega Rice Project.[55] Nevertheless, the success of the South Sumatra peat cultivation project provided sufficient evidence for those involved to believe the MRP

was apt to be called at the time. He wasn't afraid of these accusations, he told me, because he gave only scientific suggestions, not political ones.

[54] Though many scientists were aware of these differences, any details regarding the lack of ecological feasibility or misguided transfer of agricultural technology was seemingly—intentionally—lost on officials overseeing plans for the Mega Rice Project.

[55] Peat science conducted in the Florida Everglades in the 50s was the most comprehensive ever done. "We know, based on their study, what will happen in this site, with subsidence, emissions, hydrology. We already know 50 years before it will happen what this will end up like." (i 19)

would also be successful. A subsidiary of PT Sambu, PT Sumatra Timur Indonesia, was later appointed as the contractor responsible for building the MRP's canals (*Jakarta Post*, 26 January 1996).[56]

The Mega Rice Project was officially sanctioned through Presidential Decree no. 85 in 1995, which designated Central Kalimantan as the center of the 'One Million Hectare Peatland Development Project.' Suharto imagined the province would be a *lumbung padi*, or granary, that would enable Indonesia to maintain a surplus of rice. The deputy regent of Kapuas district at the time explained that Suharto's administration had presented the MRP plan to the district government, based on claims of expert knowledge concerning peatland's suitability for rice cultivation from the Faculties of Agriculture at the Institut Pertanian Bogor (IPB) and Universitas Gadjah Mada (UGM).[57] Though Indonesian scholars at Universitas Gajah Mada in Yogyakarta, Universitas Indonesia in Jakarta, and various other technical universities didn't necessarily believe the project would succeed as planned, they were asked to provide soil maps, engineering plans, and other technical support. So while individual scholars might not have believed the project as a whole could work, they nevertheless did not hesitate to provide the Suharto regime with the requested technical information. IPB, for instance, provided soil and topography maps to the central government, despite levying quiet criticism at the project (i 75).

Preliminary studies by IPB showed that roughly 250,000 hectares were suitable for rice cultivation, much less than the one million hectares designated for the project. Even if ecological conditions had allowed for cultivation, the areas farthest from the rivers were far from existing

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[56] Secondary canals were built by state-owned PT Pembangunan Perumahan and PT Widjaja Karya (*Jakarta Post,* 26 January 1996)

[57] He was never made aware of the specifics of the research but after a group of agricultural researchers visited the district, they assured local government officials that they believed the plan would succeed. But, he explained, he thinks the researchers that conducted the studies of peatland suitability only told the government what they wanted to hear, instead of telling them the truth (i 75).

local markets and lacked road infrastructure to bring rice to ports for export to other islands. Project developers also had little data on the subtleties of peatland topography they needed to design canals that avoided draining the peat completely. Because peatland hydrology is so sensitive, a change of elevation of just a few centimeters will cause water flows to shift or certain parts of the soil to be exposed to air during a dry season. Planning information was rarely circulated from the central government to the districts during the New Order, and when development plans arrived ready for application, local governments had to quickly accept and implement them (i 71). And despite concerns within and beyond the central government that the project might not succeed, skepticism of its viability didn't keep the MRP from moving forward as planned.[58]

One of the only vocal critics of the project was WALHI, the Indonesian Forum on the Environment NGO. They opposed the project on the basis of the fact that the AMDAL (*Analisis Masalah Dampak Akan Lingkungan,* or environmental impact analysis) had not been completed. During the New Order, WALHI was one of the only organizations that publicly protested peatland development in Central Kalimantan. In the 1980s and early 1990s, environmental advocacy organizations in Indonesia were very reluctant to share their ideas with the government, or publicly criticize the Suharto regime (i 63). WALHI's national-level directors, however, spoke out against the project on the basis of the fact that the AMDAL needed to be completed and the potential ecological impacts of the MRP made transparent before the project

[58] "There was some resistance, but only at the margins. Some people didn't want to know better because they had financial interest" (i 37), explained an environmental consultant and longtime resident of Indonesia. An Indonesian NGO worker living in Palangkaraya at the time told me that few government officials in Jakarta were able to challenge Suharto's plan because if you did, "tomorrow people won't see you anymore" (i 28). But in Central Kalimantan, residents who had knowledge of the project spoke out locally. They organized workshops to educate local residents about the looming negative socio-economic impacts and encouraged petition writing. But they still feared challenging Suharto more directly or forcefully. Most people with advance knowledge of the project privately objected to it, but few people spoke out against the project publicly.

proceeded. While the AMDAL was started in 1995, under the Ministry of Environment, the analysis wasn't complete or circulated to other ministries when the first excavators broke ground in 1996.

Executives at WALHI's national office in Jakarta wrote a report in 1996 stating their objectives to the MRP on the basis that it would have negative ecological impacts on the peatland. The coordinator of WALHI's forest campaign, Lili Hasanuddin, cited past examples of government-led rice paddy development for Dayaks in the MRP area that failed because of mis-matched cultivation methods to the local ecosystem (*Jakarta Post*, 9 July 1996). WALHI was especially critical of the government's push to convert agricultural land in Java to industry, housing, and golf courses as justification for agricultural expansion in Kalimantan. They also highlighted the fact that much fauna and flora in the area had yet to be documented, and that the peat ecosystem was home to one of the largest primate populations in the world. Though WALHI gave the report directly to the Ministry of Environment—their sole ally in the national government—and to the Ministry of Forestry, the project proceeded in spite of this NGO opposition (i 63). Though none of the ministries responded publicly to WALHI's report, the director of resettlement at the Ministry of Transmigration, Widarbo, did admit that they were having "difficulties in 'evacuating' the primates" in the surrounding peat forest (*Jakarta Post,* 9 July 1996).

5. Project Mechanics: Financing and Construction

In early January 1996, a large ship carrying ten excavators and tractors sailed up the Kapuas River from the Java Sea, passing the small district capital city of Kuala Kapuas. The general concept for the Mega Rice Project was to connect the Kahayan, Kapuas, and Barito Rivers through a series of primary, secondary, and tertiary canals that would draw water from the rivers to irrigate rice paddy (figure 6). There were existing canals in the southern part of the site—Block D—that had been used for transportation, but none in Block A before the project. Block E wasn't intended to be developed through the Mega Rice Project because planners recognized that the topography started sloping upward towards the northern end of Block A, into Block E, and so would be harder to maintain water flow in canals there. So while project planners did set aside a portion of the standing peat forest for conservation to maintain hydrologic flow into the southern portion of the site, they didn't consider how water would drain through the remaining 700,000 hectares severed by canals. The largest canal, SP1 (*saluran primer Ibu,* the 'mother of primary canals'), was later seen as an engineering folly because it tried to connect to rivers at right angles.[59] This largest east-west primary canal separated Block A from Block E with a grid of secondary canals feeding into it to the south. It was intended to connect the Kapuas and Barito Rivers directly, but scientists later determined that the deepest peat soils were found in the mid points between the rivers, at the apex of the peat domes. Construction managers started digging this canal at the rivers, intending to meet in the middle. They failed to recognize, however, that attempting to build such a large canal through the middle of a peat dome would require water to run uphill. This was, to say the least, an engineering impossibility and the canal was left disconnected in the middle.[60] Canal construction also

[59] Construction contractors were paid on the basis of the number of canals dug, so it hardly mattered to them whether the canals were functional or properly engineered. Additionally, the largest canal, SP 1, was originally designed to be 50 meters wide. Yet the contractors hired to dig the canal only made it 32 meters wide, pocketing the remaining funds that had been budgeted for the larger canal. In retrospect, the smaller canal size likely caused less environmental damage than a larger canal would have, yet the Habibie administration sought to persecute officials who had been involved with the MRP for illegal land clearing.
[60] One person described flying over the main canal, SP 1, in a river-landing plane and seeing the canal meet the river at a 90 degree angle. "I don't know how an engineer can design such a channel, with the intention [to

revealed the land's variable elevation across the peat domes, making it impossible for water to ascend as it flowed away from the rivers.

Peatland drainage proceeded despite being technically illegal because the site was gazetted as part of the national forest estate, not for commercial agricultural production. But Suharto's presidential decree setting the terms of the project didn't release it from *Kawasan Hutan* (state forest area), which was under the management of the Ministry of Forestry. The first spatial plan approved by the Ministry of Public Works was rejected by the Ministry of Forestry because it proposed taking all of the land out of the State Forest register, and thus out of the control and financing of the Ministry of Forestry. The spatial plan that the Ministry of Public Works ultimately used to break ground, however, kept most of the land within the state forest but didn't convert it to conversion forest, the designation through which it could be legally converted from forest to agriculture. So on paper, the MRP was illegal on the basis that land conversion occurred without the requisite permission from the Ministry of Forestry to release the land from the forest estate (i 53). Management of the area was effectively handed over to the Ministry of Public Works, angering the Minister of Forestry, Djamaluddin. This land transfer also eliminated fees paid to the Ministry of Forestry for timber taken from the site. Suharto reassured him, however, that the Ministry of Forestry-run sawmills would still be collecting huge amounts of timber from the project.

Despite stemming from a highly centralized development plan, there were tensions within the national government between ministries in the execution of the project.[61] Some of these

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have water flowing] east to west. If you see it on a map, everybody has to think about why the rivers are flowing north to south. They would have to make bridges and keep the [water] level higher" (i 58).

[61] The Ministry of Transmigration was also in tension with the Ministry of Public Works. While the Ministry of Public Works was rushing to meet project construction targets, and often cutting corners to do so, the Ministry of Transmigration was more cautious about placing transmigrants in areas that weren't yet ready to receive them and often missed their target goals.

tensions revolved around project financing.[62] Most funding for the project was channeled through the Ministry of Public Works, though the National Development Planning Agency (BAPPENAS) and the Ministries of Transmigration and Agriculture also supported the MRP through budget allocations. Ironically, most of the financing for the MRP was siphoned from interest on the Ministry of Forestry's "reforestation" fund (*dana reboisasi*).[63] Timber companies operating in the area under HPH concessions had paid 'reforestation fees' to the central government for several decades, which was intended to facilitate forest rehabilitation for ongoing timber extraction. The fee amount was based on the volume and species of timber harvested. The MRP scheme took advantage of this funding under the guise of land re-development in order to transfer these funds from the Ministry of Forestry to the Ministry of Public Works. Funding was further channeled from the Ministry of Public Works to a series of contractors and subcontracts, many of whom were close affiliates of the Suharto family.[64]

Subcontracting companies treated workers poorly, according to one Javanese man who worked for a company. I interviewed one man in Mantangai who worked for a subcontractor, PT Widjaya Karya (Wika), for nine months under the premise that the workers would be transferred to a higher paying job at headquarters in Jakarta after the project was complete. He told me that he received no salary or payment during the nine months he was employed by the company. None of the workers ended up relocating to Jakarta because the project ended before it was finished so the company couldn't (or didn't need to) follow through on its commitment. He

[62] The projected cost of the project in 1996 was US$217 million (*Jakarta Post*, 26 January 1996).
[63] In late 1995, the reforestation fund totaled Rp2.6 trillion, while interest was nearly Rp800 million (roughly US$400 million).
[64] A series of subcontractors was appointed to the project under PT Sumatera Timur Indonesia (PT STI), including PT Brantas, PT Perumahan Pembangunan (housing development), PT Tugu Lancar, and PT Haji Jumri. All of the subcontractors were based in Java, though some had satellite offices in Kapuas for the duration of the project (i 44).

described work for the company, which was involved with preparing the land for canal construction, as being very difficult. The company allowed them little rest, only a short break for a morning and evening meal. The work conditions were dangerous, and the small boats they were given to transport materials were always over capacity. Seven Javanese men in his group died when they fell in the river and were unable to swim. Yet the remaining workers kept working because the company promised them that if the project succeeds, they will also succeed (i 44).

In addition to the tens of thousands of workers, a huge amount of machinery was brought in to dig the canals at rapid speed. A European couple who has lived in Palangkaraya since the early 1990s described the frenzy of activity in the MRP site during canal construction: "They worked all day and night to organize enough drivers, enough fuel… Just to get all the fuel into this place! They were working 24 hours around the clock under flood lights" (i 58; figure 7). A massive amount of machinery imported from Japan was used to dig holes in the peat using iron planks. During his visit to the area at the height of project construction, a scientist described the forest prior to the project as "nothing really nice, mostly small trees, really low." But what was impressive, he said, was "all these workers around, all this machinery. They were building transmigrant houses that started at one end [of a canal] and went to the other. So at one end you just see the floor [of the houses] and at the other end, like a film, the houses were finished. It was amazing, very impressive." (i 29). By late 1996, hundreds of canals of all sizes had been dug. In some places, five or six canals meet at a central point, like a star, while in other places canals starting at opposite rivers fail to meet in the middle.

Though canal construction proceeded rapidly, housing for transmigrants—a key step in settling farmers in the area—was falling far short of project targets. The Ministry of

Transmigration had set a goal of building 20,000 houses in Lamunti and Dadahup by the end of 1997. By October 1996, they had only constructed 600. The Minister of Transmigration, Astri Surjanto, explained that the biggest challenge facing housing construction was transporting building materials. Because there was little road infrastructure in the area, materials had to be bought in via river and then moved several kilometers inland. Though the largest canals were wide enough to transport materials on small boats, much of the transmigrant housing was planned along narrow canals designed for irrigation and drainage, not transportation (figures 8, 9). The ministry was unable to source local wood because of a law stipulating that only private forest concessionaires the right to supply timber. Because peat soil is prone to rapid compaction and subsidence once drained, they had to rely on the lightest building materials available: asbestos and aluminum. "We have not received any health hazard notices from the World Health Organization or the Department of Health on the use of asbestos," stated Minister Surjanto, and gave themselves the green light to continue building with the hazardous material (*Jakarta Post*, 2 October 1996).

Though district government officials were aware that the project was being planned for the area, they weren't given notification that ground was about to be broken, until the machinery was offloaded next to the river and the excavators started digging the primary canals. Despite the district government's—and the village inhabitants'—surprise that the excavators were slated to clear and drain such a vast expanse of peatland immediately, the project was not a "miscommunication," explained one former district government official. It was not, according to the official, a mistake on the part of the central government to begin clearing the peatland without the district government's awareness, but "an intended lack of coordination or permission between the levels of government" (i 75). District government played a relatively marginal role in the MRP.[65] An official from the *Dinas Pertanian* in Kapuas (district agriculture department office) described how his agriculture department was asked to help coordinate agricultural activities in 1998, after the project was already underway. The department functioned as *instruktur* (instructor or educator) or *narasumber* (source of knowledge or expertise) to the project, but only in relation to technical agricultural knowledge. The department provided assistance to the transmigrants for issues of plant diseases, compost technology, weed control, and water level management. Because the land was considered 'marginal,' with high acidity and low mineral content, the department was tasked with educating transmigrants directly about how to improve soil function for agriculture so they could get higher rice yields from their two hectares of land (i 59).[66]

The test plots contained Green Revolution hybrid rice varieties, including IR 66, Membrano, Musi, and Cisanggarung, which were supposed to be adapted to swamp and tidal irrigation conditions (figure 10). These species also required herbicides and fertilizers, Para Col and Gramoxone, which were manufactured by a project subcontractor, PT Zeneca Agri Products Indonesia.[67] Agricultural officials boasted about the labor-saving and yield-boosting powers of herbicides, saying that they would be able to reap two harvests per year and cut planting time from 55 days to just 15. Several farmers involved with the test plot were seemingly able to nearly double their rice yields using the herbicides and fertilizers, at least for the first harvest. "If this

[65] Approximately 85% of the land designated for the MRP was located in Kapuas District, while the remainder was in present-day Barito and Pulang Pisau Districts. Pulang Pisau District separated from Kapuas District during decentralization in 1999.

[66] Anxious to show the viability of growing rice in a peat swamp, district agronomists helped develop two 10,000 ha test rice plots in 1995 in Mampai village, near Kapuas district capital. These were then converted into demonstration fields for farmers to learn growing methods (*Jakarta Post*, 26 January 1996). Because the test plots were cultivated prior to canal construction, it is likely that they were located on shallow peat soils closer to the city, not the deeper peat farther inland. They were also part of the coastal tidal irrigation—*pasang surut*—that had enabled rice cultivation in that area for centuries.

[67] Dayak farmers traditionally used a tool called a *tajak,* which had a 40 centimeter-long curved blade, to eliminate weeds from their fields, and a *tatuja*, or a 30 centimeter pointed wood stick, to plant seedlings.

plot is successful, then the whole million-hectare project will probably be successful as well," declared Kapuas *bupati* Odji Durachman, though he acknowledged that success also depended on settling at least 200,000 transmigrants to do the work (*Jakarta Post,* 4 April 1996).

An advisor to Suharto proposed remedying the soil acidity problem with limestone and phosphate, and opened new concessions in Java to do so. Not coincidentally, he controlled limestone concessions in Kalimantan and Java and profited from the barges of calcium carbonate being dumped in the MRP area. Indonesia was previously believed to have few phosphate reserves and had been dependent on imports of phosphate-based chemical fertilizers. The French Bureau for Geology and Mineral Research, with the Indonesian Agency for Technology Assessment and Application, found a large reserve of phosphate in Ciamis, West Java. Suharto inaugurated the site's phosphorus mining and processing plant in October 1996, trumpeting the need for phosphorus-based fertilizers for farming on peatland as well as this new domestic supply.[68] Fertilizer imports were impending the country's ability to open up new peatland areas, explained Suharto in his speech to inaugurate the mine, and "We realize that without the success of agricultural development, our economy will continue to be undermined by a large volume of rice imports" (*Jakarta Post*, 10 October 1996).[69]

In April of 1997, local project managers and subcontractors were given two weeks' notice that Suharto was coming to Central Kalimantan to check on progress of the MRP. A European carpenter in Palangkaraya was tasked with constructing a helicopter landing pad, walking paths, and a receiving pavilion for Suharto and his advisors (figure 11). They spent 24 hours a day

[68] The mine was owned and operated by PT Istana Kanematsu Indonesia, which was 60% Indonesian owned and 40% Japanese owned.
[69] Suharto was actually unable to attend the inauguration in person because poor weather prevented his helicopter from landing at the site. He instead had his Minister of Mines and Energy, Ida Bagus Sudjana, read Suharto's prepared speech.

building the structures in Lamunti, Kapuas, near a cluster of completed transmigrant houses. To make up for the fact that little rice was growing in the area at the time, PT Nusagro, the company in charge of supplying farming equipment to transmigrants, collected rice paddy sod from a test plot several kilometers away, along with vegetable plants that had already borne produce, and replanted the crops so the area appeared productive. Suharto's site visit, by most accounts, lasted a mere two hours (figure 12). The President landed in the fields by helicopter, greeted project managers and transmigrants selected for the occasion, and after seeing the fields lush with rice, declared the project a success (figure 13). He was, however, defensive in responding to WALHI's claims that the project was leading to environmental destruction during this visit with transmigrants. "'Frankly speaking, this is not a haphazard decision, but based on very strong reason,'" he said. "'This is not a matter of whether we had the guts (to do the project) or not, but it's for the interest of our nation, not only now, but for the future.'" (*Jakarta Post,* 24 April 1997). As Suharto's helicopter departed, transmigrants ran to the field to collect the transplanted crop bounty (i 44, i 58).

6. Transmigration: Placing People in the Peatlands

Roughly seven million transmigrants were relocated in Indonesia during the 20th century, nearly all of them originating in Java and Bali and re-settled in Sumatra, Sulawesi, and Kalimantan. Many transmigrants have stayed in their new settlements, in areas where agriculture was prosperous for them and have had other relatives follow (by some accounts, four voluntary migrants relocated for every official transmigrant). In relatively fertile areas of Western Sumatra, such as in Lampung province, successful transmigration projects coupled with accompanying spontaneous migration, bolstered the population from just 150,000 residents in the early 20th century to over 8 million by the end of the century. Countless other transmigrants returned to Java or Bali after years, to take care of aging relatives back home or follow a spouse back to their relatives. Others were able to foster a career out of transmigration, even if the projects they were re-settled into were not productive. They would sign up for a project, receive the one and a half years of *jahidup*, the government subsidized food aid, and one hectare of land. After one and a half years of working the first hectare, they would receive a second hectare. Several years after that, once the land had become sufficiently productive, the government would issue them a land certificate, which functioned as a 25 year lease. Some transmigrants sold this land certificate to other transmigrants already settled in the area, returned to Java, and re-registered with a different project to start the process over again. They would continue to receive government support that way.

Despite plans to settle 300,000 families in the Mega Rice Project, only a fraction of the planned transmigrants ever arrived. About 15,000 families[70] moved to the area in 1997 and early 1998, and most returned to Java after their first year. According to current government statistics, approximately 9,000 transmigrant families remain in the MRP area (see appendix d). The majority of transmigrants who settled in the MRP area came from East, Central, or West Java (including Jakarta), though some came from Bali, particularly the small islands off the southeast coast, Nusa Penida and Nusa Lembongan, which have little fresh water and poor soils. A smaller proportion came from East and West Nusa Tenggara (provinces east of Bali). Some families were also re-located from previous transmigration projects on other islands.[71]

[70] Ministry of Transmigration counted families by "KK," or Kepala Keluarga, meaning Family Head. Total KK settled in the MRP area between 1996 and 1998 was 15,147 KK, or 62,474 individuals. According to official tabulations, 9,311 KK or 36,412 individuals remain.

[71] One family I spoke with was originally from Bali but had moved to Kalimantan from Sulawesi, where they had been participating in another transmigration project.

To the Javanese, having access to farmland is generally equated with higher social status, so landless Javanese were willing to be “pioneers” in a project like the MRP. Some of the transmigrants who arrived in the MRP site early in the project, in 1996, were “tricked” into believing that they were leaving behind jobs in Jakarta for their own fertile land in Kalimantan. One man described how he had been working in Jakarta as a trader and went to his family’s village in West Java for a visit, where he happened to meet a representative from the Ministry of Transmigration who was sharing information about the MRP. The representative showed him pictures of lush rice paddy and told him that he and his family could have their own house with electricity and start-up capital to grow rice in Central Kalimantan. Though he had no formal experience in agriculture, he decided to move. When he arrived in the MRP site there was a house waiting for him, but without electricity and surrounded by swamp forest (figure 14). His land was full of grasses and inundated with water; he wanted to leave immediately. But he held out, cleared his land, and has been living there for 16 years (i 80).[72]

Some of the Javanese workers employed by timber concessions with previous concessions in the area stayed in Kalimantan after the timber concessions were revoked and bought land certificates from departing transmigrants. A man originally from East Java said that he first came to Kalimantan in 1988, married a woman from South Kalimantan in 1994, and bought land in the MRP area in 1997 from a Madurese family (part of East Java) who was leaving. They were very uncomfortable here, he said, they couldn’t stand it because it was too quiet. He was used to working in the forest so the quiet didn’t bother him (i 81). A Balinese man whom I met in central Bali described how he had gone to Central Kalimantan to work for a timber company in the early

[72] He started planting vegetables and with his experience as a market trader, has built a good business selling vegetables at the markets around Mantangai. He and his wife produce enough for their family to eat, plus they generate enough profit to send their three children to school.

1990s. He met his wife there, who was born in Central Kalimantan to a transmigrant Balinese family that had settled near Banjarmasin as part of a transmigrant project before the MRP. They moved to Bali several years after they got married because the husband's father had fallen ill. He was also heir to several hectares of fertile land in Bali, so they have since inherited that land and purchased several more hectares. His wife's family still lives in Central Kalimantan, however, and are successfully growing rice and vegetables near Banjarmasin (i 62).

Though many of the Javanese transmigrants originated in urban centers and lacked requisite agricultural knowledge, they were not necessarily uneducated. One official from the government agricultural office in Kapuas district said that one of the biggest problems they had in administering the transmigration program through the MRP was that many of the Javanese transmigrants were actually more educated than the government officials in Kalimantan. Many of the Javanese, he explained, had college degrees in law or finance and had worked in government, though those who elected to join the transmigration project had often been fired from their government jobs. Officials appointed to oversee the project in Central Kalimantan, meanwhile, generally had only a limited vocational education and lacked formal Bahasa Indonesia language skills, making it challenging for them to manage the newly arrived transmigrants (i 59). Those that came from rural parts of Java or from previous transmigration projects did have agricultural knowledge, but faced challenges with Kalimantan's ecosystem. They found that weeds grew faster in the peatlands than in Java and all crops required more fertilization. While the district agricultural office offered them some basic machinery for tilling the soil, it was nearly impossible to use in peatland because the top soil layers were littered with buried tree stumps and roots. Dr. Deny Hidayati of the Indonesian Institute of Sciences (LIPI), writing in an editorial in Singapore's *The Straits Times,*[73] condemned the Indonesian government's plan to relocate over one million transmigrants to peatlands, particularly in Central Kalimantan, as problematic and misguided. While high-yielding rice varieties and chemical fertilizers have partially improved cultivation prospects in peatlands, he elaborates, "transmigrants have not been provided with any explanation on how to use this improved technology in the local environment," ultimately leading to these projects' demise (*Jakarta Post,* 2 March 1997).

Many transmigrants left the project after the first or second year because of failed rice harvests due to rats. Though most accounts of the MRP describe transmigrants abandoning their land because of the fires that tore through the area in late 1997 and 1998, or they say that their rice crop failed entirely, few mention the rats. The first rice crop, planted in 1996 or 1997 was relatively productive for most transmigrant families. But much of the harvest was devoured by an endemic population of rats, which ordinarily found little to eat in the peat swamp forest. Workers used the roots and logs amassed during canal digging to fill dams in some places, and covered the piles with soil, making them ideal breeding grounds for rats. The abundance of food caused the rat population to increase exponentially, which then completely destroyed the second year's harvest.[74] This pattern was typical of many lowland transmigrant projects: a good first year followed by a devastating second, which spurred many migrants to abandon the project. But project managers hadn't anticipated the volume of rats that would eat through fields of planted seeds in this area, and had few solutions to offer transmigrants who saw their house gardens decimated and the rice crops starting to fail (figure 15).

[73] The editorial was also published in the Jakarta Post.
[74] "They weren't farming rice, they were farming rats," recalled a couple living in Palangkaraya (i 58).

In addition to the failed second year harvest, another indication that the MRP was about to take a turn for disaster was the onset of drought during the normally wet season of 1997 amid unfinished irrigation systems in areas where transmigrants were already living. By the middle of the year 3,500 families had been resettled in the area but water provisioning systems—including dams and groundwater pumps—for both farming and personal use were still far from functional. Once the water had been drained into canals abutting their land—usually secondary or tertiary canals—they needed a pump to be able to move water from the canals to the irrigated land. Unlike in Java and Bali, where terracing along sloped land provides an easy mechanism for water to move from channels to fields, the peatlands where the transmigrants have only several centimeters of elevation change over a span of kilometers. Many families left the area immediately, returning to Java or moving elsewhere to look for work.

Furthermore, because the project's design did not include roads navigable by car or motorbike, transmigrants relied on the canals to travel to nearby villages to purchase water. When normally wet season failed to bring heavy rains that year, water levels in the canals dropped too low for small boats, leaving the transmigrants with no access to water at all. The Ministry of Transmigration provided three plastic tanks and a water purifier to each family to remedy the problem (*Jakarta Post*, 8 July 1997). However, just after Suharto resigned in 1998, the central government stopped providing *jadup (*also called *jatah hidup*, the food and money package transmigrants received as part of their re-settlement package). An official who worked for the Kapuas government at the time said that the transmigrants turned to the local government for help.[75] Without food or cash handouts, and incomplete irrigation systems and drinking water

[75] Through 1998, the Ministry of Transmigration was still distributing limited food aid; many of the translocal Dayaks took advantage of this. But the district-level Dinas Transmigrasi office struggled to keep up with the demand amid widespread national budgetary crisis.

provisions, their living conditions became really dire (i 71). Many of those who had managed to survive through the first year of the project left at the end of the second.

7. New Order Development Up in Flames

As one of the largest El Niño Southern Oscillation on record began to take shape in 1997, drought set in across Borneo during what normally would have been the start of the rainy season in late September and into October.[76] Forest and peat fires began spreading across Kalimantan and Sumatra in September, blanketing the region with acrid smoke-haze (figure 16). Amid the smoke, widespread unrest in several Javanese cities, and a spiraling Asian financial crisis that was about to cause steep Indonesian inflation, Suharto officially stepped down as President in April 1998. The Mega Rice Project was unofficially halted in 1998, nearly as abruptly as it had begun, as central government officials resigned from office during the post-Suharto government transition. Interim President, B.J. Habibie, officially ended the MRP by government decree, which canceled the 1995 Presidential Decree that started the project.

A handful of Indonesian scientists had begun publicly criticizing the project in mid-1997, joining the growing criticism from Indonesian NGOs drawing attention to the project's destructive ecological aspects. Once Suharto was out of office, this criticism would begin echoing throughout international policy circles, leaving the Mega Rice Project to be called the country's biggest environmental disaster in history.[77] Officials and scientists began to connect

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[76] Though Borneo receives rain throughout the year, November through April are typically the wettest months. During an El Niño, equatorial Indonesia is usually experience serious drought.

[77] While I elaborate on this in chapter 3, one letter to the International Monetary Fund (IMF)'s managing director, Mr. Michel Camdessus, is of note. This "Joint-NGO Request to the IMF for Immediate Intervention" was signed by over 20 NGO leaders from the US, Japan, the EU, Latin America, and Indonesia. It sought to draw attention to connections between the MRP's environmental destruction and the IMF's negotiations to bail out the Indonesian economy during the Asian financial crisis (Tjahyono 1998).

the drained peatland directly to the haze blanketing the area, making clear the negative ecological impacts of the project.

The aborted project was detrimental to all of the inhabitants of the area. While canal construction had already severely impacted Dayak and Banjar communities, the project's abrupt end was also detrimental to social groups. As one ecologist argued, "Shutting the project was a good thing on a macro scale, but terrible on a micro scale" (i 21). Amid the government transition, many inhabitants of the area lost the government assistance they had been dependent on. They instead demanded aid and compensation for their damaged land from the district government. But during the national financial crisis in 1998, district government officials had little capacity to help them.

In southern parts of the MRP site, where rice was cultivated prior to the project's arrival, canal construction undermined the shallow peat soil's potential for expanded agriculture. In some southern areas close to the major rivers, existing fields intersected by canals are routinely flooded because peat drainage upstream has affected water flow, diverting water away from the river and into a floodplain between the rivers. Various water controls, such as small dikes, were installed during the MRP but have since been stolen for their iron or steel material. Though inhabitants of this southern block still cultivate rice, there is little water control infrastructure in place to prevent flooding. Many Banjarese rice cultivators—the original rice producers in the region—in the area have thus seen their production decline since MRP construction.[78] Despite proximity to major rivers for transport and to Banjarmasin, one of Kalimantan's largest ports, the

[78] They also haven't attracted the same attention from NGOs as the Dayak communities to their north have, or the attention from oil palm companies that the transmigrant communities have.

tidal irrigated *padi ladang*[79] that inspired grand plans for turning the whole region into a rice granary was left degraded by the Mega Rice Project.

The canals also cut through indigenous land holdings with little prior discussion or permission from Dayak populations. When MRP canal construction first began, Dayak inhabitants of the river villages were hopeful that the extensive canal system would facilitate their access to forest resources that they had always been dependent on (i 44). It quickly became clear, however, that in addition to destroying the forest their livelihoods were dependent on for timber, non-timber forest products, and hunting, the canals severely affected their fishing practices. First, the canals swept fish breeding habitats from the small forest rivulets into the major rivers, where predatory river fish ate the fish eggs. Second, drainage from the canals undermined the traditional Dayak fishing system, which relied on fish ponds in the forest, called *beje.* Dayaks dug these unlined ponds during the dry season and during the wet season, tidal river flooding pushed freshwater fish deeper into these forest ponds; the biggest fish would remain when the tide subsided. Villagers would then harvest the fish all at once, eliminating the need to maintain the fish ponds with additional feed. Once the large canals were dug, draining water from the peat forest, the tidal flow wasn't strong enough to push the fish into the ponds.[80]

The failure of the Mega Rice Project is most often assumed retrospectively to be a failure of hydrologic engineering: a forested, waterlogged swamp where water could not be sufficiently controlled through canals because of the landscape's domed surface formation. But many people in the area—both in the nearby district capital and in the villages—offered an alternative view: that the MRP was a political failure, not an environmental one. One district government

[79] *Padi ladang* is the generic term used to describe any kind of unirrigated rice paddy. *Padi gunung*, or "mountain rice paddy," is often used to describe rice in the MRP area, which is a type of *padi ladang*.
[80] Most of the *beje* currently maintained in Dayak villages are more similar to standard fish ponds, in which fish are raised in the ponds from eggs to adulthood and need to be fed by people.

bureaucrat in Kapuas, the small district capital town, articulated this as he was driving me back to my guesthouse one evening: If Suharto hadn't resigned as president, he said softly but confidently, the Mega Rice Project would have been continued, the transmigrants would have stayed and improved the peat soil, and the area would be a center for rice production. Many people in the villages throughout echoed this sentiment. They are quick to mention that the MRP "failed" (always using the word *gagal,* or fail) but only because Suharto stepped down before the project was seen through to completion. Several other interviewees in Central Kalimantan echoed this. Had the President not stepped down, they said, the project would have continued and had a good chance of succeeding. It was the Javanese who wanted Suharto out of office, one Dayak man explained to me, because many people in Kalimantan supported the President's interest in bringing development initiatives to the province.

The government defined the timeline for project success or failure at five years: if transmigrants were able to harvest rice at target yields after that time, the transmigration project was considered a success. By nearly all accounts, this five year target wasn't reached as no transmigrants were selling rice commercially five years after they had relocated to the MRP area. In addition to the difficult ecological conditions for rice cultivation, officials cited the lack of governmental capacity to distribute supplies, such as compost and fertilizer, to the transmigrant areas. Settlements closer to the rivers fared better at receiving supplies but the settlement blocks farthest from the rivers lacked access to roads (even unpaved roads) and the larger canals, which could be used for transport. But, as an official in Kapuas reminded me, the government wasn't expecting quick success from the MRP; they were prepared to wait until 2002 or 2003 to determine whether the project was achieving target rice production. He said local officials thought that in 1999 and 2000 they were starting to see improvements in the transmigrants' capacity to produce rice and other products but that with the national government in the midst of transition to democracy and decentralization, funding for and attention to the MRP area fell through the cracks.[81]

In the case of MRP, the project's biggest failure was to clear and drain the land but not complete the infrastructure, especially the infrastructure that the transmigrants needed to be agriculturally productive. Instead, the project was only 20% finished when the New Order regime ended, with cleared forest land left abandoned and few of the planned transmigrant settlements established (i 44).[82] One district-level government official in Kapuas had a more blunt, competing view. “The project didn't fail,” he said. “In our program [transmigration], we placed over 100 families, gave them food for a year and a half. We gave them seedlings and tools. The only failure was their effort, but our program did not fail. It didn't produce, but it didn't fail” (i 73). He went on to explain that maybe the transmigrant farmers weren't able to produce much because of natural conditions, like floods or a long dry season. But he reiterated several times that only the farmers failed, not the transmigration program, and that the Ministry of Public Works was responsible for any flooding or fires that occurred because they didn't manage the canals and water gates properly.

8. People and Land Left in the Aftermath

[81] However, for those who stayed beyond five years, they are now the major suppliers of vegetables and other products for the local village markets.
[82] A villager in Mantangai explained that because the project was only 20% finished, many plots of land were left uninhabited and this contributed to the bad reputation that this project had later. People perceived the area as abandoned by the government because they didn't use it for any economic activity after they cleared the forest (i 44).

In the years since the project ended, community livelihoods and land cover in the area have followed dramatically different trajectories. Divergences in community adaptation to the degraded landscape have, in part, been accelerated through the various rehabilitation and re-development schemes I discuss in following chapters. Here, I provide a brief overview of what the site looks like today, based on my field visits in 2013 and 2014. Block C—which abuts Palangkaraya and is transected by the Trans-Kalimantan highway—is sparsely inhabited and highly degraded. There are some oil palm plantations close to the city, but most of this area is covered with scrub brush, ferns, and single-species secondary forest. Many of the MRP canals here have not been used and so are filled with overgrown weeds (figure 18). There are frequent peat fires throughout this area, though there are some remnant intact forests here as well, which maintain higher water tables and thus are more resistant to burning than scrub brush.

The northern third of the original MRP site (Block E) is still largely forested (figure 19). The MRP nevertheless did considerable damage to the hydrology throughout Block E, as large canals in the southern blocks of the MRP site drained water away from the north. Opportunistic loggers—both Dayak and transmigrant—also pillaged Block E between 1998 and 2000, as rapid decentralization left little regulatory or police oversight in the area, leaving the forest with dozens of small, hand-dug *tatas* canals, which led to further hydrological damage (McCarthy 2001). Illegal logging rates in Block E have fluctuated over the past decade, partially in response to whether there are conservation projects ongoing in the area (as discussed in chapter 3). According to villagers and consultants who were familiar with the area, the illegal sawmills along the Kapuas River in Block A were ramped up production significantly in 2014, after the REDD+ project ended (figure 20). I observed a lot of illegal logging in Block E and the northern part of Block A in 2014, hearing the unmistakable sound of chainsaws as we sped along the forests' small winding rivers. At many points in Block E and A, I saw hundreds of logs loosely nailed together and waiting to be pulled out through the canals to the sawmills (figure 21). Though I have no way of knowing for sure whether there was quantitatively more logging going on than in years past, several people in the area seemed to think that there was. Many Dayaks currently see logging as their sole option for income, despite its illegality.[83] The prevalence of logging and sawmills in plain sight also highlights the role of corruption in maintaining such operations, as local police are paid off and district government officials look the other way.

Despite the MRP's reputation of having been a rice-producing failure, rice is still cultivated throughout the area. In the south (Block D) near Kuala Kapuas, predominantly Banjar communities still cultivate *padi gunung* ('mountain rice') on shallow peat mixed with mineral soils. Here, the rice paddies are lush, densely concentrated, and dotted with coconut palms. Farther north, Dayak communities also cultivate *padi gunung* within a kilometer or two of the major rivers. Often, rice is planted in tracts of cleared secondary peat forest, around charred tree stumps and across uneven, seasonally waterlogged land (figure 22). Many Dayaks spend several weeks per month fishing in the major rivers and throughout the canals, staying in small work huts (figure 23, 24). They use the canals in Block A to access smaller rivers farther east, though several people mentioned that if the canals were blocked off, they would still be able to access rivers for fishing (not so for loggers, who rely on the canals for forest access). While Dayaks used to be able to produce their own food before the MRP, they are now dependent on the Javanese transmigrants for food. A group of elderly Dayak women explained that while they had been entirely self-sufficient in producing food for their families prior to the MRP's arrival,

[83] Proliferation of 'illegal' logging following the MRP echoes the criminalization of natural resource management across Indonesia more generally (Peluso 1992), in which a previously allowable action—such as selectively harvesting timber from the forest—becomes subject to persecution.

through fishing, cultivating *padi gunung*, and raising vegetables in small subsistence plots near the river, they were now dependent on the Javanese from nearby areas for their food (i 76, 78). While many Dayaks in the area still catch fish for their families and sell the surplus at the local markets, nearly all of the vegetables and the cooking oil[84] they consume is produced by Javanese transmigrants, along with some tofu and tempeh (figure 25).[85] Most of the rice they consume is imported from Java[86], though some families told me that they can sometimes harvest enough rice from their plots of *padi gunung* to feed their families for the year.

Transmigrants who stayed in the area after the project ended invested in improving the soil's capacity for production and have had somewhat successful agricultural livelihoods in the peatlands[87], finding ways to adapt to the difficult growing conditions (figure 26). Several people I interviewed in Central Kalimantan—government officials and Dayak villagers alike—echoed the notion that the Javanese transmigrants were able to succeed with agriculture in peatland because they are hardworking, diligent, and patient: "good" farmers. One of my Dayak research assistants explained it to me this way: "The Javanese are very patient. They invest in one place and they work and work until something grows, and they can sell it. The Dayaks are not very patient. We like to do many things at once, and if something doesn't work the first time, we just toss it out [give up]."[88]

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[84] Indonesians now cook almost exclusively with processed palm oil, though they used to use coconut oil, which was produced and sold by villagers.

[85] A traditional Dayak diet does not include soy-based products such as tofu and tempeh. However, I saw Javanese people selling homemade tofu and tempeh door to door in Dayak villages and at local markets primarily patronized by Dayak families.

[86] Dayaks always say they prefer the taste of the local *padi gunung* rice, while Javanese transmigrants prefer rice from Java.

[87] Some of the transmigrants that came from Java in 1997-98 brought seedlings with them, anticipating that there would be nothing to plant in Central Kalimantan. One woman said she brought several *rambutan* (a lychee-like fruit), coconut palm, and banana saplings, but when she arrived in the MRP area there were those crops growing in nearby areas (i 80).

[88] Another Dayak assistant summed it up this way: "we just like to be in the forest [not the fields]." When I asked one Javanese woman who had migrated to the area when she was young and seen the transformation in

Javanese transmigrants have also been successful, however, because they have adopted some traditional Dayak tools and techniques for farming in shallow peat soils. While the transmigrants with agricultural experience expected to use a hoe to till the soil, they found hoes ill-suited to the dry peat soil. They instead began using a traditional Dayak took, called a *tajak*, for turning the soil. One elderly Dayak man described the Javanese use of the *tajak* as an improvement on the traditional use because the Javanese have been able to use it to cultivate rice and vegetables more intensively. The Javanese have also developed better cultivation fields, he explained, by clearing the tree stumps and roots out and building up the soil nutrient quality with livestock-derived fertilizer. "There are no differences [tensions] with the Javanese who come here," he told me, "we work together. We use *tajak* and then they follow that method, too. We've seen their land become a little higher, less uneven" (i 74).

In addition to cultivating food crops for subsistence and local sale, Dayaks and transmigrants have traditionally relied on rubber gardens for income (figure 27). However, during my field visits, the price of rubber had dropped so low than many trees were being left untapped. The low price of rubber was a frequently cited driver of illegal logging throughout Dayak communities. Facing low returns from rubber, however, has led many transmigrants to convert their land to oil palm or to take up jobs as day laborers for oil palm companies. The Dayaks I interviewed were unwilling to work for oil palm companies as day laborers, claiming either low pay[89] or that the work is too difficult. Javanese transmigrants, meanwhile, described this work as a good livelihood option for them, particularly compared to the few options they had for income or subsistence production when they first moved to the area in the late 90s. As I

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her family's land if it is hard work to cultivate crops in these peat soils, she smiled and shrugged, and replied "kind of hard, kind of not hard."

[89] I heard, variously, that oil palm companies pay between Rp50,000 and 72,000 (about $4-6 at current conversion rates) per day. Loggers said that in a good day's work, they can get Rp100.000 from selling logs.

elaborate on in chapter 5, much of the transmigrant-occupied areas in Block A (in Lamunti/Dadahup) have been converted to oil palm in the past decade (figure 28, 29).

9. Conclusions

Though the Mega Rice Project was by many measures a colossal failure of state planning, the project's impacts on the area's inhabitants have been uneven. The indigenous Dayak groups have unquestionably suffered from the loss of peat forests, and with it a loss of livelihoods. However, the transmigrants who settled in the area have been able to generate income through the arrival of oil palm plantations, as I discuss further in chapter 5. And while the MRP left much of the previously forested area covered with 'colonizer' tree and fern species that are of little use to the Dayaks (Page et al. 2008), some of the burned land and secondary forest has been used for locally productive agriculture (rice, rubber, and jelutong, a tree grown for timber) over the past 15 years. While the MRP brought immediate challenges for the area's inhabitants and catalyzed massive peat fires in 1997-98, the canals permanently altered the hydrology throughout the site, leading to ongoing degradation. Absent vegetation and drained of its high water table, the soil surface begins to undergo microbial oxidation, releasing carbon dioxide into the atmosphere and has become extremely flammable under dry conditions.

The particular conjuncture of attention to tropical forests and climate change, and the political upheaval in Indonesia, enabled the production of knowledge surrounding tropical peat soil's carbon capacity in the early 20th century. This degradation—most immediately in the form of the fires but later through oxidation as well—mobilized scientific expertise to draw connections between Kalimantan's peatlands and planetary climate change, which is the subject of the next chapter. Furthermore, it has led to the emergence of a mainstream consensus in which many scientists believe that if more research about peatlands' ecology/hydrology had been circulated or conducted prior to the project's implementation, this kind of disaster would not have happened (of course, "true" scientific knowledge doesn't always lead to better land use outcomes, as I demonstrate in chapter 5).

Finally, despite its social and ecological heterogeneity, this large degraded peatland area becomes a site on and through which new ideologies of tropical rural development play out in the years after the project. The Ex-Mega Rice Project site, as it is now referred, is not simply a blank slate—in spite of its large swaths of barren land—on which new values can be inscribed, and new value can be extracted; clearly, there are many existing land-use strategies already at play. The question thus shifts from why did this project unfold as it did and then fail, to how can new forms of value be extracted from the messy landscape left in its wake.

Chapter 3: Scientific Consensus, REDD+, and the Scalar Politics of Peatland Degradation

The 1997-98 fires were unprecedented in Indonesia[90], not only in the extent of land area that burned but in the social and political ramifications as well. By 1998, after the fires raged during September and November of 1997 and started up again in late January 1998, it was increasingly clear to scientists and some government officials that a majority of the fires were burning through subterranean carbon stock—peat soil—in addition to forest vegetation (*Jakarta Post,* 27 January 1998). The smoke-haze from the fires was of immediate concern: the haze crisis cost an estimated $6 billion in economic losses,[91] sickened millions of people,[92] and caused at least one plane crash in Sumatra.[93] While I further elaborate on the causes and effects of smoke-haze in chapter 6, I turn here to the other environmental consequence of the fire episode: carbon dioxide emissions.

Scientists, consultants, and policymakers often reference the large proportion of carbon emissions that Indonesia's peatlands contribute to the national total. "Facts," such as the claim 50 percent of Indonesia's total emissions originate in peatlands, have come to populate contemporary conversations and policy reports (Sari et al. 2007) as a kind of common knowledge, and as a scientific fact. But as the history of scientific research in the peatlands described in chapter 2 illustrates, researchers—both foreign and Indonesian—have not always found carbon emissions data significant. After rains cleared out the haze in late 1998 and the

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[90] There were also extensive fires in Borneo during the El Niño year in 1982, but 1997-98's fires covered a larger land area and were also more concentrated on peatland (Dennis et al. 2005).
[91] This was a preliminary estimate for economic costs to Indonesia; the economic costs to Singapore, Malaysia, and Thailand no doubt raised this total considerably.
[92] It is difficult to connect the prevalence of smoke-haze directly to illness or death, though there are many known health risks, particularly for people with existing respiratory conditions (see chapter 6).
[93] A Garuda Indonesia plane crashed in September 1997 near Medan, Sumatra, shortly after the pilot complained of poor visibility due to smoke-haze (CNN, 26 September 1997).

fires died down, scientists (primarily foreign) began to investigate precisely how much carbon was released from that year's fires. Throughout the first decade of the 21st century, knowledge of the connection between Indonesia's peatland conversion to agriculture and massive carbon emissions began to circulate through international policy circles.[94] The Mega Rice Project was at the center of both the production of this knowledge and its circulation. Because peat combustion in this site was so concentrated and attention was already turned within Indonesia to the disaster unfolding on the ground as a result of the project, the data from the MRP informed several significant publications on the magnitude of carbon emissions from peat fires.

A salient narrative about tropical peat soil thus emerged at a conjuncture of national political upheaval, emergence of a global environmental concern about greenhouse gas emissions, and the MRP fire disaster. Following the emergence of this narrative, I argue that this scientific knowledge galvanizes state and non-state (NGO) actors to respond to peatland degradation as a global problem requiring climate change mitigation strategies. Scientists' shift in understanding of the degraded peatlands as a significant source of carbon in the global climate cycle and the circulation of this knowledge in international circles, repositioned the MRP site's degraded peatlands—and peatlands across Indonesia more generally—within global political, economic, and scientific circuits as a threat to the atmosphere. This repositioning of the degraded peatlands as a global atmospheric threat has consequences for rehabilitation in the site, as attempts to "clean up" the MRP mess become tied to international carbon offset mechanisms rather than domestic financing. Scientific focus on carbon emissions, rather than the impacts of smoke-haze, subsequently organizes international funding to re-value the site as a carbon offset as if a market for carbon offsets existed, although it does not.

[94] This is worthy of extended discussion within the framework of Foucault's *epistemes* (Foucault 1970), though it remains beyond the scope of this chapter for the time being.

In this chapter, I first describe the scientific research that was key to repositioning Indonesia's degraded peatlands and the MRP site as significant sources of carbon emissions. I then show how early attempts to rehabilitate the MRP site as a forest habitat transitioned to carbon-based conservation schemes in the first decade of the 21st century. States, individual actors, and NGOs have sought to extract value from the degraded landscape through carbon mitigation efforts that focus on rehabilitating the site in order to prevent carbon emissions. This type of ecosystem rehabilitation through carbon offsets is, however, quite different from most tropical conservation schemes that seek to preserve intact ecosystems for the purposes of safeguarding biodiversity and/or carbon stock. The series of rehabilitation projects that unfolded in the Ex-MRP site between 2000 and the present culminated with a Reducing Emissions from Deforestation and Degradation (REDD+) project, called the Kalimantan Forest Climate Partnership project (KFCP). The KFCP project was the latest state-funded, NGO-run attempt to commodify degraded peatland. The project ultimately fails to make the site valuable to financial investors, however, as a result of the lack of political, scientific, and economic structures that would (in theory) commodify degraded peatland as a carbon offset.

1. Commodifying Forest Carbon: Offsets and REDD+

The idea of using market mechanisms to reduce carbon emissions can be traced in mainstream discourse to the United Nations Framework Convention on Climate Change (UNFCCC) 1997 Kyoto Protocol. The agreement mandated for its signatories that industrialized countries reduce their national carbon emissions to about 5% below 1990 levels. Developing countries, meanwhile, were largely exempt from reducing greenhouse gas emissions within the context that they were not historically responsible for climate change to the extent of already developed countries (Liverman 2009). Critiques of this arrangement notwithstanding, market-based mechanisms emerged as the means through which countries were to cap and reduce their greenhouse gas emissions. Within this framing, the atmosphere effectively became a carbon dump and countries were allocated industry-based permits—carbon credits—to pollute. In order to continue dumping as much or more carbon into the atmosphere, industrialized countries needed to purchase additional 'carbon dumps' by investing in carbon emissions-reducing activities in less industrialized countries (Lohmann 2005).

Such activities are referred to as carbon offsets. At their most basic, carbon offsets refer to the sequestration of carbon in one location in order to continue emitting carbon elsewhere.[95] Carbon offsets emerged as one of the primary routes through which countries mandated by the Kyoto Protocol could reduce their emissions, whether through voluntary or involuntary carbon emissions trading schemes. For fossil fuel-combusting industries (or individual actors) in the developed world, carbon offsets have become a less expensive way to offset emissions than to curb emissions within the original polluting industry. Most carbon offsets are forms of 'natural' carbon sequestration.[96] Any part of an ecosystem that absorbs and stores carbon can, in theory, be rendered a carbon offset, including trees, oceans, and soils. In order to turn a part of an ecosystem into a carbon offset, there must be a known 'baseline' quantity of carbon emissions that would be released regardless of whether the offset project occurred. The investment in the carbon offset thus provides the necessary "'additionally' that differentiates the emissions produced by an offset project from the business-as-usual scenario of baseline emissions without

[95] This neoliberal strategy of enacting climate change mitigation has been thoroughly critiqued elsewhere. See for instance, (Bumpus and Liverman 2008; Boykoff, Bumpus, and Liverman 2009; Lovell and Liverman 2010; Boyd, Boykoff, and Newell 2011; Lohmann 2011).
[96] Carbon offsets can also be forms of combustion that release fewer amounts of greenhouse gasses than the emitter seeking the offset. Installing solar panels instead of a coal-burning power plant can be considered a carbon offset if the coal-burning plant is not built elsewhere.

the project" (Lohmann 2005; Bumpus 2011, 615). Furthermore, within such a market-based regime greenhouse gasses, and their specific components (carbon dioxide, methane, ozone, etc.), must be made commensurable in order to be exchanged as a carbon offset {Callon:2002he, Star and Griesemer's (1989) concept of 'boundary objects' does similar work).

Carbon, as an exchangeable product subject to the laws of markets, is difficult to define. While there are obvious parallels between the commodification of carbon and the neoliberal production and privatization of water, biodiversity, and even land itself (McAfee 1999; Castree 2003; Bakker and Bridge 2006), processes of carbon commodification also have significant differences. Making carbon commensurable as a commodity differs, as some scholars have argued, from commodifying other forms of nature, in part because of the material dimensions of carbon itself (Bumpus 2011; Bridge 2011). Because its gaseous form is invisible, odorless, and otherwise difficult to detect without specialized equipment, techniques for measuring carbon dioxide emissions are necessarily more involved than that for measuring water flows, tree species, or even biodiversity losses. While this is worthy of extended discussion, for the purposes of this chapter I make this point only in relation to tropical forestry projects as they have been made into carbon offsets. This becomes significant when considering carbon offsets, the means through which carbon emissions trading as mandated by the Kyoto Protocol and its affiliate market strategies[97].

Geographers have thoroughly critiqued this neoliberal strategy of environmental protection. Within some of this literature, Polanyi (1944) has become a foil for thinking about the creation of carbon markets, and the "fictitious" commodification of carbon[98] (Lohmann

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[97] Here I am referring to the Clean Development Mechanism, the European Union Emissions Trading Scheme, and a host of other cap-and-trade schemes.
[98] Echoing Polanyi's assertion that land, labor, and money are fictitious commodities.

2010; Carton 2014). In arguing for a society-driven 'countermovement' that pushes back against self-regulating capitalist market forces, Polanyi's notion of countermovements *should* be useful for thinking about the extent to which the commodification of carbon through offsets and emissions trading schemes remains partial and/or incomplete. However, as I show in this chapter and chapter 4, because there is no market in which forest carbon offsets produced through REDD+ projects can be exchanged, Indonesia's peat soil-based carbon is never commodified because there is no market to begin with. Though many of the coordinating activities to render it a commodity occur, as they would in other forms of ecosystem commodification, the lack of a market, self-regulating or otherwise, makes it difficult to argue that the failed attempt to commodify the peat soil through carbon offset projects is the result of a Polanyian countermovement.

One scheme to offset carbon emissions in the Global North through ecosystem protection in the Global South is the United Nations-led Reducing Emissions from Deforestation and Degradation, or REDD+. REDD+ projects allow Global North countries, seeking to reduce their national emissions rates to levels mandated by the Kyoto Protocol, to pay developing countries in the tropics to conserve their forests as carbon offsets. During a series of disappointing UN Convention of the Parties (COP) meetings in 2006-09 that produced few climate agreements, REDD+ emerged as one of the few bright spots in international climate change mitigation.[99] The 2007 COP-13 marked a turning point for considering tropical forests within global science-policy regimes. Because tropical forests overall sequester and store more carbon than forests in temperate and boreal latitudes, tropical forest conservation became an attractive way for global

[99] In 2007, many scientists and policymakers assumed that after the Kyoto Protocol expired in 2012, a subsequent agreement would feature a compliance market through which international carbon credits would be traded.

policy makers to attempt to rein in climate change through carbon trading mechanisms (Laurance 2008).

The concept of having developed countries pay tropical countries to maintain their forests for climate change mitigation was first introduced internationally at COP-13. The idea is based on a 2005 proposal from the Papua New Guinea-based Collation of Rainforest Nations. In 2007, the United Nations climate change community acknowledged that tropical deforestation was a major source of carbon emissions and moved towards adopting mitigation plans that included mechanisms for reducing deforestation and forest degradation. REDD+[100] was formally adopted by the UNFCCC as part of the Cancun Agreements following COP-16 in 2010. However, the underlying principle of REDD+ is based on involuntary international carbon credit trading that would be set up by the UNFCCC, which has so far failed to materialize. In the absence of involuntary carbon credit trading, REDD+ projects have remained donor-funded or tied to provincial level political mandates.[101]

Avoiding deforestation remains the primary objective of most REDD+ projects. Because a REDD+ project needs to claim "additionality" for a potential investor, forests that are already in protective regimes (national parks, for instance) are ineligible for protection through REDD+. Project developers instead seek forests that are threatened by both large-scale (corporate-led) and small-scale (community-led) deforestation. Avoiding forest degradation, the second "D" in REDD+, has been challenged by the lack of common definitions of what constitutes forest

[100] REDD became REDD+ several years after it was first introduced. The "plus" refers to additional benefits, including livelihood development and restoration activities, in addition to reducing deforestation and degradation.

[101] While REDD+ projects in Brazil—particularly the state of Acre—have been supported by the local government and might actually succeed in becoming market based, all REDD+ projects in Indonesia remain donor funded.

degradation.[102] The ‘plus’ in REDD+, meanwhile, refers to enhancement of forest carbon stock that can be included with avoided deforestation and degradation activities, such as ecosystem rehabilitation. Forest ecosystem rehabilitation has not been the focus of most REDD+ projects, given more logistical obstacles than merely preventing ecosystem destruction, including the ambiguous definitions of ‘degraded’ forest land (S. Thomas et al. 2010; Barr and Sayer 2012).

One of the major obstacles to implementing REDD+, let alone making forest carbon projects investable, is the measuring and monitoring of carbon emissions required over a period of time (Gibbs et al. 2007). However, providing evidence that carbon emissions have been prevented through avoided deforestation initiatives (or carbon sequestered through ecosystem rehabilitation projects) is the key mechanism through which carbon offset payments are intended to be distributed to national governments and/or forest inhabitants (Aarti Gupta et al. 2012). As such, developing the systems through which carbon emissions from REDD+ projects are measured and monitored have been a key focus for international and national-level REDD+ development. I expand on and demonstrate some of those challenges in creating Measure, Report, and Verify (MRV) systems for REDD+ in chapter 4.

In Indonesia, REDD+ emerged as a market mechanism through which tropical forests can be conserved during the time when Indonesian and foreign actors were figuring out what to do with the Mega Rice Project mess in the mid-2000s. The Kalimantan Forest and Climate Partnership (KFCP), a REDD+ project operating in the Ex-MRP from 2010 to 2014, attempted to develop a portion of the site as a potential carbon offset by rehabilitating the degraded peatland ecosystem as a means of preventing further carbon emissions. I discuss this further later in this chapter. Elsewhere in Indonesia, REDD+ has mainly taken the form of ‘avoided

[102] For more on this, see J. Goldstein (2014).

deforestation' projects in Sumatra, Kalimantan, and Sulawesi, in forested areas threatened by agricultural conversion. Because Indonesia has one of the highest rates of deforestation in the world, the country is seemingly an ideal place in which execute REDD+. However, momentum for REDD+ in Indonesia has stalled in recent years for a variety of reasons, including land tenure conflicts, longstanding corruption in the forestry sector, a highly decentralized governance structure, and a national-scale forest ecosystem that is fragmented across hundreds of islands (Angelsen 2009; Brockhaus et al. 2012; Sunderlin et al. 2013; Astuti and McGregor 2015).

Research on information sharing within REDD+ projects has most often taken policy-related knowledge into account, but not necessarily scientific knowledge. In their study of the KFCP project implemented in Central Kalimantan, Gallemore et al. (2014)found that local NGO groups were very critical of the project's top-down focus on carbon markets. Local NGOs, which felt they best represented the interests of the indigenous inhabitants in the area, believed that the local population remained confused about what carbon was, which led to issues of free, prior, and informed consent in their participation in the project.

While I do not focus on free, prior, and informed consent in the coming chapters *per se*, this has become a significant issue for many REDD+ practitioners and scholars. It pertains to the knowledge, or lack thereof, of potential benefits and consequences of REDD+ project participation that is shared with participants before engaging with a REDD+ project. As Moeliono et al. (2014) note, the KFCP project hit obstacles when information about the purpose of carbon measuring and monitoring was not sufficiently shared with participants. Through a study of networked relations between organizations (governmental and NGO) and actors involved with the KFCP project, they found that information sharing was most often concentrated in clusters of similar organizations. For instance, national government agencies shared information with other national government agencies; and international organizations shared information with other international organizations. The authors speculate that this indicates higher levels of trust between similar institutional entities, but also point to this as a hindrance in effective REDD+ policy and implementation (Moeliono et al. 2014). These flows of information has consequences for the degree to which project participants are informed of their rights and the project's objectives prior to participating. It also points to the degree to which local inhabitants were fully informed about the scientific purpose of measuring and monitoring carbon, particularly as it became clear to the project managers that the data collected by participants would be scaled up for use at the national level, as I discuss in chapter 4. Regardless, the circulation of knowledge within a particular REDD+ project and between institutions involved with REDD+ worldwide is key to understanding the outcomes following the attempts to transform tropical landscapes into carbon offsets.

2. Early Rehabilitation Efforts in the Ex-Mega Rice Project Site

In the first few years after the MRP disaster, the earliest attempts to rehabilitate the Mega Rice Project site as a forest habitat quickly transitioned to carbon-based conservation in the first decade of the 21st century, culminating with the Kalimantan Forest Climate Partnership (KFCP) project, a REDD+ project operating in the site from 2010 to 2014. Prior to carbon-based conservation tactics, however, the earliest NGOs on the ground in the aftermath of the MRP were focused on rehabilitating forest habitat for orangutans. In the immediate aftermath of the 1998 fires and the national political transition, few NGOs were working in MRP area. In the absence of government and NGO support, infrastructure was left incomplete and the transmigrant and indigenous Dayak communities had little direct relief. One of the first organizations to assess the early damage of the MRP was the Borneo Orangutan Survival organization (BOS), which had a long-standing presence in East Kalimantan. The group was primarily concerned with the fate of the orangutan population inhabiting the MRP site. BOS's only existing orangutan rehabilitation center was in East Kalimantan, which was too far from Central Kalimantan to relocate the animals. BOS constructed 'Nyaru Menteng' just outside Palangkaraya, a rehabilitation center and safe house for orangutans from the surrounding area. BOS promised donors that the center would plan for their eventual re-release into forest habitat, which required preserving some intact peat forest in the area. With most of the surrounding forest in disarray following the MRP, the northern third of the 1.5 million hectare site—Block E—had not been directly drained or clear-cut during the project.

The MRP nevertheless did considerable damage to the hydrology throughout Block E, as large canals in the southern blocks of the MRP site drained water away from the north. Opportunistic loggers had also pillaged Block E between 1998 and 2000, as rapid decentralization had left little regulatory or police oversight of the forests, leaving the forest with dozens of small, hand-dug canals, called *tatas*. BOS thus pledged to conserve the remaining peat forest in the MRP area and rehabilitate Block E by blocking the *tatas* with dams (figure 30).[103] BOS Mawas, with its organization comprised of a handful of paid employees and many volunteers, had neither the capacity nor the funds to conduct extensive rehabilitation themselves, however. The organization thus tried to solicit Shell Oil to finance forest rehabilitation as a carbon offset. Organization directors began promoting the rehabilitation project as a potential carbon offset, several years before the idea became mainstream[104] and found that Shell Oil

[103] This 309,000 ha area, called BOS Mawas, remains under BOS management and currently has relatively intact secondary peat forest cover, which supports orangutan habitat.
[104] Private investment in tropical forest conservation for carbon offsets proceeded on an *ad hoc* basis until REDD+ was introduced at the UN Conference of the Parties (COP) in 2007.

Company was one of the few interested early investors in forest carbon offsets.[105] A study had been conducted in 2000 to determine the feasibility of conserving or rehabilitating sufficient land for the existing and future orangutan population in the ex-MRP site with funding from the Dutch government. Consequently, the Dutch government asked Shell Oil, or Royal Dutch Shell as the larger conglomerate is known, to invest in forest rehabilitation as part of a debt-for-nature swap. "Shell was the only one willing to throw money away," laughed an Indonesian consultant involved with the project. "At that time we hoped that if a company like Shell is willing to invest, than the other companies will follow" (i 70). Before the UN drew attention to the possibility of trans-national investment in carbon offsets through tropical forest conservation in 2006-07, few investors were interested in the scheme.

The Indonesian government, however, ultimately dismissed the idea of a debt-for-nature swap managed by an environmental NGO promoting orangutans. The Indonesian consultant recalled "It's like alien for them! [officials in Jakarta] How can orangutans get the money?" Despite the salience of 'saving Borneo's wild mega fauna' for Europeans, Indonesian national government officials never considered orangutans worthy of special protection—let alone a multi-million dollar debt swap—and turned down the offer. As carbon trading gained international attention after the COP meetings in 2006 and 2007, Shell was still willing to get involved. Conservation officials were divided as to whether including an oil company in conservation funding would help or harm their efforts, however. BOS and other environmental conservation NGOs worried that involving an oil company in conservation activities would appear poorly to other investors and taint the whole project. Shell ultimately pulled out of the agreement (i 70).

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[105] In 2002, the idea for carbon offset trading had caught the attention of investors looking to compensate for fossil fuels burned elsewhere.

These early attempts to determine which parts of the ex-MRP site were most in need of rehabilitation were hampered by the lack of available data for the entire hydrological system, prompting novel efforts by conservation organizations to gather and interpret scientific data themselves. While scientists had conducted research on carbon emissions from the site, including the 2002 *Nature* paper, this research had focused on emissions measured through remotely detected burn scars to measure the impacts of fire. Though data on soil depth had been collected by UNPAR scientists at several locations close to Palangkaraya, few consultants or researchers knew precisely how the subterranean geomorphology and hydrological structure had been affected by canal construction throughout the broader ex-MRP site. There were, in other words, no compendiums of data that led to clear rehabilitation strategies in the early 2000s. As the Indonesian consultant described, "at that time, the knowledge of peat was not available that much" (i 70), referring to the lack of data on subterranean carbon stock. In 2004, BOS started a remote sensing company called SarVision, in conjunction with the University of Wageningen in the Netherlands, to develop technical capacity for detecting peat soil carbon in the area. Although BOS was never considered a research institute, they still needed to collect data on peat soil so they could better determine where and how to block *tatas* canals that were impacting peat hydrology. The Indonesian consultant involved with the project elucidated:

In 2004, we found there was a peat dome using radar to see the content of the water. Using a long boardwalk, we put some devices there [in the water], which collected data on the movement of the water table. So from there we knew that the peat is expanding and collapsing. And we know there is a breathing thing… this was amazing for us (i 70).

These early field experiments by SarVision in 2004-5 were some of the first conducted *in situ* to determine how much carbon was being emitted from the landscape over a given period of time.

This was in contrast to the data published in the 2002 *Nature* paper, which derived emissions data from post-fire burn scars detected remotely. It also reflected the initial attempts of conservation organizations to produce their own scientific data, rather than rely on knowledge generated remotely or by external, unaffiliated scientists.

Using data collected by BOS and Wetlands International on the most critical areas of the Ex-MRP site in need of rehabilitation, the first formal donor-based attempt to rehabilitate the Ex-MRP site through dam building and tree planting was the Central Kalimantan Peatland Project (CKPP).[106] Through a consortium of five partner organizations (BOS, CARE-Indonesia, WWF, Wetlands International, and the University of Palangkaraya), this three-year project was set up in the Ex-MRP site using emergency rehabilitation funds from the Netherlands in 2006. It encompassed the whole 1.7 million hectares affected by the MRP and claimed to have restored the hydrology in 50,000 hectares of the Ex-MRP site through blocking small *tatas* canals and some larger, secondary canals built by the MRP. Though the "Peat CO_2" report did not directly rely on data from the CKPP, it involved many of the same Britain, Netherlands, and Indonesia-based scientists and consultants. Ultimately, funding for the CKPP dried up at the end of the project, leaving Indonesian scientists who had been involved with it frustrated that they had some small successes in rehabilitating the site through dam building but no opportunity to continue the work (i 68, 69).

[106] Though the Netherlands did not extend funding for the CKPP beyond 2008, they financed a concurrent series of technical reports titled *Master Plan for Rehabilitation and Revitalization of the Ex-Mega Rice Project Area in Central Kalimantan*. The reports were put together under supervision of the Central Kalimantan provincial government and the Royal Netherlands Embassy in Jakarta; research and writing of the reports was largely carried out by Dutch consultants from Deltares/Delft Hydraulics, a private environmental consulting firm, with additional support from researchers at the University of Wageningen in the Netherlands and additional Dutch experts. Though the *Master Plan* is the most comprehensive plan to rehabilitate the ex-MRP site written to date, little of the plan has been executed on the ground because of lack of Indonesian government funding (i 21).

3. Circulating Carbon Emissions Claims

Then it all went up in fire in 1997. Then I got big money. Once it was on fire, I was in business.
—European scientist who had conducted research in the Mega Rice Project area prior to 1997

After the dust had settled—literally and figuratively—following the 1997-98 fires and the MRP was officially ended by government decree in 1999, scientists turned their attention to the probable release of carbon dioxide from the peat fires. As one scientist described (also quoted above), the fires significantly shifted the focus on his research program. Because his team had already collected extensive benchmark ecological data, they were able to look at the impact of the MRP on the ecosystem through before-and-after analysis. This comparative data, coupled with the fact that they could more easily publish in internationally-recognized journals than Indonesian scientists working alone, forced their research to the forefront of knowledge about the peatlands' carbon emissions. As the authoritarianism of the New Order ended with Suharto's resignation in 1998, foreign scientists who had previously refrained from publishing research that countered Suharto's peatland development plans began to circulate their research more publicly. Prior to that, foreign scientists speaking out against the plans risked getting their visas revoked. Researchers from institutions who had worked in the peatlands since at least the early 1990s—from Universities of Nottingham and Leicester in the UK, the University of Helsinki in Finland, and the University of Hokkaido in Japan, along with Deltares and Altera, two Dutch consulting firms—were the first on the ground in Central Kalimantan following the 1997-98 fires. Based on their research, two papers published in the early 2000s shaped perception that

Indonesia's peatlands, and the MRP site in particular, contribute significantly to global atmospheric change.[107]

Drawing on previous data collected in the MRP site prior to the project's arrival, the team of British scientists was able to determine how much carbon dioxide had been released during the 1997 fires in the MRP site. They also extrapolated this data to calculate how much carbon had been released from all of Indonesia's peat fires that year. Their results appeared in a prominent *Nature* paper published in 2002, using data from the MRP site to determine that the 1997 peat fires across Indonesia released carbon emissions on an order of magnitude larger than had been released previously. In this study, research objectives were three-fold. They first mapped the location and extent of the fires that occurred in 1997 in Central Kalimantan surrounding the Mega Rice Project site. Then they measured the difference in fire damage between intact and cleared or drained peatland, and finally, they extrapolated the amount of carbon released from that year's fires across all of Indonesia's peatlands. Using Landsat and radar imagery from a contiguous 2.5 million hectare area[108] overlaying the Central Kalimantan site, they showed that 32 percent of the site had burned that year, 91.5 percent of which was peatland. They concluded that the 1997 Indonesian peat fires had released between 13 and 40 percent of the mean carbon emissions from all fossil fuels globally (Page et al. 2002). Put in other terms, this was equivalent to the total annual emissions from Western Europe's power plant and transportation sector combined (Harwell 2000; Sari et al. 2007). Subsequent studies on Indonesia's peatlands have similarly emphasized that tropical peatlands are one of the largest

[107] The connection between scientific publication of carbon emissions and Indonesia's nascent democratic government is worth exploring more extensively. If Suharto hadn't resigned, would scientists have published this data? Or can the circulation of this data be better attributed to the rising attention to carbon emissions internationally?

[108] This size reflects the size of the Landsat composite tiles. It encompassed the Ex-MRP site and also some of the surrounding area, which scientists speculated was also affected by MRP drainage.

terrestrial carbon stores on earth, have the capacity to affect planetary atmospheric flux (Page, Rieley, and Banks 2011; S. Moore et al. 2013), and that Indonesia's peatland development should take into account the large below-ground carbon pool, which is several orders of magnitude greater than above-ground peat forest carbon storage (Paoli et al. 2011).

This publication in *Nature* galvanized NGO interest in the site, leading some organizations to take a closer look at the policy implications of "peat carbon." A second study on degraded peatlands' emissions was published in 2006 by several of the same authors as the *Nature* paper. This research was coordinated by the Netherlands-based NGO Wetlands International, funded by the Dutch government, and produced by Delft Hydraulics (now called Deltares), a Netherlands-based environmental consultancy. Called the "Peat CO_2" report, it sought to demonstrate the quantifiable impact Southeast Asia's peatland drainage has on global carbon emissions. Though peatlands only cover 3 percent of the world's land area, the report explained, the amount of carbon stored in these soils are up to 70 times that of annual global carbon emissions from fossil fuels. Furthermore, the report's authors hoped that by demonstrating the impact of peatland management on carbon emissions, tropical peatlands would be recognized in global climate change debates as much of a planetary atmospheric risk as fossil fuels are (Hooijer et al. 2006). This consultancy report, more than the *Nature* article, was incorporated into the World Bank via the Indonesian environmental consultancy *Pelangi Energi Abadi Citra Enviro* (PEACE), which had been tasked with writing a report on Indonesia's land-based emissions. By 2008, the report effectively became the defining piece of evidence in international policy circles that peatlands and peat fires are a significant source of carbon emissions.

Circulation of this expert knowledge in the years since the 1997-98 fires has generated consensus within certain policy networks about how peatlands should be managed. After this study was published, the World Bank and other development agencies began citing Indonesia as the world's third largest carbon emitter, owing to land-based emissions such as these peat fires (Sari et al, 2007). Within Indonesia, pressure from other international NGOs also forced the Indonesian government, and Indonesians more generally, to pay attention to peatlands as a carbon source rather than simply a site of local fires. The most well-known NGO to do this was Wetlands International, which pushed tropical peatlands' greenhouse gases to the top of their research and advocacy agenda in the early 2000s.[109] These published findings and reports coincided with increasing international attention to carbon emissions from tropical wetland forests, leading to attempts to rehabilitate the peatlands. In addition to being more policy-oriented than the *Nature* paper, the Peat CO_2 report was timed to be released in advance of the UNFCCC 13th Conference of the Parties (COP) held in 2007 in Bali, drawing further attention to the carbon offset potential of the degraded peatland through REDD+.

Among the international scientific community and actors who draw on their research, the 1997-98 fires rapidly shifted the ecological scale of the perceived consequences of peat soil fire and oxidation, from local and regional to global. It also solidified the role of large-scale plantation agriculture, such as oil palm, in contributing to these carbon emissions and thus to planetary atmospheric crisis. Through this shift and the peatlands' reconfiguration as land suitable for agribusiness investment, as I discuss in chapter 5, experts began to understand tropical peatlands as a hazardous carbon source needing protection and/or rehabilitation. Yet following these fires, little doubt remained in the international scientific community that Indonesia's peatlands were transformed from a carbon sink to a carbon source under the conditions produced by large-scale cultivation, such as in the MRP site (Galudra et al, 2010; Sari

[109] Wetlands International began working on peatland rehabilitation in Central Kalimantan in 2003 with funding from the Canadian International Development Agency.

et al, 2007). More significantly, the politics of scale as Reed and Bruyneel argue, determines who becomes involved with environmental governance and under what circumstances (2010, 6). As the perceived consequences of peatland degradation shifted scales, so did the range of actors who not only became involved in the site but were held *responsible* for the carbon emissions originally attributed to the MRP.

4. Shifting to Carbon-Based Rehabilitation

"Carbon is just a vehicle to take us to the destination that we want." —Indonesian NGO-affiliated forest researcher (i 13)

Norway's 2010 US$1 billion grant jumpstarted REDD+ in Indonesia. With the Norway grant, several provinces were designated as REDD+ pilot provinces,[110] including Central Kalimantan, which directed future REDD+ projects to those provinces. The funding was not intended to start specific projects, but to establish the national institutions and policies that would enable future REDD+ projects. The funding was also contingent on evidence of emissions reductions at a national scale through avoided deforestation or by curbing land-based emissions through ecosystem rehabilitation. A key piece of this objective was the Measurement, Reporting, Verification systems developed to assess land-based carbon emissions, which I focus on in chapter 4.

REDD+ institution building at a national scale was occurring even in the absence of any international agreements that would mandate involuntary carbon trading, the main mechanism through which REDD+ projects were supposed to be funded. In 2010, the UN REDD+ task

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[110] Provinces were selected primarily on the basis of having a large proportion of intact forests threatened by conversion to agriculture for oil palm or pulpwood.

force, ONICRD, set up a national REDD+ agency, BP-REDD+, to oversee project funding and enforce benefit sharing[111] (Astuti and McGregor 2015). National REDD law No. 36 was also enacted, to ensure that REDD+ projects would have "additionality" and provide "benefit sharing" for communities.[112] BP REDD+ became a project broker, in which developers registered a project with the agency and the agency received funding via the UN from donor countries. The agency then distributed funding to project leaders on the ground to facilitate the projects. This enabled developers to bypass central government channels in which funds might be stolen or skimmed. In creating the agency, REDD+ proponents were also hoping that REDD+ would remain above the fray of national ministerial corruption, as all of the ministries that were affected by REDD+ projects—the Ministry of Forestry and the Ministry of Agriculture in particular—would try to halt projects or bring existing grievances to the table (McGregor et al. 2015).[113]

Within a carbon-based conservation model like REDD+, ecosystems with higher carbon stock—the total amount of carbon stored in the ecosystem's vegetation and soil—are more

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[111] REDD agency was recently absorbed by newly merged Ministry of Forestry and Environment, by Joko Widodo's administration in 2015.

[112] There was concern among carbon project financiers regarding how payments would be distributed to communities tasked with avoided deforestation projects. In 2011, there was still great uncertainty about how the national government would oversee REDD+ schemes and how the payment mechanisms would function. While carbon developers—often private investors from abroad—were willing to pay for a project's start-up costs directly as a potential return on investment—there was "no certainty of national scale management of carbon credits," described one foreign carbon-project consultant working in Indonesia (i 14). The Ministry of Finance initially set up a scheme in 2010 in which the ministry would collect all of the money, take a 30 percent cut of REDD+ project profits, and distribute the rest to the project developers. But most project developers wanted more of the funds—either start-up donor funds or future returns—to go directly to the communities living in the project sites. "If you give the money to a central government, there is fear that the communities won't get the money at all," explained the consultant (i 14). In a country notorious for corruption at all levels of government, many doubted that this payment scheme would succeed.

[113] When I mentioned to a REDD+ project developer that it was interesting that institutions for REDD+ were being created in the national government prior to certainty of an international carbon market to finance REDD+, she explained that "REDD is such a complex scheme, it has to be tested and proven on the ground because there are so many doubts internationally. Then investors can be more confident. But at an international level there still has to be an agreement" (i 4).

valuable to investors looking for higher future returns,[114] despite the fact that there is yet no involuntary international market for carbon emissions offsets.[115] The potential for future returns on carbon offset investments has therefore shifted project developers' priorities towards conservation in ecosystems with high carbon value. As such, environmental NGOs[116] have found Kalimantan's peatlands attractive sites for establishing forest conservation projects because of their high carbon content.[117] As one Indonesian consultant working for an international environmental NGO said, "We always choose peat land for our projects. It's high carbon, so it's easy to attract investment" (i 15). In other words, carbon is the "vehicle" (i 13) to attract funding in order to pursue other objectives, such as biodiversity conservation and/or livelihood development. This is, as I expand on in chapter 4, a kind of development that appears as if a market existed, and a principle by which project developers can organize their forest conservation activities. Preventing or reducing carbon emissions thus becomes the overarching conservation goal. Most REDD+ projects are designed to do this by preventing deforestation and forest degradation, thereby reducing the amount of carbon released from biomass into the atmosphere.

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[114] Though there is no official market through which to invest in REDD+ projects in Indonesia, project developers can receive advance financing from banks, who—for a time in 2009-12—saw financing these credit offsets as an upfront investment should a carbon market materialize. So project developers in Indonesia accepted financing from JP Morgan, Merril Lynch, and Australia's McQuarrie Bank. However, after the UN failed to follow through in creating an involuntary international carbon market in subsequent years, most banks stopped underwriting REDD+ projects in Indonesia as of late 2014.

[115] In the absence of such a market, most REDD+ and similar projects have been funded by international banks, companies, foundations, and national governments through traditional donor-based mechanisms, rather than investments.

[116] The World Wildlife Fund, Flora and Fauna International, Wetlands International, CARE, and many smaller Indonesia-based NGOs are some examples.

[117] NGOs often hire outside consulting firms to conduct carbon storage studies of a given peatland area using remote sensing techniques; the higher potential carbon stored in the soil, the greater the potential future investment opportunities. Though some Indonesian NGOs, as I mentioned with regards to BOS and SarVision, have opted to develop in-house remote sensing capability.

Environmental NGOs in Indonesia began to link their existing forest biodiversity conservation projects to potential carbon financing mechanisms by moving such projects onto still-forested peatland or selecting intact peatland areas for new projects. One consultant echoed the concern above, however, explaining that peatland is often located in government-designated "conversion forests," which the Ministry of Forestry is quick to offer as concessions to oil palm or pulpwood companies (i 15). But this designation for conversion to commercial, mono-crop agriculture is also what makes Indonesia's peatlands more valuable to project developers and investors, as they can claim "additionality" if they are able to demonstrate an imminent threat of deforestation.[118] As one foreign REDD+ consultant put it, "In the deep peat is where you'll get the biggest bang for your buck" (i 19), meaning that a conservation project located on deep peatlands with intact forests will generate the most carbon offset potential. Another foreign carbon offset project developer described it this way:

"We look for pink areas on the map — those are [areas] that are designated for conversion [to agriculture through government concessions]. These are threatened by mono crop plantations, oil palm, logging. As a REDD project developer, that's [the land] you want. And if you can get that on peatland, that's what people are salivating over. So, if you're looking at the maps, you want that pink land" (i 5).

Many environmental NGOs and individual project developers have thus seized on this idea and see conserving carbon-dense peatland as "low-hanging fruit" (i 5) that could prevent the largest amount of ecosystem carbon emissions within a relatively small area.[119] Intact peatland forests

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[118] As explained further in chapter five, oil palm can be cultivated on drained peatland so long as it is fertilized and the water table remains low enough to prevent surface flooding. Unassisted complex forest regeneration rarely occurs on drained peatland, however, as such landscapes are typically dominated by a few species of ferns and shrubs and support few fauna (Blackham, Webb, and Corlett 2014).

[119] A study by (Busch et al. 2012) found that peatlands in Kalimantan and Sumatra would have the highest expected emissions reductions beyond business-as-usual in response to REDD+ pricing mechanisms if carbon was priced at US$10 per ton of carbon dioxide.

designated for conversion to agriculture are thus most attractive to REDD+ project developers. Forests that have already been cleared are more challenging to incorporate into REDD+ projects, unless developers can prove carbon offsets through future afforestation.[120]

In contrast with REDD+ projects that seek to prevent future forest loss by conserving intact forests, peatland *rehabilitation* projects present new challenges for conservation investments. The Indonesian national government first formally recognized the need to rehabilitate the Ex-MRP site in a 2007 Presidential Instruction. This instruction mandating rehabilitation was not tied to carbon offset credits, nor did the government indicate how such rehabilitation would be financed. Once the promise of international investment-based financing began to take shape through REDD+, however, both the national government and project developers began to see carbon offset trading as a mechanism for rehabilitating degraded peatland areas such as the Ex-MRP site. As one consultant working in the site explained, "most peatland rehabilitation is not about carbon, but now people are saying it goes together" (i 18). The basis for this, of course, was to generate financing for costly rehabilitation activities, particularly infrastructure construction such as blocking and damming the ex-MRP's large canals.

As the initial institutions for REDD+ at a national level were being created in Indonesia in 2009, Australia was eager to get involved with carbon trading as a means to offset their domestic greenhouse gas emissions. The Australian delegation to the UNFCCC had supported REDD+ beginning in 2007[121] when it was formally introduced at the COP meeting in Bali, and were particularly in favor of tying carbon offsets to market mechanisms rather than rely on traditional

[120] These "green grabs" as Fairhead et al, (2012) call them, or land acquisitions for environmental services conservation, also raise questions as to what extent they are reproducing the same dynamics surrounding land access as other large-scale land acquisitions, as discussed in chapter 5.
[121] The London School of Economics' infamous Stern Review on the Economics of Climate Change (Stern 2007) was supposedly a major influence on the Australian delegation (i 37).

donor-based mechanisms (i 37, 31). Australia was among the earliest countries, in addition to Norway, to support REDD+ in Indonesia, committing US$200 million through the 'Global Initiative on Forests and Climate' just after the 2007 COP meeting for financing land use-based emissions reductions. This funding supported formation of the Indonesia-Australia Forest Climate Partnership (IAFCP), a joint collaboration between the national governments of Indonesia and Australia primarily funded through AusAID.[122] The stated purpose of this partnership was to assist Indonesia in establishing the "necessary technical, system, and financial pre-requisites to participate in international carbon markets" (Kalimantan Forests and Climate Partnership (KFCP) Design Document 2009, 130), and to create forest carbon projects on the ground that would produce carbon emissions reductions from forest landscapes.

The pillar project of the IAFCP was the Kalimantan Forest Climate Partnership (KFCP), a REDD+ venture that unfolded in a portion of the Ex-MRP site (figure 31). The Ex-MRP site was initially selected for the REDD+ project because of its heterogeneous, highly degraded land cover across a relatively small area. The particularly large contrast in land cover between blocks A and E provided a suitable place to test peatland rehabilitation activities in Block A, where the MRP's largest canals were dug, and Block E, which was never cleared during the MRP and thus has secondary standing forest intact.[123] A total of 14 villages were in the KFCP project area, all of which are situated on either the Kapuas or Barito River. In the 2009 KFCP design document, the project had a stated goal of rehabilitating up to 50,000 hectares. This was revised down from

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[122] The IAFCP also designed a similar project in Sumatra's Jambi province, but this was quickly abandoned in favor of devoting more financial resources to KFCP in Central Kalimantan.

[123] The entire KFCP site was 120,000 hectares, 70,000 of which were in Block E. The largest canal, 30 meters wide running east to west from the Kapuas River to the Barito River (though the canal does not actually reach either river), bisects the KFCP site and marks the border between Blocks A and E. Block E is crossed by numerous small rivers that provide forest access, as well as dozens of shallow, hand-dug canals that are used primarily for illegal logging. Block A, meanwhile, has an extensive grid of canals six to ten meters wide.

an original goal in 2007 of rehabilitating 200,000 hectares. These original, very ambitious goals were contingent upon receiving funding from sources beyond AusAID, which failed to materialize. In both instances, KFCP aimed to conserve 70,000 hectares of standing peat forest—nearly the entirety of Block E—by preventing illegal logging as well as peat fires.

The design for KFCP was based on a set of guidelines written by the Indonesia Forest Climate Alliance group. They recommended designing a peatland-based REDD+ project in which all of the possible components of REDD+ were incorporated, including payment mechanisms, livelihood improvements, peatland ecosystem rehabilitation, and avoided deforestation activities. Activities carried out by village community members, who were paid for their participation,[124] included canal blocking (primarily dam building, not filling in the canals), planting native tree species, and measuring peat carbon emissions, which is discussed in chapter 4. Though data collected from KFCP's attempt to measure and monitor peat emissions was intended to be incorporated into a national system of carbon accounting from the beginning, the project never, however, had an objective of generating tradable carbon credits as most REDD+ projects do. It was instead established only as a "demonstration project," or a "laboratory" (i 19, 21) for testing the mechanisms that would allow Indonesia to leverage peatland rehabilitation in future carbon market participation. To this end, project designers stated that "the KFCP is intended to be a learning activity in which technical, scientific, and institutional innovations are tested, refined, and communicated to add to the body of REDD knowledge and experience" (IAFCP 2009, page 2).

[124] One of major objectives of KFCP was to test a "performance-based" payment system in which community participants would be paid for demonstrable reductions in landscape emissions, or avoided emissions. By all measures, this payment system was never put into effect, becoming one of the major failures of the project. Project participants were instead paid daily wages.

Though the magnitude of emissions attributed to the degraded peatlands was clear to both the Indonesian and Australian governments, and this was ultimately enough to justify the project, the Australian government had early reservations about KFCP. As Robin Davies (2015) describes in his post-project analysis, “there was not universal enthusiasm for situating Australia’s flagship REDD+ project on mostly logged-over and degraded peatlands” (page 26). Several Australian national level government officials wanted solely to pursue ‘avoided deforestation’ strategies, as opposed to afforestation or rehabilitation, both for the caché of ‘saving Indonesia’s rainforests’ and because standing forests were perceived to have fewer inhabitants, and thus fewer obstacles for the project. The Australian government was also wary of the complexity required in monitoring the degraded peatlands because measuring avoided emissions in an already-degraded landscape. Locating a REDD+ project in this degraded site, with a majority of the carbon stock located underground, required constant emissions monitoring *in situ* by trained community members, rather than their preferred method—remote sensing—which could be conducted by scientists in Australia, enabling foreign scientists more authority over the data. Eventually, the prospect of preventing such a large amount of carbon emissions from the landscape was enough to convince them to pursue the project (Davies 2015). However, the Australian government’s interest in avoided deforestation activities, rather than rehabilitation, did end up shaping the project design by including forest conservation measures in Block E.

The incentives for the Indonesian government to locate the REDD+ project in the Ex-MRP site, however, were obvious. In the early stages of negotiating the terms of the KFCP project in 2008-09, President SBY was simultaneously coordinating leases of several million hectares of forest land throughout Kalimantan to Chinese-owned oil palm companies (Davies 2015). The most desirable land for oil palm companies to lease are those that have existing forest, so companies can profit from clearing the trees prior to cultivating the land. Already cleared land, meanwhile, is less attractive to investors. The government was not considering allocating the still-forested part of the Ex-MRP to oil palm at that time (Block E), and the Ministry of Forestry (which oversees land concessions for oil palm) urged the President to encourage REDD+ donors to develop projects not under consideration for oil palm development. The Indonesian government thus had no alternative plan to make the Ex-MRP site economically valuable[125]. Nor were they willing to fund conservation or rehabilitation in the Ex-MRP site from national government coffers despite having written a Presidential Instruction stipulating just that.[126]

5. Conclusions

In the context of Indonesia's degraded peatlands, carbon has thus far eluded commodification through REDD+ or any alternative carbon offset scheme. The KFCP project ended in 2014, after several years of discontent in the Australian parliament over failures to meet project targets. In the absence of an international policy agreement that would enable an involuntary carbon offset market, forest carbon projects in Indonesia have not become a viable option for investors. Yet in the Ex-MRP site, this has not stopped NGOs, and subsequently

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[125] As one REDD+ project manager said about the ex-MRP site, "the degraded mess is now profitable" (i 19). But while project was pitched to the Indonesian and Australian governments as potentially profitable, it is questionable whether KFCP could have ever been profitable, and if so, profitable to whom, as it was funded through government donations, rather than market-based investment. In other words, because it was designed as a "demonstration activity" there was no mechanism built into the project as originally conceived through which it would generate capital.

[126] This is obviously indicative of broader neoliberal trends in conservation over the past several decades. Negotiations over setting up KFCP, however, also reveals the extent to which the provincial and district governments were left out of the project, at least initially. The project's design focused on involving only local communities—villagers and village heads—while neglecting the significant role the district government has in overseeing land management in post-New Order Indonesia. While villagers were paid for their involvement in the project, Kapuas district government leaders were not, despite their role in implementing some emissions reductions measures on the ground (Davies 2015).

district and national governments, from organizing rehabilitation activities around the promise of such a commodification scheme, as I detail in chapter 4.

Causes of climate change can be traced to specific, located chemical processes in which carbon is emitted, which necessitates knowledge production that is both an accumulation of knowledge made in local places but also a global conception of the environment that is perhaps fundamentally different from ecological change conceptualized at a local scale (see (P. Edwards 2010) on the technologies that make this possible). Several scholars have noted that climate change is often defined as a problem in terms of atmospheric greenhouse gas concentrations rather than as a problem of human vulnerability (T Forsyth 2003; Cohen and Bakker 2014). By naturalizing carbon emissions as the dominant cause of climate change, biophysical change becomes the guide through which the 'global' is conceptualized and solutions are made visible. Responses are generally focused on technical options without "questioning either the specific social relations that organized prevailing production and consumption choices or even the global restructuring implied by technical emission abatement policies" (Braun and Castree 1998, 273). Cohen and Bakker urge us to advance understanding of carbon emissions beyond their origin as a socio-ecological outcome of capital accumulation (2014**)** and instead to look at what forms of environmental governance emerge *after* carbon emissions are defined as the pivotal global problem. Reed and Bruyneel similarly call for more "attention to the challenges of governance across borders" (2010: 4) as a response to transboundary environmental concerns.

In the Ex-MRP site, the production of knowledge, and general shift in understanding the peatlands as a global carbon source, was not in itself sufficient to shift concern among international actors towards this place. Rather, the publication of this data in respected journals and reports enabled its circulation among a wider audience. In this sense, the circulation of scientific data in internationally-respected publication and distribution channels enables its validity as much as its production does. As a result of this circulation of knowledge, climate change mitigation through carbon emissions reductions becomes a defining objective for investment in the landscape. Yet similar to the historically uneven application of colonial forestry and other national scientific knowledge in natural resource management {VandergeestPeluso:2006wa}, global environmental knowledge regimes aren't uniformly applied across places. They encounter local ecologies, and social resistance, which makes their circulation and application uneven across places and scales (Mahony 2014). Nevertheless, defining carbon emissions as the pivotal environmental problem (as opposed to biodiversity or livelihood losses from forest degradation) in the Ex-MRP site makes the site financially valuable to a range of state and non-state actors. This in turn drives the obsession with precise measurement and monitoring of carbon emissions from degraded peatland within new scientific infrastructures, as chapter 4 discusses. While degraded peatlands might prove to be too volatile of a biophysical environment for carbon offset investment, I discuss the ways in which science (its methods, practices, and actors) are trying to make the environment less risky—more investment ready—by shoring up knowledge of emissions from degraded peatlands.

Chapter 4: The Politics of Doing Science in a Peat Swamp

During an interview in 2013 with a foreign forestry researcher working in Indonesia, he mentioned that despite the growing attention to the role the country's peatlands have in the global carbon cycle, there was still very little accurate emissions data from the peatlands. Yet the Indonesian government and institutions such as the World Bank regularly cite statistics on carbon emissions from peatland drainage and burning, like 60 percent of the country's total emissions comes from land-based activity. And that of the 41 percent intended emissions reductions by 2020, 80% of those reductions would come from cutting emissions from peatlands.[127] Given the centrality of Indonesia's peatlands in climate change discourse, and even in the country's climate change mitigation plans, the lack of data seemed surprising. I asked him to elaborate. Why aren't there more scientists working in Indonesia's tropical peatlands then, if the data from this vast ecosystem is still so sparse? "Because it sucks!" he exclaimed. "It's a hard ecosystem. Would you want to spend hours and hours out there making measurements? It's a swamp!" he said. He went on to describe how the heavy soil coring equipment they sent out into the peat swamp would sink the flimsy canoes that are used for transport in peat swamp forests. And how they built a boardwalk to gain better access to an area of deep peat soil, which was under several meters of standing water. The boardwalk kept breaking because the poles were sinking into the mud, so eventually they gave up on collecting field measurements from that site (i 30).

Despite the global significance attributed to nationally aggregated quantities of carbon emissions, there is a striking lack of attention to the socio-political, as well as physical,

[127] See, for example: (Hilman 2010; Joosten, Tapi-Bistrom, and Tol 2012)

conditions through which these numbers originate.[128] And despite continuously advancing satellite technology that can detect emissions changes remotely, that technology still needs validation from fieldwork conducted *in situ*, or 'ground truthing.' While I demonstrated in chapter 3 that knowledge claims about carbon emissions from the MRP site, and tropical peatlands in general, were produced at a particular historical conjuncture, ongoing claims about peatlands' role as a carbon source are often reduced to numbers abstracted from their location of production. This is evident in the Indonesian government's goal to establish a national carbon accounting system (INCAS), in which aggregated quantities of carbon emissions are extrapolated from data collected in landscapes at the national scale. A national carbon accounting system necessarily functions as a kind of scientific "view from nowhere" (Shapin 1998), as carbon dioxide emissions are abstracted from their place of production (Bergmann 2013). Furthermore, this invisible gas is located both everywhere and nowhere in particular, making it particularly susceptible to aggregation into a "number from nowhere."[129]

But despite the physical challenges of 'doing science' in a peat swamp, financial investment in degraded peat forests as a carbon offset demands highly precise emissions data. In particular, the concept of REDD+—paying forest inhabitants to prevent carbon emissions by safeguarding ecosystems—necessitates thorough and accurate data on precisely how much carbon a particular area is emitting over time. As such, the development of carbon accounting 'methodologies' to document precise changes in peatlands' carbon emissions rates became a significant step through which state and non-state actors could make such degraded land

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[128] It's additionally striking considering that the peatlands are "natural," and thus within the purview of biophysical science, as opposed to emissions from factories. Yet where there is "thicker" data on emissions from peatlands is in oil palm plantations, an industrialized form of agriculture.

[129] In addition, the carbon emissions factors from Indonesia's peatlands vary widely from dataset to dataset, which I elaborate on in chapter 5. See also (van Noordwijk et al. 2014) on the disparities in peatlands' emissions data.

economically and ecologically valuable. These methodologies, or the Measure, Report, and Verify (MRV) systems used to track land-based emissions changes, have been a hallmark of the United Nations' Clean Development Mechanism (CDM) and REDD+ projects since their inception. Few MRV systems have been developed specifically for tropical peatlands, however. REDD+ projects on tropical peatland, including KFCP, have therefore had to create new MRV systems, or methodologies, as a way to calculate changes in carbon emissions from these landscapes specifically. Existing maps of peatlands' carbon emissions are static, indicating how much carbon remains locked underground. But in order to make interventions in the landscape—such as canal blocking or vegetation replanting—financially valuable, investors need more precise data. In seeking to render the Ex-MRP site investable as a carbon offset, one of the KFCP project's primary objectives was to develop a "methodology" that could be used to determine the exact quantities of carbon emitted from the landscape.

As discussed in chapter 3, the objective of KFCP was to be a "laboratory," to test the methods that would enable Indonesia to participate in an international carbon market in the future, not to generate tradable carbon credits itself. One of the central activities in the process of 'readying' REDD+ for market investment has been the creation of a national forest carbon accounting system. Some of this system has been developed through projects such as KFCP, which required a peatland monitoring unit to determine how changes in the local environment contribute to greenhouse gas emissions in tropical peatlands. Yet because an international carbon market has yet to materialize, many REDD+ projects in Indonesia are proceeding as donor-based projects amid uncertainty of whether they will ever be economically self-sustaining. The KFCP project was one such donor-based project: though it was never designed to generate carbon credits for a market, it was supposed to show how development through carbon conservation could work *as if* a market existed. Ultimately, the MRV system developed through the KFCP project highlights how carbon accounting systems are attempting to impose some legibility on the peatlands as a means to rendering the land economically and valuable at national and global scales.

One explanation for why the KFCP project did not meet its stated objectives of rehabilitating over 200,000 hectares of degraded peatland is tied to what Davies (2015) deemed the project's "excessive preoccupation with scientifically precise carbon measurement," in addition to the challenges of tying carbon offsets to global or national level financing. The preoccupation with precisely measuring carbon emissions distracted from what, as he argues, should have been the main goal of the project: granting performance-based payments to local inhabitants for estimated emissions reductions, such as through canal blocking. Yet I contend that while interest in developing precise scientific management may have obstructed other project goals, it has ultimately been successful in building new scientific institutions that make certain landscapes—designated as significant at particular scales—legible in new ways. The KFCP REDD+ project functioned, then, not as a project to advance scientific knowledge about peatlands' emissions *per se*, but to establish an institutional structure in which peatlands' carbon emissions can be legible to non-scientists at local, national, and global scales. In this chapter, I advance this argument through a discussion of two of the primary activities undertaken by KFCP: dam building and developing peat emissions measuring and monitoring systems.[130]

Finally, while attempts to precisely measure carbon emissions from peat swamps are guided by the financialization of carbon for international markets, they actually serve to make

[130] KFCP was terminated by the Australian government in June 2014, largely the result of internal Australian government disputes. These sections thus are reflective of fieldwork undertaken in the KFCP site shortly after the project ended, but not while the project was ongoing.

degraded peatland more *politically* valuable, rather than simply economically valuable for investors. This chapter concludes with a discussion of the Indonesian state's renewed interest in collecting scientific data from the peatlands in over to create a sovereign carbon accounting system. The scientific infrastructure generated by the abandoned KFCP project is currently being used to develop this national carbon accounting system (INCAS), which reflects the state's attempt to consolidate and control knowledge about the country's land-based carbon emissions. I suggest that this is occurring because the Indonesian national government, particularly the Ministry of Forestry and Environment, now recognizes that they can leverage international concern about peatlands' emissions in climate change negotiations for their benefit. They also see an opportunity to fill the vacuum created by the retreat of speculative capital in carbon offsets: should carbon become a less risky investment in the future, the national government will be better positioned to intervene in transnational investments in Indonesian land.

1. Towards a Scientific Carbon Forestry

Tropical peatlands' vast stores of subterranean carbon make them a compelling landscape through which to understand the messiness of building scientific infrastructure that seeks to measure and monitor land-based carbon at local, national, and global scales. To be sure, projects attempting to measure land-based carbon for incorporation into commodification schemes are not unique to sites like the former MRP. Indeed, that is the strategy currently deployed by REDD+ and other Payment for Ecosystem Services (PES) projects throughout the tropics (McAfee 2012). Much of the data on tropical forests' emissions rates has been collected through remote sensing—satellite-based detection methodology—requiring only occasional 'ground truthing' or fieldwork *in situ*. While remote sensing is fairly precise at measuring carbon stored in above-ground biomass, it is currently less successful at determining how much carbon is below the surface, stored in soils, tree roots, buried logs, and other subterranean organic matter. Calculating subterranean carbon remains significant, however, for scientists and policymakers, who draw on the amount of carbon stored in an ecosystem to value the land through carbon offset mechanisms, such as REDD+. Even with respect to globally aggregated climate data, some of the data is still collected—and the science is practiced—at local scales and in particular places.

Yet as with prior forms of state forest management, national, and now international, knowledge regimes about how a landscape should be made legible are not applied uniformly across places. As in the past, exogenous schemes to make environments legible continue to confront local ecologies and local resistance (Sivaramakrishnan 2000). As Martin Mahony writes, "It would be wrong to suggest that global climate science and politics erase local specificities" (2014, 113), even as such science aggregates carbon emissions data from multiple scales. Yet efforts at making peatland legible through MRV systems encounters the physical difficulty of conducting field work in a peat swamp and of enrolling local inhabitants into such a project. Furthermore, subterranean carbon stock, more than past scientific forestry initiatives that primarily sought to measure trees or species, presents a different set of obstacles to making land legible (Scott 1998), which I detail in this chapter.

While global climate knowledge regimes, like the International Panel on Climate Change report or national carbon accounting strategies like INCAS, draw landscapes into schemes to make land-based carbon emissions more legible (and thus economically valuable), they too confront local practices and ecologies, which do not necessarily align with carbon legibility processes. For instance, Mahony (2014) found that scientists in India were far less concerned with making their research relevant to the IPCC's concern for global climate change than they were with tying their research to national matters, such as changing monsoon patterns in the Indian subcontinent. Yet in industrialized Western countries, scientists increasingly need to show synergy between their proposals and global concerns, such as greenhouse gas emissions or climate change more generally, to attract funding for their research programs. Projects to make peatlands' emissions legible and thus economically valuable, like KFCP, similarly emerge out of concerns for global carbon emissions. If making climate change knowable at a national scale is more complex than simply "downscaling the results of global climate projections" (Mahony 2014, 120), making carbon emissions knowable is similarly more complex than downscaling international or national concerns. Because Indonesia's peatlands *contribute to* climate change, they are not merely impacted by it, then predictions and evidence about emissions will encounter local resistance specific to this socio-ecological landscape.

Attempting to measure and report the change in emissions over time in response to specific, located interventions is still challenged by the technical and social difficulties of conducting fieldwork in a complex, inhabited landscape. Most MRV systems used in REDD+ projects rely heavily on remote sensing data to calculate changes in the landscape's carbon stock over time. But the peat swamp's carbon stock is almost entirely subterranean, making remote satellite detection more difficult, as already mentioned. Furthermore, the KFCP project sought to incorporate as many local inhabitants as possible so the project design incorporated villagers into MRV system development directly. Villagers became lay scientists for the duration of the project, collecting data throughout the site on hydrological function, vegetation growth, and fire hotspots. For largely foreign managers of the project, there were challenges associated with having non-experts gather scientific data to the standards required by outside experts, in addition to the obstacles presented by the peat swamp environment itself.

The Indonesian National Carbon Accounting System (INCAS) is an additional manifestation of this project, helping Indonesia build credibility in international negotiations over carbon emissions values. Having data produced within a government-overseen institution also lends credibility to other governmental jurisdictions' use of this data to justify certain land use decisions at provincial or district levels. In some sense, this is a forest management strategy that echoes earlier state forestry management regimes in Southeast Asia, which purported to make forests legible through numerical tree inventories for extractive timber economies. The science of forestry in Indonesia also sought to manage tree species by controlling forest labor and land through scientifically-grounded strategies of tree maintenance, planting, and harvesting (Peluso 1991). Projects like KFCP, along with earlier rehabilitation strategies in the EMPR site, function as a kind of scientific *carbon* forestry, driven not by resource extraction but by management of a global atmospheric risk.

Regardless of whether local actors' (local scientists and non-scientists) share those concerns about measuring carbon emissions, local actors are being called upon to participate in carbon forestry knowledge regimes. Star and Griesemer, writing on the translation of scientific knowledge across different communities, argue that new scientific institutions require "disciplining" the information collected by non-scientists in order to turn this information into credible knowledge. This is partially accomplished through a series of "boundary objects" that maximizes communication between different worlds of expertise (Star and Griesemer 1989) asserts, this "presumption of equivalence" extends beyond the natural objects of study to the behavior of scientists and non-scientists doing the work. This enables "scientists to presume that research in other labs involved people who are like them and who are behaving as they do" (Gieryn 2002). Laboratories thus allow for data collection that is independent of place-specific variables, including behavioral differences of scientists themselves. But in non-laboratory spaces, such as tropical peatlands, scientific practices confront heterogeneous and unpredictable ecology, and are sometimes enacted by people with no formal scientific training. So KFCP, by contributing to the Indonesian National Carbon Accounting System, sought to make this knowledge compatible across "divergent worlds" (Star and Griesemer 1989) and, as I would argue, across scales.

2. Making Peat Soil Carbon Legible: Scientific Practices and MRV Systems

Many of the same universities that led scientific research in Central Kalimantan's peat swamps in the late 1980s and early 1990s were the first to document carbon emissions changes in the early 2000s. In addition to the British researchers discussed in chapter 3, much of the early research on emissions was conducted by scientists from the Universities of Hokkaido in Japan, Helsinki in Finland, Nottingham in England, and Wageningen in the Netherlands. Indonesian scientists from the Center for International Cooperation of Sustainable Management of Tropical Peatland, based at the University of Palangkaraya in Central Kalimantan, sponsored and collaborated with international scientists, enabling them to collect field data. Within this relatively small community, scientific knowledge remained insular. For many years, the same several dozen scientists attended annual conferences and scientific peer review was inevitably conducted by friends and close colleagues. The strongest alternative viewpoint—outside this academic community—often came from the industry-funded Indonesia Peat Society, which was rarely taken as credible in the scientific community (i 37).

After increased global attention to the peatlands' climate change mitigation potential following the "Peat CO_2" report in 2006 and subsequent discussions about using peatlands as a carbon offset, funding for scientific research on peatlands' carbon emissions increased dramatically. Alongside increasing opportunities for research, far more universities and non-academic institutes from around the world have begun to conduct research in peatlands in recent years. Significantly, the number of Indonesian scientists collecting data on peat carbon emissions has recently started to increase, both those collaborating with international scientists and those working independently. While the proliferation of scientific researchers means the knowledge community on peatlands is no longer insular, it has also led to an increase in differing opinions on how to best measure and monitor carbon emissions. In what follows, I describe some of the methods scientists use to calculate peat carbon emissions in order to then discuss what political and economic dynamics are at stake in these scientific tools and practices.

Because of the physical limitations of conducting science in a peat swamp—broken boardwalks, subsiding ground, equipment stuck in the mud—much of the data collected through fieldwork on carbon emissions from peatland to date in Indonesia has been on corporate-held land cleared for oil palm or pulpwood (i 30). This is arguably because researchers want to understand the relationship between tree plantations and carbon emissions rates. But it is also because companies drain the soil, which leads to compacted ground firm enough to walk on, and construct roads through the peatlands. What is otherwise a difficult to access field site thus becomes a much more feasible place in which to conduct research, particularly data collection requiring hundreds of test points. Much like scientists working in Central Kalimantan in the early

1990s who used logging railroads to access the peat forest, large-scale capital intensive plantations provide the physical basis for research that is intended to be objective and politically neutral. Some scientific practices and the data they generate, in other words, are shaped by existing land use, an issue that I also address in chapter 5.[131]

These sites are insufficient, however, for scientists interested in establishing the difference in rates between emissions from plantation land and from intact peat forests. To determine such differences, or to determine changes in carbon emissions over time in peatlands without corporate plantation infrastructure, scientists use a combination of proxy methods and *in situ* fieldwork. Similar to the methods used by the scientists who published the 2002 paper in *Nature*, many researchers determine peat carbon emissions from fire by analyzing burn scars detected remotely via satellite. By measuring the depth and area of the burn scar from a particular fire event, they then calculate the volume of peat soil and vegetation matter burned. Combining this data with land classification maps, they calculate—and extrapolate—the amount of carbon released during that fire event.[132] This proxy-based method is relatively easy to 'scale up' across large areas in order to obtain rapid assessments of carbon lost during a big fire event.[133] It also does not require researchers to collect data on the ground beyond a brief venture to validate the findings gathered via remote sensing.

There are some major uncertainties surrounding data on peat fire emissions gathered remotely, however. One uncertainty is the presence of deep peat fires themselves. Smoldering

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[131] Without data gathered prior to forest clearing for agriculture or in nearby intact peat forests, however, it is difficult for scientists to determine how carbon emissions rates have changed over time or in response to forest clearing.
[132] I am simplifying this description for the purposes of this discussion.
[133] This is the primary method used by scientists conducting rapid assessments of carbon emissions during the September and October 2015 fires, for instance, leading to gross comparisons of peat fire emissions with other countries' emissions.

fires that burn several meters into the peat layer and release the most carbon dioxide are difficult to detect via satellite because they do not produce a high enough temperature differential. The temperature difference between the smoldering peat soil underground and the surrounding area, in other words, is often not great enough to be detected through remote sensing methods (i 33). This leads to an enormous range in possible emissions from peat fires, especially aggregated over a large area.[134]

Calculating *total* carbon emitted from a particular landscape over time is even more challenging. The total must take into account rates of emissions change through microbial peat soil oxidation, not simply through fire. The methods through which emissions from peat oxidation is calculated has been the subject of major scientific disputes between researchers, especially within the context of the International Panel on Climate Change (IPCC) reports. Some scientists calculate emissions lost through oxidation by measuring the loss of soil through subsidence and compaction.[135] Soil loss is thus a type of proxy for carbon loss, which is then extrapolated to encompass a larger area. An alternative method, which some scientists consider to be more accurate, uses chambers placed on the soil directly to capture the amount of carbon dioxide being emitted over time. This requires someone to check the chambers twice daily to record the machine's numerical output.[136] Yet other scientists maintain that this method does not account for carbon dioxide uptake by plants (biological respiration) in the air being measured, which offsets some of the carbon dioxide emitted into the atmosphere. Regardless, each of these

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[134] Other uncertainties surrounding peat fire emissions relate to what the soil layer is composed of (logs, leaves, and the soil itself all release different amounts of carbon when burned). Also, it is difficult to fully know how deep and wide a subterranean peat fire burns over time.
[135] Again, I have simplified this explanation for the purposes of this discussion.
[136] One scientist leading several of these studies said that they send Indonesian M.A. students to the field for a month at a time to collect this data.

methods requires data collected from many points in the field—ideally, thousands across a given area—and people to check each chamber daily.

Some of these methods, such as measuring soil subsidence as a proxy for carbon dioxide loss, were developed in contexts that did not require the same degree of accuracy demanded by the UNFCCC and by financial investors. Many were developed in the Netherlands, where scientists have long measured peat subsidence in order to determine when levees would collapse. In this context, predicted soil loss needed only to be accurate to roughly a meter, whereas in order to extrapolate carbon dioxide emissions, soil loss needs to be measured accurately to less than a centimeter (i 21).

These practices and methods highlight some of the challenges to obtaining precise and accurate emissions data from a peat swamp to the degree demanded by climate change mitigation policy makers and carbon offset investors. But they are also, perhaps inevitably, precursors to future technologies that will measure emissions from these landscapes more thoroughly and accurately than current practices do. For instance, past methods used to calculate peat depth relied on soil coring. This is the method the scientist was referring to when he mentioned equipment sinking flimsy canoes. Heavy augers are drilled into the peat layer to extract a 'core' of soil, the content of which can then be analyzed in a laboratory. But new technologies are being deployed to make emissions numbers more accurate, such light, backpack-sized radar tools that a team can carry throughout the peatlands, which estimates peat depth and content (including below-ground biomass) without extracting soil and from which emissions estimates can be derived (i 32).

I heard many researchers talk about increasingly sophisticated tools that will make estimating carbon emissions easier and more accurate. But these are techno-scientific responses to scientific problems: many of the tools and methods will remain difficult to scale up to national and international levels required by climate change mitigation policy[137], and by financial investors in degraded peatlands as potential carbon offsets. These kinds of scientific problems can also remain scientific in that they seek to maintain as many constant variables on the ground as possible, within as least a complex landscape as possible. They do not—or can not—take into account the degree to which the degraded peatlands they are seeking to measure are inhabited and thus continuously being altered through mundane interventions in the landscape, which in turn affects the data.

But integrating these scientific methods into the scientific infrastructure required by international climate change mitigation policy and carbon offset markets shifts what is otherwise a *techno-scientific* problem into a *political* problem. This political problem is compounded by the demands made by speculative capital on the data needed for carbon offsets, which in turn makes demands of the political institutions within which the scientific data is generated. The systems used by and *created through* carbon offset projects, including REDD+, are not simply scientific practices leveraged to create the basis for a carbon credit market. They have to take into account both local social practices and global political dynamics in a way that science practiced for the sake of expanding scientific knowledge does not. In the case of turning degraded peatland in Central Kalimantan into a potential carbon offset through REDD+, KFCP project designers had to grapple with conducting scientific practices to the exacting standards demanded by potential investors in an inhabited landscape. Furthermore, scientific practices are intended to be universal in their application and can ignore, for example, local communities' presence and participation.

[137] UNFCCC regulations stipulate, for example, that in order for countries to participate in carbon offset markets regulated by a UN agreement, they need 'Tier 3' data, which is disaggregated from a national level (Tier 2) into emissions factors by industry.

The methods devised to measure and report carbon emissions in the Ex-MRP site, however, had to be both particular to this complex ecosystem and to Indonesia's political context, and incorporate the area's inhabitants in the scientific practices themselves.

In addition to determining how benefit sharing and payment mechanisms work, a key piece of implementing REDD+ nationwide is the Measurement, Reporting, and Verification (MRV) systems through which carbon emissions—and reductions—are determined. Nearly everyone with knowledge of REDD+ whom I interviewed mentioned MRV as one of the most important components of all carbon projects.[138] For project developers, measuring carbon is the first step to starting a REDD+ project; for investors, it is what makes their investments viable. While REDD+ overall seeks to establish incentives for curbing actions that contribute to carbon emissions, the MRV processes embedded within REDD+ determine whether emissions reductions have occurred at national and sub-national levels. If an international carbon credit market materializes, release of payments to government, communities, and investors will be triggered by MRV mechanisms (Graham et al. 2014). Of the $1 billion Norway pledged to Indonesia for REDD+ start-up funding, Indonesia had only received around $30 million as of 2014. An Indonesian consultant explained that the rest of the money will be paid only after Indonesia "can perform and measure greenhouse gas reductions. So the bulk of the money, we will not see it here unless we can prove there is a decrease in emissions. So MRV needs to be in place" (i 32).[139]

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[138] This came up in several interviews: i 4, 13, 14, 19, 21, 30, 37, 38.

[139] Also, additional funding for REDD+ activities that has come from the US government, through USAID, is in channels designated specifically for climate change mitigation, not adaptation. MRV systems count as mitigation activities, so they are generally eligible for larger amounts of funding than adaptation. As one Indonesian researcher told me "Climate mitigation is perceived to be everyone's responsibility" so other countries are more often willing to fund these activities. Adaptation to climate change in Indonesia, meanwhile, is considered the responsibility of local governments (i 13).

MRV systems have stringent sets of requirements. Not only must the data collection follow protocol, but the data must be 'reported' on and 'verified' by international certifying organizations as well. MRV systems are generally described in terms of methodologies, or a set of tools that can be implemented to measure forest carbon, often with socio-economic impacts of avoided deforestation on local populations incorporated.[140] Carbon pools within ecosystems are found in above-ground biomass (trees, shrubs), below-ground biomass (roots), dead wood, leaf litter, and soil. The IPCC details how to determine the amount of carbon stored in each of these pools, and how to accurately assess if the amounts of carbon have changed over time. The potential for emissions reductions catalyzes the potential financial investment. This is done through ground sampling and the field data correlated with remote-sensing based landscape-scale data (Graham et al. 2014). Any project developer can create a new methodology, but getting it internationally accredited and thus accepted for project use is difficult. In Asia, Verified Carbon Standard (VCS) and the Climate Community Biodiversity Standard (CCBS) are two certifying agencies that approve methodologies for project implementation. Auditors are also involved with methodologies, to see if project developers are implementing the methodology correctly on the ground, correctly calculating carbon stock, and clearly attributing forest carbon to a land title (i 14).[141]

Although REDD+ projects are ultimately intended to contribute to Indonesia's national emissions reductions, there is no single, overarching MRV system used for carbon projects in Indonesia to determine all of the land-based carbon stock across the country. A national MRV

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[140] Methodologies to measure forest carbon stock depend on the type of ecosystem in which a project is situated: agro-forestry systems, peatland, and intact primary forest each require different MRV methodologies. It also depends on what the REDD+ project is trying to protect the forest from. Different methodologies are used in areas threatened by illegal logging, versus commercial agricultural plantations.

[141] REDD+ schemes stipulate that payments must be made to a documented land title holder.

system would, in theory, determine all of the above and below-ground carbon stock across the country. However, multiple government agencies, including the national development agency (BAPPENAS), the Ministry of Forestry and Environment,[142] and the Ministry of Agriculture each have their own MRV system to measure carbon emissions in their jurisdictions. In 2011, an Indonesian researcher recounted the ongoing "power struggle" between the Ministries of Forestry, Environment, and Agriculture to establish a national MRV system (i 13), compounded by the differences in definitions of "peatland" used by each ministry. While government actors acknowledged that emissions need to be measured and reported nationally for international verification, each agency was, and still is, doing its own monitoring. A United Nations consultant explained that many agencies are working on the same thing but that they do not integrate their data. Yet REDD+, as an "international venture" is forcing them to collaborate and submit what they have, which he argued "means one voice is required. That's a good thing," he said (i 38). Without a nationally standardized MRV system, some scientists involved with REDD+ caution that there is no way to account for leakage (i 1). Emissions prevented and measured under one system could be moved to another place within the country, for instance.[143]

Discussions of both the scientific practices used to measure peat carbon emissions and the development of MRV systems risk remaining, or becoming, arcane. But in the case of KFCP's MRV system development, this is precisely what links local practices in the Ex-MRP site to international debates surrounding climate change mitigation. Such practices also push questions

[142] The Ministries of Environment and Forestry were merged into one ministry shortly after President Jokowi was elected in 2014.

[143] This is a longstanding concern surrounding REDD+ internationally, that carbon emissions prevented in one country will cause the offending causal actor to cause deforestation in another country with less stringent policies.

of specific, located carbon emissions from this landscape out of the realm of the (ostensibly objective, apolitical) scientific and into the political.

3. The Rise and Fall of Participatory Science

Developing MRV methodologies has been a key component of REDD+ projects, and of KFCP in particular, as it needed to demonstrate how total ongoing carbon emissions could be estimated—and then prevented—through a participatory development model. In preparation for REDD+ investment, one of the central goals/activities of KFCP was to monitor carbon emissions change in the field. KFCP therefore needed to devise a peat carbon monitoring system that could meet goals of accurately recording carbon flux through environmental change in the site, use this monitoring data to construct a model for estimating carbon emissions from tropical peatlands across all of Indonesia, and involve inhabitants from the villages in the project area in this work. A key component of KFCP that emerged from these objectives was the establishment of vegetation, fire, and peat hydrology monitoring teams.[144]

Because carbon emissions in tropical peat swamps occur through two mechanisms—fire and microbial oxidation—KFCP's MRV system in development included methodologies for monitoring both peat soil flux and vegetation, in addition to fire. Vegetation monitoring was carried out in eight locations throughout the KFCP site in representative land cover areas between 2011 and 2014. Locations were initially selected on the basis of being in the LiDAR remote sensing flight paths in order to corroborate the data with remote sensing data. Teams collected annual data along transects on trees, including height, trunk width, and the prevalence

[144] This sub-section draws on informal interviews with several former field monitoring participants as well as several days traveling throughout former monitoring areas with my research assistant, who worked for KFCP.

of new saplings or seedlings. Field teams also measured data within the forest plots pertaining to environmental conditions, such as light intensity, ground cover, fire history, hydrology, peat depth, and peat subsidence. Fire monitoring was based on hotspot data obtained through MODIS satellite: each potential fire was then investigated by field teams and local community members, who were instructed to collect data on fire location, presumed beginning and end times of the fire, weather conditions, potential causes, land tenure and use in the location, and fire intensity (Graham et al. 2014). Local indigenous leaders also shared their knowledge of historical fire occurrence in the area.[145]

KFCP implemented a participatory selection process for the field monitoring teams, with the objective of including as many people as possible who wanted to participate from the seven villages along the Kapuas River within the project boundaries. While many villagers, particularly women, regularly joined the teams raising seedlings in nurseries for vegetation replanting, involving a range of villagers in the field monitoring teams was more challenging. Participation was conducted on a rolling basis and participants were given day-to-day contracts. While this allowed many people from each village to join the field teams, managers and team leaders were not able to spend much time training participants before they went into the field. Though villagers reportedly considered this a fair system, data managers later struggled with what they felt was inaccurate data collected by people without extensive field methods training. They also encountered challenges obtaining accurate measurements from people with poor vision or were elderly or disabled, compromising the reliability of the data. Over the course of the project, however, many people began to opt out of the most difficult monitoring fieldwork, leaving a

[145] In addition to drawing on final KFCP reports, this section is based on several informal interviews with informants who participated in the project as well as my time traveling throughout the site with an assistant, who had worked as a field monitor for KFCP.

more experienced core team—almost exclusively young men—who were willing to spend several weeks in the field at a time. Villagers also opted out of KFCP work when rice or other crops needed to be planted or harvested, leading to a conflict of time when the measurement data collection was time-sensitive and operated on an inflexible schedule (Graham et al. 2014).

Project managers believed that field teams prioritized familiar places for data collection, which may have skewed the overall data on peat emissions. Teams were in the field for three years, from 2010 to 2013, to establish the most effective and practical methods for calculating carbon from such a remote area that's difficult to access. One of the objectives of creating these monitoring teams was to determine how to coordinate and train community members to obtain "high quality data" so estimations of total carbon emissions from the site would be accurate (Graham et al. 2014). For KFCP project mangers, high quality data included both plentiful data from many points across the entire site and accurate measuring at a given location. Yet because participants from the community ultimately determined where they would collect the data, they tended to prioritize fire hotspots, for instance, that were easily accessible. Hotspots next to canals, on compacted peat soil where they could walk, or near overnight camps were measured with more frequency than those on un-compacted soil or far from canals. Semi-permanent transects, which were used for soil and hydrological measurements, were often set up on land that participants were familiar with, whether close to their own farmland or near well-traveled canals.

According to foreign and Indonesian project managers, while fire monitoring teams understood the purpose of their task—since they often checked for fires in or near their own fields—KFCP managers complained that they struggled to convey the importance of accurate measurements to the peat hydrology monitoring teams. Peat fires often occur in managed or easily accessible land, making these hotspots easy to reach. But vegetation and hydrology monitoring needed to be conducted in deep peat areas, most of which were waterlogged for much of the year and thus difficult to thoroughly monitor. In order to determine whether decreasing peat soil level was attributable to oxidation versus compaction, for example, hydrology monitoring teams needed to collect highly precise measurements on surface elevation that had less than one centimeter of error per one kilometer of surface area. This would help data managers determine surface water flow as well as probable carbon emissions rates. Yet with little scientific training prior to enrolling in this fieldwork, many participants considered the purpose obscure and failed to take sufficiently accurate measurements of peat subsidence and . As the final KFCP report explained:

Monitoring activities within REDD+ may not be immediately understandable to the layperson. Whilst community members may immediately understand the benefits of reducing fire incidence, reforestation or small canal blocking, they may struggle to see the relevance of measuring tree density or peat depth. (Graham et al. 2014)

Project managers were also frustrated with what they saw as opportunistic participants. Some managers, for instance, believed villagers conducting fieldwork stole some of the necessary field equipment and returned to monitoring points later to conduct illegal logging. Participants were instructed not to undertake activities such as hunting or non-timber forest product collecting near permanent peat subsidence poles because they could risk moving them but at the beginning of the project in particular, many subsidence poles were knocked over by people, likely by accident. Small box devices used for measuring canal water depth were frequently reported missing; they sometimes turned up later as participants' lunch boxes. Project managers also observed an increase in illegal logging in many of the plot areas set up for vegetation monitoring. They suspected that after observing valuable tree species while working in the field, villagers would return to the sites later to log the trees, including some that were tagged for long-term measurement. An increased number of small canals were also observed through LiDAR remote sensing to have been built throughout the project site during the duration of KFCP, which in turn altered the hydrology that fieldworkers were monitoring (i 21).

Some of the same people involved with ongoing illegal logging operations in the Ex-MRP were also frequently involved in building the scientific infrastructure on the ground, which complicated the process of measuring and monitoring peatland carbon. While the Ex-MRP site was partially re-envisioned as economically valuable through carbon-based conservation tactics through rehabilitation, the site continues to be socio-economically valuable to local inhabitants through illegal logging, which hinders rehabilitation. Many inhabitants, especially Dayaks from the villages stretching along the Kapuas River, see logging as their only viable strategy for basic income in the area. Others have found intermittent work constructing dams blocking the channels used by loggers to access the forest on behalf of conservation organizations. Yet some of these same people involved with these local practices that complicate the process of measuring and monitoring peatland carbon were involved with building the scientific infrastructure on the ground. KFCP thus illustrated the difficulty of maintaining a “laboratory” in a peat swamp for precise carbon measuring when the field is inhabited by people continuously altering the landscape.

Environmental monitoring, particularly with measuring carbon to the degree of accuracy demanded by market-based investment opportunities, proved to be far more challenging to implement as part of a participatory development model than other, more common REDD+ activities such as tree planting or avoiding deforestation. Such activities also do not require extensive training or prior expertise, as accurate carbon monitoring does on the ground. At the conclusion of the KFCP project, project managers decided that using a participatory environmental monitoring model for REDD+ would require more in-depth participant training in order to better communicate the project's objectives. Those who had participated in the monitoring activities, meanwhile, were frustrated and angry that the REDD+ project had ended after just a few years, as they appreciated—and needed—the employment (i 47). In an inhabited landscape where the indigenous communities have few alternative livelihood options following the destruction of the forest during and after the MRP, participation in the project provided them with an opportunity for a political voice.

4. Building and Dismantling Dams: Rehabilitation in the Ex-MRP Site

The primary objective of peatland rehabilitation in the ex-MRP site was less about restoring a previous ecosystem than about merely halting the ongoing emissions from the current ecosystem. Tropical peat domes of the type found in the ex-MRP site were formed during the last ice age, so scientists have hypothesized that they won't necessarily form under the current climatic conditions, even if the other conditions for formation are present (Dommain, Couwenberg, and Joosten 2011). Most of the actors involved with KFCP were frank about the impossibility of ecosystem restoration in this area. "I don't talk about restoration," one forest ecologist involved with the project told me. "It's just not a possibility. We know now that we have fundamentally altered the hydrology so we will never restore that ecosystem" (i 20). Another ecologist explained that it is impossible to return the landscape to the extensive swamp conditions that were present before the MRP, because extensive subsidence has occurred at the edges of each canal (i 21). This subsidence has led to the formation of multiple small peat domes in between the canals. Therefore, even if the canals are dammed, water will flood the soil next to the canals but will not necessarily flow over the domes. Though peat soil can act as a sponge and draw water higher than the surrounding water table, water levels still fluctuate seasonally, leaving the top of the peat dome dry and prone to oxidation.

So while landscape restoration was not an objective of KFCP and earlier projects, rehabilitation to stabilize the current landscape was planned through dam construction, or canal blocking, and vegetation replanting. The objective of canal blocking—and its associated project, dam building—is to raise the water table throughout the whole hydrological system so the peat will remain wet, thus preventing oxidation and reducing the risk of fire.[146] Some of the earliest dams built in the ex-MRP canal network in the early 2000s were simple dams, constructed from logs and nets and built as single barriers across the canals. These initial attempts to rewet the surrounding peat soil were not particularly successful (i 69). Most of the earliest dams collapsed in a matter of months because the volume of water entering the canals from the surrounding soils was too large to be contained by the dam. The earliest dam designs also had spillways, so people could drag small boats over the top of the dam and continue to use the canal for transportation. Yet this was undermining the purpose of the dams by failing to push the water beyond the canals rather than continuing to let it flow through. Scientists also believed that inhabitants from nearby villages were using the canals to access forest areas to the north for illegal logging and fishing; many dams were thus suspected of being partially dismantled by determined villagers (i 17).

[146] A parallel KFCP activity to the canal blocking was contracting villagers—largely women—in the project areas to grow seedlings, which could then be planted in areas adjacent to the blocked canals to speed up regeneration. The seedling nurseries and planting effort was largely seen as a success for those involved with the project: over 30,000 trees were planted between 2010 and 2013. Yet for critics of the project, the failure to meet original tree planting planting goals was a flash point on which KFCP was determined a failure (i 31).

Canal blocking, meanwhile, emerged later, as a solution to fill in the Mega Rice Project's largest canals. The theory behind the canal blocking was that by raising water tables more consistently than through dam building, vegetation regeneration would occur, which would in turn help the soils retain water, halting oxidation and fire. This practice was first proposed by Wetlands International, which attempted to use infill in a small portion of the SP1 canal in Block A (i 28). Wetlands International ultimately did not have the funding to conduct the canal blocking, but the organization's test site for canal blocking was later used to hypothesize that this method could work to fill in a portion of the canals in Block A.[147] This type of canal blocking involved using excavators to push biomass debris and peat soil from adjacent areas into the canals, filling them in at points in the hydrological system where the blocked canal would have the most expansive effect. Blocking the largest canal was a key component of KFCP's original plans, and it eventually received backing from local village leaders after several years of wrangling. But by the time project managers were ready to undertake such a large infrastructural project, Australia ended the funding for KFCP in 2014, cutting off a significant financing channel for a costly project.[148]

It remains unclear what effect blocking the largest canals would have on the livelihoods of villagers in Block A of the Ex-MRP site. While loggers said that they would have trouble accessing portions of the forest (i 40), people who fish say they could still access places they need to via the area's small natural rivers (i 41). KFCP managers were aware that blocking the

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[147] This was detailed in *The Master Plan for Rehabilitation* (Master Plan 2009).

[148] While the plans have been drawn and many local and provincial government actors still support the initiative, financing is uncertain. When I returned to the area in November 2014, a World Bank team had just visited Mantangai for a two day tour of the area, including the SP1 canal. Rumors were circulating around town that the World Bank was going to step in and finance the canal blocking plan because of its carbon offset potential. Many former KFCP participants seemed excited about this, believing that if the canal were blocked, the forest would come back and the fish would return. Life before the Mega Rice Project could be restored.

canals would cut off a source of income—selling logs to the local sawmills—for many villagers. Indeed, one of the objectives of KFCP was to "change their whole livelihood" by changing the landscape (i 20). Most of the canals slated for blocking were far from the villages, several hours ride in a motorized canoe, so villagers could still use the canals to access nearby fields. Canal blocking, however, was assumed by many scientists involved with KFCP to have the biggest effect if it was undertaken in the largest canal, SP1, running east to west between the Kapuas and Barito Rivers. Though many of the smaller canals closest to Mantangai (and south towards Lamunti) are used daily by village inhabitants to access nearby rice fields and to collect *gemur*, a valuable tree bark, SP1 runs along the southern border of block E but doesn't join the two rivers. So while many of the canals are used frequently for access, this canal provides no access from the major rivers in the site. It is, however, primarily used by loggers for accessing the southern part of Block E and occasionally by villagers looking for fish. Several people who rely on fishing for subsistence and income said that if these biggest canals were blocked, they would still be able to access the small rivers where fish are most plentiful.

KFCP, however, focused on small dam building as a means to re-wetting the peat soil so vegetation regeneration could occur. The REDD+ project model mandated local community involvement, so villagers were hired to build dams on daily contracts. Most dam building occurred in the northern part of Block A and the southern part of Block E in the KFCP site, as project managers sought to close off access points for loggers, preventing further forest degradation.[149] Ironically, while currently many men from the villages receive a substantial portion of their income from illegal logging, some had taken up contract jobs with KFCP to build dams in the project site, which were intended to prevent illegal logging. My research assistant for

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[149] Dam building efforts are ongoing, so any incidences referenced here were being carried out by BOS Mawas in late 2014, after KFCP ended.

instance, who was local to the area, had derived a substantial portion of his income from illegal logging before he started contract work with KFCP, he told me. Once he learned how to do vegetation and hydrology monitoring through the project, however, he started to see the importance of standing forest. Even though KFCP was over, he still preferred to work with researchers or build small dams, which has ongoing funding from BOS Mawas. He won't go back to illegal logging, he said. But many young men (and logging is almost exclusively done by men in this area) have not been reluctant to return to illegal logging after their KFCP contracts ended. The two sawmills just north of Mantangai have ramped up production since the project ended in early 2014, several people told me anecdotally, as more and more groups are traveling farther north into Block E to log timber. A common refrain among villagers when I asked about forest-based work activities was often *harus makan*, or 'have to eat.' If not for KFCP activities, those who worked for the project told me, all of the village's men would be involved with illegal logging.

My Dayak assistant defended those who chose to do illegal logging because he believes they only do it to get enough money to survive, though he recognizes the detriment logging is to forest conservation efforts. Those who had been trained to do hydrology and vegetation measuring were, like my research assistant and others in Mantangai assisting researchers, in more of a predicament since the end of the project. They knew it was harmful to forest conservation efforts to do logging. But they also sympathized with those doing the logging, since it was the only livelihood strategy in town that guaranteed enough cash to live on. One group of loggers I spoke with said that they get about Rp100.000 (about US$10) per day, per person in the group, from selling timber to the local sawmills (i 40). Their only other option, as they saw it, was to work for an oil palm company, which paid a daily wage of Rp50.000 (about US$5). My assistant remarked to me as we sat in a small river late one morning, surrounded by standing peat forest, listening to the sound of chainsaws in the distance, that many believe people do illegal logging so they can get a lot of money to save for a better life. “It’s just not true,” he said, “these guys are only making enough to survive the day-to-day. Enough to eat. And they have few other options,” he added.

Interspersed with the illegal loggers’ *pondoks,* or small tarpaulin huts constructed alongside the canals and rivers for overnight stays, are numerous other identical *pondoks*, though my assistant always seemed to know which were occupied by illegal logging groups and which weren’t. Many of the guys camping along the river edges build small dams out of logs to block *tatas*, the small channels dug for timber extraction. KFCP funded a lot of *tatas* blocking during the project, and by some accounts many are still intact. We passed several while exploring the area in our motorized canoe that were dismantled; my assistant pointed out that those had been built by KFCP. Now that the KFCP project is over, BOS pays for ongoing dam building throughout the Mawas conservation area, which encompasses block E. A *tatas* takes weeks to dig in the dry season, while a dam only takes a single man two or three days to build, or just a few hours if several people work on it. We chatted with a group of about eight young men and one older guy in a *pondok* along the largest east-west canal on the border of block E, a few hundred yards from where a larger group of loggers was amassing a large pile of logs that day. The older guy told me that his uncle owns the tatas next to them, which was built during the Suharto era, and is getting paid by BOS to build the dam on behalf of his uncle, who is too old to do the work. I ask him and some of the guys just back from the forest what the point of the dams are. They laugh. They say to keep the forest from being logged. But, they add, loggers can still enter the back of the *tatas* after the dam is built. *Serakan kepemerintahan*, they say. This literally translates to "government policy garbage" (i 40).[150]

Dam building isn't mandated by government policy, though *tatas* construction used to be. According to the men I spoke to in the *pondok*, one had to get permission to build a *tatas* from the *kepala desa* (village head) in whichever forest jurisdiction the area was in. The *kepala desa* would issue a written letter certifying that person as the owner of the *tatas*; anyone wishing to enter the *tatas* to extract timber would have to then get permission from the owner. But *tatas* permits haven't been issued since the 1990s, they tell me, at which time there were numerous and overlapping legal timber concessions in the area and a strong company presence. Logging companies no longer operate in this area but the old *tatas* are still in place; many more are constructed illegally in the forest each dry season. As part of the BOS program to build dams as a means of encouraging hydrological restoration to encourage forest growth, BOS pays *tatas* owners to build dams. Though owners are happy to receive the money for what amounts to just several days of work, they will also accept payment from illegal loggers to break the dams. The owners can then accept more payment from BOS to build another dam. This back and forth continues until loggers determine an area has run out of valuable timber and they move on to another site. Often, a *tatas* owner will take out all the logs of value themselves and then request payment to build a dam. I asked several dam builders if they think the dams are successful. In areas where the dams aren't being dismantled, they say, they do notice that the forest is coming back over the course of a few years.

[150] As I discuss in chapter 6, the expanded presence of groups spending several days or weeks in forests that have dried out has potentially led to peat fires in recent years. Though tossed cigarette butts are always cited as a culprit, several scientists who study peat fire said there is no hard evidence that cigarette butts cause ground fires. But cookstoves and camp fires do cause fires. Each group of loggers who stay overnight in the forest use portable gas stoves or less commonly, build small camp fires, which can cause small ground fires that later ignite dry peat soil and spread underground.

In the absence of other long-term employment opportunities, villagers will switch between dam building and logging in order to earn some income, though they do not necessarily see dam building as an environmental rehabilitation activity as much as something to do when there is no more valuable timber at the end of a *tatas*. While this environmental monitoring could be seen as a means to making environmental subjects who learn to care about forest conservation (Agarwal 2005), it is not clear that training villagers to collect scientific data on peat hydrology has prevented additional deforestation. Many used the knowledge they gained through monitoring to access new areas for logging, which removes carbon-rich biomass from the landscape, alters the hydrology further, and risks peat fires through use of camp stoves.

Though a core team of field workers have abstained from extractive activities such as logging after their involvement with KFCP, they have also been lucky to find new, related employment opportunities. Some are eager to work with foreign researchers or lead visitors, such as the World Bank contingent, through the ecosystem that they know so well. Others have continued to do environmental monitoring work through new lines of research that picks up the data collection where KFCP dropped off. But many others told me in interviews that they wish they still had contracts with KFCP because it provided a steady income. In the absence of project-based wages, they have returned to whatever opportunities are most lucrative. For some, they would prefer to build dams—as an ecological rehabilitation activity—than participate in illegal logging. But many more are content to travel increasingly far for valuable timber, and they find buyers at the illegal sawmills in Mantangai willing to pay them more cash than they'd get from working for an oil palm company, the only other employment opportunity in the area. Many others are willing to build dams when BOS or another conservation organization is willing to pay for this work, but they don't necessarily see dam building as a environmental rehabilitation activity as much as something one does when there is no more valuable timber at the end of a *tatas*.

What will happen with respect to future carbon emissions in the Ex-MRP peat landscape in response to interventions such as dam building is still largely speculative. Some scientists believe that raising water levels will help the landscape reach a future equilibrium, even if canal blocking does not completely flood the landscape year round (i 21, i 30). But regardless of what future equilibria might be reached through interventions, the more significant question for potential investors in these activities is *how long* it will take various equilibrium scenarios to be reached. Because drained peat soil is continuously oxidizing in the ex-MRP site even without any additional drainage, the potential carbon emissions savings through future interventions is decreasing day by day, gradually making the landscape less valuable to potential investors.

Though dam building was intended to be a rehabilitation activity within a REDD+ schema, it actually served as an attempted avoided deforestation tactic, especially in the absence of the large canal blocking that would have had a far greater impact on ecosystem rehabilitation. Small dam building, and frequent dam dismantling, highlights the fact that landscape rehabilitation is perhaps not an end goal but an ongoing process that depends on broader structural factors. Those building the dams and those dismantling the dams (both groups are predominantly Dayaks from local villages) are both seeking income amid falling rubber prices and expanded oil palm plantations, which the Dayak communities have not profited from. Both dam building and dam dismantling are practices that disrupt the imperative to make the landscape financially investable through carbon accounting.

5. Accounting for Carbon: "The Science is Difficult"

"My view is, by the time you've accounted for every ton of carbon, the game is probably over."
—European ecological consultant working in Central Kalimantan (i 21)

Carbon accounting in a degraded peatland ecosystem such as KFCP demonstrated the difficulties in making such land investable through carbon offset markets. Both the subterranean nature and the social complexities of an inhabited landscape have thus far complicated the processes of simplification and commensuration necessary for carbon offset investment. It can be argued that the attempts at developing a participatory MRV system—the scientific infrastructure that was intended to make the degraded peatlands financially valuable—failed in the KFCP project because the project was never intended to produce tradable carbon offset credits in the first place. However, by the time the KFCP project ended in 2014, many financial actors—including the major international banks—had already given up on the potential for investable forest carbon credits in Indonesia regardless of what happened with the KFCP project.[151] Speculative capital had abandoned the idea of investing in burning and oxidizing peatlands in Kalimantan as carbon offsets, deeming them too risky an investment. One reason for this, no doubt, is the lack of international policy regulations for an involuntary carbon market. Yet another reason given by a scientist involved with the KFCP project was not only the lack of reliable data but the uncertainty surrounding some of the science. When I asked him about the potential for carbon offsets in peatlands told me bluntly: "What I decided is that the science is difficult. Trying to measure every ton of carbon has problems" (i 21). But what is significant about "difficult science" in the context of accounting for carbon is not that measuring emissions is an impossible scientific problem, but rather that the demands the *financialization* of carbon emissions has placed on the science are difficult.

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[151] As of late 2014, JP Morgan, Merrill Lynch, McQuarrie Bank, and Deutsche Bank had all pulled out of REDD+ projects in Indonesia that they had been underwriting previously.

First, KFCP's focus on developing peatland carbon accounting methodologies rather than avoiding deforestation (which they could have done in Block E) highlighted the challenges in measuring carbon emissions in an ecosystem where the majority of carbon is subterranean to the degree required by investors. Turning this monitoring data collected in the swamp into something that could be used for investing in carbon offset credits has proven even more challenging. In order to calculate how much carbon would be saved by implementing certain landscape interventions, scientists and investors need accurate baseline emissions data. Unlike in forests in non-peatland areas, where carbon stocks are mostly found above ground and can often be monitored through remote satellite methods (J. E. Goldstein 2014), monitoring below ground carbon requires more boots on the ground, so to speak.

Furthermore, because so little is known about future emissions rates in peatlands through oxidation and fire, it's hard for scientists, and thus interested investors, to predict how various ecosystem interventions will prevent emissions. Because so little is known about future emissions rates in peatlands through oxidation and fire given the number of variables, it is extremely hard for scientists, and thus interested investors, to predict how various ecosystem interventions—canal blocking, fire prevention—will prevent emissions.[152] Though KFCP was operating under the presumption that such interventions would prevent more carbon emissions than doing nothing, scientists don't know when the drained peat soils will reach an equilibrium on their own. Without intervention, the peat will subside to a new low and emissions rates will slow. With interventions such as dam blocking, the ecosystem will reach a different equilibrium

[152] While carbon emissions rates from oxidation have proven difficult to calculate with any accuracy, carbon emissions from deep peat fires are so high that accounting for fire emissions might be enough to attract investors to finance canal blocking or related activities (i 21). But while a single major fire event in a given area can emit more carbon than through oxidation in the same area over a longer period of time, scientists generally believe that total emissions from Indonesia's peatlands are higher through oxidation rather than through fire because oxidation is happening continuously (i 33).

and emissions will decrease to zero or near zero. "So your potential carbon emissions savings, at a maximum, lies between those two potential future equilibriums," explained a scientist familiar with the area (i 21).

The other significant variable affecting future carbon emissions rates is El Niño occurrence. During El Niño years, Borneo experiences moderate to severe drought, further decreasing water tables and enabling enormous fires in drained peat, as happened in 1997-98. So an El Niño event causes increased emissions from fire as well as from oxidation, and any activities that decrease emissions during an El Niño event maximizes the amount of carbon emissions saved through interventions. Anyone investing in preventing emissions would thus hope for more frequent El Niño events because the emissions savings would be greater. But for investors calculating risk in the investment, they would also have to calculate the severity of future El Niño events: if a severe El Niño year causes a large amount of peat to burn away, an El Niño event the following year wouldn't necessarily cause such high emissions. An accurate methodology, in other words, would take into account the severity of future El Niño events as well as their frequency.

Predicting how much carbon a given peatland area will emit in the future also requires certainty about how much it has emitted in the past. In order to calculate how many tons of carbon emissions could be prevented, there needs to be some past start date against which later emissions are measured. Between 2010 and 2012, a research team affiliated with the Center for International Forestry Research (CIFOR)[153] undertook a massive soil coring project across Indonesia's wetlands in order to calculate soil carbon baselines. These cores effectively establish a historical baseline against which future carbon losses or savings can be compared (i 10).

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[153] CIFOR is an international research institute based in Bogor, Indonesia, and part of the worldwide CGIAR consortium.

Despite the extensive carbon cataloguing that KFCP undertook, they were working with no established baseline because they never intended to generate carbon offset credits through these activities, only to demonstrate a possible methodology for doing so in the future.[154]

Finally, MRV systems rely heavily on remote sensing and radar technology to calculate carbon stock across landscapes, in addition to the on-the-ground monitoring conducted in the site. But the applicability for the subterranean in the Ex-MRP site has been hindered by its inability to penetrate dense ground cover. While LiDAR remote sensing can determine the amount of carbon below ground in peatlands at coarse scales, its applicability in the Ex-MRP site has been hindered by its inability to penetrate dense ground cover, like the fern and shrub-dominated land cover in much of the Ex-MRP site. KFCP project designers responded to this by having field teams clear patches of shrubs so LiDAR could be used along certain transects. But this method proved time-consuming and labor-intensive to use across a large site. So while remote sensing has enormous utility in REDD+ projects based on avoiding deforestation, the biophysical nature of this particular degraded peatland ecosystem proved difficult for coupling remote sensing methods with field-based monitoring at the scale at which a potential investment in the landscape would be worthwhile. This is one reason why few peatland carbon methodologies have yet to be accredited through international certifying bodies, or implemented in investor-based projects (i 33).

[154] The Rimba Raya REDD+ project in western Central Kalimantan province illuminated the significance of establishing accurate baseline emissions. This was focused on avoided emissions via saving land from conversion through agricultural concessions. Project investors claimed 100 million tons of CO2 over the project span, but this estimate was “shoddy,” according to one scientist [i #NM]. They used an estimate of zero emissions as a baseline, but that presumes the site is currently emitting no carbon dioxide, which isn’t necessarily true. Infinite Earth and Daemeter were involved with the methodology. This project also raised the issue of leakage: PT Best was supposedly to have avoided developing land based on the REDD project. But they went elsewhere, so the emissions still occurred. KFCP “is not a carbon project,” so it had no baseline (i 21).

The problem of accounting for carbon to the degree of accuracy that financial investment demands is thus compounded by not only scientific uncertainties in the present, but by the inability of scientific methods to model ecological equilibriums, and thus emissions from the landscape, in the future. Not coincidentally, the inability to precisely predict future emissions equilibriums parallels the breakdown in indigenous knowledge surrounding relatively minor interventions in this landscape. For instance, while Dayak communities were able to dig small canals in the forest and selectively log trees, these otherwise mundane acts can have much larger ecological repercussions within a degraded landscape that is undergoing unpredictable and volatile change. While I was traveling throughout the still-forested Block E, the sporadic sound of chain saws in the distance, I asked an ecologist who was with me if it matters, from her perspective, if the villagers cut down a tree here and there in the forest. She explained that in an ecosystem that is already heavily degraded, the loss of just one tree can have a big impact in the surrounding area, even affecting peat soil carbon emissions rates over time. The scale of impact of such ordinary activities within the communities in the Ex-MRP site is perhaps as uncertain and unknowable as accounting for every ton of carbon, not only in the present ecosystem but that will be emitted in the future.

Finally, I have thus far emphasized perspectives from foreign—primarily Western—scientists and their Indonesian affiliates. There was an alternate perspective among Indonesian scientists unaffiliated with Western universities or researchers, however. Some of these scientists voiced frustration at the ongoing, and seemingly never-ending, process of carbon emissions accounting but the lack of political action or change on the ground. At an internationally-funded workshop on peat fire in Central Kalimantan for local government officials, an Indonesian scientist stood up after an American scientist's presentation. "The challenge for Indonesians is to create policy, not do more research," he argued forcefully. "They don't need foreigners to come in with more data. The forests are gone, and the problem is that the policies are wrong. A lot of data is on our table, but has never been compiled to form policy" (i 61). Another scientist in Palangkaraya was similarly annoyed at the increase in foreign scientists who had arrived in Central Kalimantan in recent years: "Yeah, those people are stupid, actually there's already a lot of research on peatlands; we don't need more basic research. It's already a lot beginning in 1992," he said (i 69). He went on to argue that research is "throwing money away" and what is needed is action that will help the communities in the area. Yet another Indonesian scientist, based in Jakarta, when asked about carbon accounting going on in Central Kalimantan said:

"Foreign scientists also try to make activities that are not so useful. Only for their own interest. Like lot of study of emission and so on. Not so useful for that area. Yeah, many people from foreign areas are measuring carbon. So what. I think nature already work to reclaim that area. There is a kind of natural succession. You can see plants are growing naturally, without any rehabilitation. I believe the peatland, the more intensive you touch the land, the more degraded." (i 39)

While these Indonesian scientists may feel, bitterly, that they have been ignored in international plans to rehabilitate the area, they also have a different scale of concern than that dictated by carbon emissions. Because plans for rehabilitating the area that were underpinned by objectives to reduce carbon emissions have thus far failed to provide lasting positive change for the communities in the area, they raise the question of whether global scale mitigation efforts could ever be compatible with the material needs of such a degraded area's inhabitants. In speaking out against the proliferation of foreign-led research on matters of global concern, they are pointing out the gap between scientific and political imperatives: while the continual production of techno-scientific knowledge may be a 'solution looking for a problem,' politics, by way of financial investment, requires socio-scientific knowledge that "global" science cannot provide.

6. The Political Value of Degraded Peatlands: INCAS and International Negotiations

During the initial stages of KFCP, the national government was only directly involved in creating the policy framework in which REDD+ projects in Indonesia were situated and the payment mechanisms through which projects were funded. MRV system development, by contrast, was largely controlled by foreigners or Indonesians affiliated with international centers. Now, however, the Indonesian national government has begun to control the scientific infrastructure left behind by the abandoned KFCP project.

The national government, via the Ministry of Forestry, is inserting themselves between the local and the global: gathering and aggregating the data collected on the ground and generating a national carbon accounting system. By having their own numbers, this system enables the national government, the Ministry of Environment and Forestry specifically, to have more leverage in international climate change negotiations, such as the forthcoming COP meeting in Paris in December 2015. As one Indonesian environmental consultant explained, "If you have this kind of very precise data, you can use it as a bargaining position into the international system, like at COP" (i 28). It is increasingly clear to the national government that in the absence of direct financial investment in land-based carbon offset projects, areas like the Ex-MRP site can still have political value within the state's broader portfolio of carbon emissions.

In March 2015, a working group affiliated with the Ministry of Environment and Forestry released the first version of an Indonesian National Carbon Accounting system (INCAS), the country's first nation-wide attempt to inventory and track changes in Indonesia's land-based carbon stock. A report from IAFCP (Indonesia-Australia Forest Climate Partnership, which oversaw KFCP), described INCAS as designed to be "policy blind" in calculating the impact of

Indonesian land management policies on carbon emissions but also to "provide scientific and technical basis to promote Indonesia's national interests" (Kalimantan Forests and Climate Partnership (KFCP) Design Document 2009). The design of this carbon accounting system included "wall-to-wall coverage" of land-based carbon pools and associated greenhouse gas emissions obtained through remote sensing and data collected annually in the field (Krisnawati et al. 2015).

The version of INCAS released in early 2015 did not account for the entire country's carbon pools, however, only those in Central Kalimantan province. INCAS designers drew from the emissions data generated through KFCP, along with maps owned by the Ministry of Forestry. The results of the INCAS pilot report from Central Kalimantan are intended to be "scaled up" to the national level in preparation for the UNFCCC Conference of the Parties (COP) in Paris in December 2015, in anticipation of a new global climate change agreement. Because INCAS captures changes in carbon emissions at a relatively fine scale, it allows Indonesia to shift from a Tier 2 to a Tier 3 MRV system in the UNFCCC's ranking of emissions accuracy by country.[155] A Tier 3 system is considered the most accurate assessment of a country's national greenhouse gas emissions. It also enables countries implementing such systems more leverage in international negotiations, as well as the possibility of bi- or multi-lateral partnerships for carbon offsets if an international involuntary carbon market remains elusive.

The organization of INCAS has been explicitly driven by interest in attracting investors—governmental or private—like the World Bank. With little uncertainty about the overall objective

[155] Brazil was one of the earliest countries to utilize satellite technology to create their own database of deforestation, giving them leverage in international negotiations, like over the Clean Development Mechanism. NASA has collaborated with the Brazilian government, with benefits for both Brazilian authorities in conducting in-house forest monitoring and US science agencies, which have been able to use the Brazilian data to better understand global carbon storage (Lahsen 2009).

of INCAS for carbon investment, the Minister of Environment and Forestry stated that "I am hopeful that the establishment of the INCAS as Indonesia's official MRV system for the land sector will increase investor confidence in REDD+ activities in our country" (Krisnawati et al. 2015).[156] But the logic of such a system is, like KFCP, organized around the promise of future involuntary carbon markets, rather than the existence of such a market itself. Furthermore, the institutionalization of INCAS into the national government reflects the fact that Indonesia is much more receptive to admissions about carbon emissions from its peatlands than it was in the 1990s or early 2000s. But it also highlights a perverse, underlying tension in Indonesia's national land use practices. The scale of domestic and international investment from the oil palm and pulpwood sectors continues to dwarf conservation funding, even with the multi-billion dollar grants from Norway and Australia that have kickstarted REDD+.

Enforcing emissions cuts from land use activities while allowing growth in sectors that contribute to the country's GDP through fossil fuel combustion enables Indonesia to 'catch up' in economic growth, while complying with international initiatives to reduce emissions that don't contribute to the country GDP. Under President Susilo Bambang Yudhoyono (SBY), Indonesia committed to reducing its total national emissions by 26 percent—or 41 percent if international funding is provided—by 2020. Significantly, government officials and foreign consultants have argued that emissions reductions in peatlands are among the least expensive, especially when compared with implementing techno-fixes to reduce emissions from fossil fuel

[156] Ironically, BP REDD+, the REDD agency that had remained unaffiliated with any government ministry, was absorbed by the newly merged Ministry of Environment and Forestry by President Joko Widodo soon after he took office in late 2014 in the name of improving government efficiency. Several actors who had worked for BP REDD+ prior to its absorption strongly criticized this move, arguing that by situating REDD+ as a "project" within the Ministry of Forestry's portfolio, it would lose its cross-sectorial power to address land-based carbon emissions (Rakhman and Sekarsari 2015). Situating REDD institutionally within a ministry long known as the king of corruption (Forestry) would also dampen REDD+'s credibility in Indonesia for foreign investors. In 2013, INCAS was made a permanent function of the Ministry of Forestry in 2013, also decoupling it from prior donor-based funding such as the IAFCP.

combustion. Within Indonesia's total profile of emissions by sector peat decomposition, LULUCF (land use, land use change, and forestry activities), and agriculture are the top three sources. In particular, the Indonesian National Council on Climate Change writes: "The rehabilitation of Indonesia's degraded peatland, e.g. areas within the Ex-Mega Rice Project in Central Kalimantan, is the second largest abatement opportunity of peat emissions" (DNPI 2011: 18). Dam building and vegetation replanting in the EMRP site represents one of the biggest bangs for the buck, in other words, to 'cost-effectively' reduce Indonesia's total national emissions. Reductions from transportation, petroleum/gas, and cement production sectors, however, hardly figure into country's projected abatement strategies. Shifting attention and funding to reducing peatland emissions, meanwhile, allows Indonesia to comply with international initiatives to reduce global emissions under the guise of taking responsibility for their standing as world's third largest emitter.

If Indonesia can show that all of the necessary emissions reductions are made by stopping peat fires or rehabilitating peatlands, it frees up more necessary emissions reductions generated by other sectors, including fossil fuel use, so long as national emissions overall are reduced. As Lahsen (2009) explains in relation to Brazil, "The larger the size of a given country's estimated anthropogenic carbon sink, the easier and less expensive it is for a country to meet the emission reduction targets to which they have committed under international agreements such as the Kyoto Protocol" (Lahsen 2009). Countries with large tropical forests therefore have incentive to generate the lowest possible national emissions estimates. Estimates of Indonesia's national emissions made by international scientists have typically been higher than those proposed by the Ministry of Forestry (van Noordwijk et al. 2014). Therefore, if Indonesia is able to point to their own Tier 3 data as mandated by the UNFCCC and claim lower land-based emissions than have been assigned to Indonesia in the past, it might give their climate delegates more room to maneuver, vis-a-vis overall land use practices. If they can show that all of the necessary emissions reductions are made by stopping peat fires or rehabilitating peatlands, it also makes possible more emissions generated by other sectors, including fossil fuel use, if national emissions overall are reduced. Meeting stated national goals of 26% emissions reductions by 2020—or 41% with international financing—is thus easier when the state generates and disseminates the data underpinning these objectives.

Indonesia is in a peculiar position with regards to global carbon: they generally fall in line with other non-Annex 1 countries, which are not committed to emissions reductions through the Kyoto Protocol (which is most developing countries). Blaming Indonesia for carbon emissions flips conventional thinking about Global North versus South countries. Global North countries have typically been implicated in contributing higher levels of carbon emissions to the atmosphere, while the Global South, or poorer countries, are more adversely affected by a changing climate while doing little to contribute emissions historically. Pushing Indonesia to the position of the world's third largest carbon emitter, behind only the United States and China, has profound implications for their accountability to climate change mitigation plans on an international stage. While Indonesia emitted 4.5 percent of global greenhouse gas (GHG) emissions in 2005, their share of global real GDP was only 0.6 percent (DNPI 2014). This proportional statistic also points towards the outsize role land-use emissions have in contributing to Indonesia's total national emissions—estimates range from 38 to 50 percent—as opposed to fossil fuel-based industry that contributes to GDP (Hilman 2010). Some reports have compared the GHG attributable to peat fire and oxidation in Indonesia to the total GHG emissions from Germany (DNPI 2014).

But given that many in the scientific community believe that Indonesia's peatlands contribute significantly to global emissions, they are under increasing pressure to find ways to reduce their emissions. The quasi-scientific activities undertaken through KFCP reflect this tension, between emissions prevention and sequestration. Furthermore, a national carbon accounting system is not only trying to catalogue emissions sources, but also possible land-based carbon sinks. With the world's third largest tropical forest, Indonesia has a stake in claiming a significant emissions sink. If a national accounting system were able to show that Indonesia's overall carbon budget was near zero—that is, their forests absorb as much carbon as deforestation and peatland drainage and fire produce—they could argue that they don't need to focus on changing land use practices away from those that contribute to emissions.

7. Conclusions

Bruce Braun argues that the consequence of "geologizing" or creating geologic knowledge of Canadian territory, was that this territory was then drawn deeper into circuits of global capital (Braun 2000). In the case of 'carbonizing' Indonesia's peatlands, this territory is drawn into global knowledge regimes through international climate change institutions as a consequence of its *attempted* inclusion in circuits of global capital. Yet in the process of trying to render the site financially valuable through its carbon offset potential, the site instead acquires political value for the national government. The Indonesian state has opted to continue to fund the scientific infrastructure—indeed, make it part of a sovereign carbon accounting system—because they believe it will serve their political ends in the future. In the absence of speculative capital, or state-led capital exogenous to Indonesia (in the case of Australian-funded KFCP), the Indonesian state is seeking to continue carbon accounting as a kind of scientific project. The state assumes responsibility for this, however, because the degraded peatland in sites like the Ex-MRP might yet be financially valuable in the future. This is contingent, of course, on international policy to create the necessary market. It also remains to be seen what role sites like the Ex-MRP play for the national government vis-a-vis larger land-use ambitions to expand oil palm cultivation, which is discussed in chapter 5. Though most scientists believe these two land-use strategies are in conflict—peatland rehabilitation and oil palm cultivation—the national government may be reconciling these strategies by shoring up the scientific data justifying both simultaneously.

Finally, in a shift from the Mega Rice Project in which Dayaks were given little agency, the indigenous communities inhabiting the area were able to exercise some agency over the scientific process, and in turn, over the political process of creating a sovereign national carbon accounting system. This occurred, most clearly, through their participation in the development of the MRV system directly. But disruptions to the development of this system—through dismantling dams and logging—also provided openings for local agency in the process of generating global financial and political value. Some of this agency was intentional on the part of KFCP designers and managers: they hoped that by "educating" Dayak communities on the purpose and methods of peat carbon monitoring, the communities would participate in rehabilitation, and conservation, writ large. But attempting to make the degraded peatlands valuable to the communities for the purposes of preventing carbon emissions also makes these communities responsible for preventing emissions that they did not cause in the first place.

Chapter 5: Oil Palm Development and the Uncertain Underground

"Have you heard the joke about REDD?" an Indonesian environmental consultant asked me during an interview in 2011, laughing. Without waiting for answer, he continued "The joke is that on the day Norway announced a $1 billion investment for REDD [in Indonesia], an oil palm company announced a $3 billion investment in Indonesia!" (i 3). When I returned to Mantangai in late 2014, it became clear that his comment was not only a joke. Indeed, in part of the site that just months before had been part of the KFCP REDD+ project, several hundred hectares of secondary forest used by local communities had been cleared for oil palm in a matter of days (figure 32). Despite the intentions of REDD+ actors at all scales who have tried to generate momentum for REDD+ projects in Kalimantan, carbon-based conservation and rehabilitation projects have, for the most part, failed to offer a compelling alternative to the rapid expansion of mono-crop agricultural plantations in the Ex-MRP site.

Despite known ecological risks, why and how is oil palm cultivation expanding on peatland, particularly in the Ex-MRP site? Chapter 5 responds to this question by exploring the dynamics of oil palm expansion onto peatland at both the national and local scales (in the Ex-MRP site). As previous chapters have discussed, proliferating scientific research since the late 1990s on the carbon stock of peat soils has raised concerns in the international scientific community that without protection and hydrological rehabilitation, peat soils will continue to be a significant source of carbon emissions. Through this scientific research, peatland development has been conceptualized as an ecological crisis and a threat to the planetary atmosphere.

Simultaneously, Indonesia has become one of the world's most attractive countries for "land grabbing," or the rapid, large-scale acquisition of land for investment in agricultural production and the simultaneous displacement of people and/or activities. Much of the land grabbed for agricultural investment in Indonesia has been located in the country's vast peatlands for oil palm cultivation, further implicating the agricultural plantation industries in peatland mis-management. Many oil palm industry actors argue, however, that through proper management agricultural production on peatlands can actually decrease peat-based carbon emissions.

These counter-claims rely on alternate scientific research to justify further corporate land acquisition for large-scale oil palm plantations. Divergent knowledge, though not taken seriously by most in the international scientific network, nevertheless succeeds in shifting the questions framing peatland-based land grabbing away from whether peatland *is* suitable for agricultural development—and thus should be developed at all—to whether it can be *made* suitable for investment and how associated biogeochemical risks should be managed. In doing so, industry-affiliated actors generate enough doubt surrounding the necessity of peatland conservation to sway regulatory regimes in their favor. The tension between these two existing and potential uses of Indonesia's peatlands—protection/rehabilitation and development—and the knowledge claims that underpin them thus raises significant questions about the politics of expertise justifying land grabbing.

At a local scale, meanwhile, land previously transferred to transmigrants in the Ex-MRP site is facilitating oil palm expansion. This is not, however, occurring through "large land grabs," as the general narrative about land leased for food and biofuel production would imply. Instead, oil palm in the Ex-MRP site is expanding through smallholder *plasma* schemes, which I explain below, and piecemeal illegal land transfers. Though transmigrants are not seeing as many benefits from oil palm as they have been promised, the expansion of oil palm in the area has nevertheless provided them with an opportunity for income. Indigenous Dayak communities, however, are starting to be excluded from their own land, as oil palm companies purchase their land for very small sums. Unlike transmigrants or other workers from Java, Dayaks are uninterested or unwilling to work as contract laborers for oil palm companies.

This chapter's discussion of the trajectory of oil palm expansion traces the dynamics of land acquisition, with attention to the different conditions and interests of Dayak and transmigrant groups in the Ex-MRP site. It also traces the emergence of alternative knowledge regimes, which I call 'divergent expertise,' which underpin oil palm expansion despite mainstream scientific consensus that argues such expansion is a threat to the global atmosphere. Following the account I lay out in chapter 3, on the emergence of such a scientific consensus, and the discussion in chapter 4 on how new scientific infrastructures have made the Ex-MRP site politically valuable, this chapter argues that oil palm development on degraded peatlands is making this land economically valuable.

1. Oil Palm and Land Acquisition in Indonesia

Oil palm cultivation has exploded in the past decade across parts of the tropics.[157] Since the 1980s, Indonesia's national policy has consistently promoted loans and investments for oil palm cultivation. This state interest in oil palm development as an economic growth strategy reflects an assumption—probably well-founded—that global oil palm prices, bolstered by international demand for biofuel vis-à-vis a looming energy crisis, will continue to climb (McMichael 2014). The oil palm is adapted to lowland equatorial conditions and the oil from its fruit can function both as biofuel and as food (figure 33).[158] The largest share of palm oil is imported by China and

[157] Other crops used for biofuel and/or edible oil have also expanded in the same time period, including jatropha, soya, and sugar cane (Zoomers, 2010)

[158] Most of the oil is extracted from the pulp of the fruit; this is called crude palm oil. The kernels are also crushed to produce palm kernel oil, which is added to processed foods and used as cooking oil throughout much of Asia and increasingly in Africa.

India for cooking oil and in processed food. Their growing markets also maintain demand for the crop regardless of global biofuel prices. The Southeast Asian oil palm boom began in peninsular Malaysia in the 1980s before expanding to the Malaysian states of Sabah and Sarawak on Borneo, and more recently to Sumatra and Kalimantan in Indonesia. Indonesia and Malaysia together currently produce over 85 percent of the world's palm oil (Hall 2011).

While Indonesia has overtaken Malaysia in the amount of land under cultivation, much of the export production in Indonesia is partially controlled by Malaysian conglomerates or other Asian financial actors, particularly Chinese (Hall 2011; McCarthy 2012). As Helena Varkkey (2013) explains, although Indonesia is Southeast Asia's largest oil palm producer, the network of industry-affiliated scientists, investors, government elites, lobbying groups, and plantation managers with vested interest in Indonesia's oil palm sector is regional, reaching throughout Malaysia and Singapore. Malaysian investment in Indonesia's oil palm section is not only limited to the most recent wave of land sales, however. For instance, in 1995 a Malaysian state owned organization, *Lembaga Urusan Tabungan Haji*, acquired a 70 percent stake in a Suharto family owned company, *PT Multigambut Industri* (*gambut* means peat), to develop oil palm plantations on peatland in Riau. *PT Multigambut* had already been running 100,000 hectares of plantations on peatland in Sumatra's Riau province; the 1995 investment allowed them to establish 84,000 additional hectares plus an on-farm palm oil factory (*Jakarta Post*, 5 December 1995).

In support of state development policy in the past decade, the Indonesian Ministry of Forestry made roughly 10 million ha of state forest land available for oil palm concessions between 2000 and 2009 (McCarthy 2012). Yet the national-level statistics for land currently within oil palm concessions are widely considered inaccurate: since the early 2000s, all land transactions must be approved by local district heads rather than the national government in Jakarta. Many of these transactions are completed outside official regulations and thus don't make it into national databases quickly, or at all. Following the resignation of former President Suharto in 1998, the Indonesian state become rapidly decentralized after decades of highly centralized, resource extraction cronyism under his rule. Yet national-level statistics for land concessions are widely considered inaccurate. Since state decentralization in the early 2000s, all land transactions must be approved by local district heads, rather than the national government in Jakarta. Many of these transactions are completed outside official regulations and thus do not make it into national databases quickly, or at all. The national Ministry of Forestry once had jurisdiction over all concessions issued for development in state forest land, which includes over 80 percent of land in Sumatra and Kalimantan. Now, district heads—local elites—politically rise and fall on the basis of whether they are able to secure and control rents from resources extracted within their boundaries (McCarthy et al. 2012). As such, district governments have themselves issued 26 million ha of oil palm concession permits between 2000 and 2010, an unknown number of which coincide with those issued by the national government.

Actual cultivation of land for oil palm might be far lower, however, somewhere in the order of 300,000 ha per year. This disparity emerges from the practice of what McCarthy et al (2012) call "virtual land grabbing," or a type of land banking in which investors gain from the on-paper acquisition of and investment in land for development despite their lack of capacity to actually cultivate the land. Because land concessions in Indonesia are issued under leases, not sales, investors must use the land for its designated purpose within a set number of years or risk permit revocation. Therefore, many investors without capital for production infrastructure will invest in land concession permits, only to sell the permit later in a rising land market. Recent policy imperatives, such as a 2011 Presidential Instruction issuing a moratorium on peatland development for biofuels,[159] reflect dampened enthusiasm for heavy reliance on forest-based resource extraction in recent years, motivated by international politic-scientific discourses on the importance of land-based carbon stock conservation. Yet because the mechanisms through which land permit concessions are secured occur at local levels, these discourses are not necessarily reflected in the mechanisms of actual land transactions. In addition to securing district permission, agribusiness companies also confront indigenous land claims and rights and a series of additional bureaucratic hurdles prior to actually cultivating the land (Ito, Rachman, and Savitri 2014). Land grabbing, particularly in Indonesia's natural resource-rich Sumatra and Kalimantan islands, is thus underpinned by messy scalar political dynamics that makes it difficult to relate formal policy initiatives to the local processes through which land grabs actually occur—both implemented and virtual.

Indonesia's peatlands underpin contestations over land acquisition and management strategies for oil palm cultivation. Over the past decade, monocrop oil palm plantations have been expanded extensively onto peatlands in Sumatra and Kalimantan (Koh et al. 2011). Carlson et al (2012) determined that over 60 percent of oil palm concessions granted to companies since 2000 have been on peatlands, significantly more than in previous decades. One persistent question raised through the expansion of oil palm plantations onto peatlands, particularly on deep peat soil, is whether companies can operate profitably on peatland if such production requires

[159] A Presidential Instruction signed by the President of Indonesia in May 2013 continued the moratorium begun in 2011 that effectively banned new plantation concession licenses on primary forest and peatland for another two years. Financed by the Government of Norway through a REDD+ start-up fund, this presidential instruction (InPres 2011) specifically instructs the Ministry of Forestry to cease issuing new licenses on land designated by official government maps as primary forest or peatland, regardless of whether it is also classified as production forest and thus legally available for agricultural conversion. The Ministry of the Environment, meanwhile, is instructed to: "make efforts in reducing emissions form forest and peat land by improving governance in business activity proposed in forests and peat lands within the Indicative Map for Suspension on New Licenses through environmental licenses" (Presidential Instruction of the Republic of Indonesia 2013).

capital-intensive land management. As McCarthy et al (2012) describe in their analysis of oil palm expansion, land can be considered marginal if the costs of developing it exceeds the benefits. The process through which agricultural rents can be extracted from marginal lands, particularly those in volatile ecological systems, thus requires *making* the land suitable for production, as opposed to finding existing suitable land. For oil palm industry actors, making land suitable is synonymous with rendering it profitable (Li 2014).

But this is not a straightforward process in Indonesia's degraded peatland areas, such as in the Ex-MRP site, as it would be on forest land cleared on non-peat soils. Indonesia's peatlands are made suitable for land grabbing through extensive investment in infrastructure and agricultural technology, including fertilizers. Though oil palm is a versatile crop adaptable to a wide variety of growing conditions, peatlands need to be drained with canals prior to cultivation so the water table falls below the soil surface. Drainage, however, creates risk that the soils will catch on fire. Plantations on peatland also require ongoing monitoring and hydrological management to ensure that the water table neither drops too low nor rises too high, flooding the plantations. Many scientists also contend that even if plantation managers are able to prevent fire through monitoring, and thus mitigate soil loss through combustion, the dry peat layer will continue to oxidize until the water table is exposed, emitting greenhouse gases and making the flooded land unusable for further development. Contrary to many land grabs that have been matched to localized ecological systems that fit notions of a suitable or ideal environment for development (Wolford et al. 2013), Indonesia's peatlands have been swept into this most recent developmental trajectory in spite of their volatile nature, which renders them a global atmospheric threat.

2. Transmigrants, Dayaks, and Expanding Oil Palm in the Ex-Mega Rice Project Site

Contrary to belief that transmigration in Indonesia ended with the New Order, transmigration still exists as a semi-formalized, government-led scheme to move laborers from Java to Kalimantan to support the 'land rush' for oil palm.[160] What is different now than during the New Order is the significant role transnational companies play in facilitating transmigrants' resettlement. In conjunction with district governments, companies are encouraging the movement of contract workers from Java to Kalimantan. Though transmigration in Indonesia has been vastly scaled back from the hundreds of thousands relocated every year during the New Order, there is still transmigration into Kalimantan. The head of the Dinas Transmigrasi (district-level transmigration office) of Kapuas district explained that they receive a few hundred transmigrants each year from Java (and sometimes from Sumatra), often as a result of relocation caused by a natural disaster. When Mount Merapi erupted in Central Java in 2012, he told me, some inhabitants of the area elected to move to Central Kalimantan through the transmigration program, thereby receiving 18 months of government food aid and two hectares of land. Unlike during the New Order, however, transmigration is coordinated at the provincial or district levels, rather than the national. The governor of a province affected by a natural disaster, for instance, can contact *Dinas Pertanian* offices in the districts to ask if they can resettle migrants in areas with available land. The village head (*kepala desa*) supplies data on the available—unused or "empty"—land in that *kecamatan* (a village-level jurisdiction), and if it is in a transmigrant area, the *Dinas Transmigrasi* helps coordinate permission between the *bupati,* provincial governor,

[160] Some transmigrants came to the MRP area during the transition to democracy to look for work. Others came from Java during the post-New Order transition to democracy, when the government wasn't closely tracking transmigrants or providing consistent support. "[I] was looking for fortune as a laborer," explained a Javanese man who migrated to the area in 1999, "so here, the land is vast. So I joined trans… but with my own capital, no help from the government" (i 82).

and the company (i 73). All of the men, and some of the women, who have migrated to Kapuas district recently as transmigrants are working for oil palm companies as contract workers.[161]

In the absence of alternative government plans for the site, oil palm companies first started acquiring land in the Ex-MRP area in 2002 (Galudra et al. 2010). At the same time, at the local political level, as regional autonomy started to restructure political and financial relations between the district governments and the national government in 1999, districts were able to oversee more budgetary spending directly. During Indonesian political decentralization in 2000, funds were distributed to districts based on population. Local district heads thus wanted more people in their districts, but there was a minimum number of inhabitants per village that would enable the population cluster to be counted in as a village. In some places, district leaders (*bupati*) who had aspirations to be elected provincial governor promoted transmigration in their districts because more people meant more political votes.[162] In the Ex-MRP site where transmigrants were still living, *bupati* also recognized that oil palm could be up to 20 times more profitable than rice in peatlands (i 29). As of late 2014, there was oil palm cultivated throughout all areas of the Ex-MRP site except Block E. Over 150,000 hectares of oil palm concessions in the Ex-MRP site were operational in 2009, with tens of thousands more hectares granted in concession licenses not yet developed (Galudra et al. 2010).[163]

[161] The head of Dinas Transmigrasi told me that the daily wage for oil palm workers is Rp72,000 (about US$6), though several people I spoke to in the field areas said the daily wage was Rp50.000, or less than US$5.

[162] For instance, in 2007, the *bupati* (district head) of Kapuas District, Pak Burhanuddin, authorized a 300 hectare transfer of transmigrant-held land to *PT Globalindo Indah Lestari*, which is owned by a Malaysian conglomerate. The company paid as little as Rp500.000 (US$50 at current conversion rates) per hectare. *PT Globalindo* now oversees at least 15,000 hectares of land in the Ex-MRP site, earning more than Rp8 trillion (over US$500 million) by some accounts (i 44). About a dozen other oil companies operate in the Ex-MRP area legally, but other companies are rumored to be overseeing oil palm production illegally, without formal concession permits.

[163] That figure has increased considerably since then, though I have not been able to obtain precise figures.

Furthermore, the recent rush to develop oil palm in the Ex-MRP area has been facilitated by extra-legal—as well as legal—changes in the structure of land tenure in transmigrant areas. Oil palm cultivation in the Ex-MRP area initially violated the original terms of the Presidential Decree, which designated the area for food crops. In the years since the MRP, national, provincial, and district level government spatial plans and regulations concerning oil palm cultivation have often been in conflict with one another. Nevertheless, a significant portion of transmigrant-occupied land in the Ex-MRP site has been converted to oil palm despite being in violation of various government laws.[164] Because it was initially difficult for oil palm companies to legally obtain land in the area, companies agreed to open land in transmigrant areas if landholders were willing to give up half of their land for oil palm cultivation through *plasma* schemes. *Plasma* is a type of contract farming common within the oil palm industry throughout Indonesia.[165] It is shorthand for the elaborated "nucleus and plasma" cooperative farm structure, in which the oil palm company operates a centralized mill for processing (the 'nucleus') and gives start-up capital to smallholders to convert their land to oil palm cultivation ('plasma' land).[166]

Vis-à-vis these practices, the district government saw an opportunity to invite company investment in the MRP area, partially in response to the livelihood crisis that the transmigrants faced. With the land already cleared and drained, it was relatively easy to start planting oil palm. Although official national law stipulates that transmigrant-held land cannot be sold to a

[164] See Galudra et al. (2010) and McCarthy (2011) for more on land conflicts that have arisen in the Ex-MRP site over oil palm.
[165] The plasma structure is also used in other plantation crops in Indonesia (White 1997).
[166] Transmigrants who have joined plasma schemes complain of not being paid regularly or not being compensated for their initial investments in fertilizer and seedlings by the companies. A Balinese transmigrant family, for example, described how they joined plasma in 2012 but two years later have yet to be profiting from involvement with the company. They still rely on declining income from their small rubber garden to pay for basic necessities (i 92).

company, there was little direct oversight from the national government in the years following the MRP. As a result, transmigrants were able to sell their land certificates illicitly to oil palm companies beginning in late 1998. For transmigrants who had been settled in Lamunti and Dadahup, this enabled them to make a quick profit from the land already cleared, but abandoned, by the MRP.

Though there is much rhetoric about Chinese or Malaysian investors buying up land for oil palm cultivation, the first land transactions in the Ex-MRP area were actually transmigrants purchasing land from other transmigrants departing for Java. Some of the transmigrants who stayed in the area have amassed several lots, buying up to a dozen hectares from relatives or friends who left Kalimantan. My research revealed that transmigrants who purchased land through these small land deals since 1998 are those primarily involved with oil palm companies now through either *plasma* arrangements or smallholder direct contract schemes. One Javanese transmigrant explained that selling one's two hectare transmigrant plot was technically illegal but during the government transition in 1998-99, no one from the central government was paying close attention to what was happening in the MRP site. So transmigrants who were eager to leave right away quietly sold their land so they could get enough money to travel back to Java. Any regulations about land transfers being illegal, he said, was just "government discourse" because the government isn't "bold" enough to enforce the laws (i 90). Those with these larger landholdings—generally spread across Lamunti and Dadahup in the southern portion of Block A—have been able to diversify their livelihood strategies, devoting some hectares to subsistence gardening, some to rubber, and now that the oil palm boom has taken hold, planting oil palm or incorporating their land into company *plasma* schemes.

Legally, transmigrants hold government-granted 25-year certificates for their land, after which the land is handed over to the local government. After 25 years of land investments in rice, the government is—in theory—reluctant to convert the land to oil palm. But in Lamunti, district leaders have given licenses to oil palm companies in transmigrant-held land if they believe the land is not presently being cultivated for food crops. Plantation owners will ask the district *bupati* to sign off on the transfer, encouraged by bribes or simply a convincing argument that the district will benefit from increased corporate revenue. Furthermore, while transmigrants who were able to amass larger plots of land can sell this land to the companies for a profit. Transmigrants who hold only their original two hectares of land, by contrast, have few options other than to .

In short, most local residents involved in oil palm production, however, have received little of this profit from the area's oil palm boom. Transmigrants remain legally prohibited from selling land held through state-granted transmigrant certificates, though many transmigrants have amassed more than 2 hectares by informally purchasing certificates from migrants who left the area. Most of those who hold more than their original two hectares of land are converting some or most of it to oil palm. In the transmigrant areas of the Ex-MRP, the nucleus-plasma plantation structure has become common, though some transmigrants cultivate oil palm as smallholders and sell palm fruit to companies.[167]

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[167] Some of the original transmigrants in the Ex-MRP site, however, hold only their two given hectares of land and thus aren't able to maintain livelihood diversity if they convert their land to oil palm. One Javanese man explained to me that he made a living selling vegetables at the markets in Mantangai from 1998 to 2007. When representatives from *PT Global Indo* arrived in 2007, the company offered them start-up capital, basic tools, and seedlings—as a loan—to plant oil palm on their land. They promised that he would be able to make more money selling the harvested palm oil to the company than he did selling vegetables, so he agreed to join this plasma scheme. As part of plasma, he owes the company Rp200.000 per month to pay back the loan, plus all of the harvested product. He works for the company as a daily contract worker, making Rp72.000 per day, working from 6am to 1pm. He doesn't mind the work, and thinks the hours and daily wage are okay. The biggest problem, he explained, is that he has no more available land to grow vegetables to sell at the markets or to feed his family, so he now buys all of their food at the market (i 80). Another Javanese man echoed this,

As described in chapter 2, the first transmigrants to leave the MRP site faced a host of challenges, including non-existent irrigation and road infrastructure, little market access, and flooding. Now, the several dozen blocks of transmigrant settlements (up to a few hundred residents live in each block) have the feeling of a suburban tract housing development: orderly but lived in. Compacted dirt roads are wide and straight, with evenly spaced houses each on their own quarter hectare of land. Most transmigrant families cultivate a garden next to their house with onions, chili peppers, pineapple, and fruit trees for home consumption. Unlike the MRP canals in the northern part of Block A, closer to the Dayak villages, the canals in the transmigrant areas are more shallow and narrow. They quickly become overrun with grasses and in the dry season have almost no water in them. Therefore, the transmigrants cannot use them to access fields or other villages as the Dayak communities do; they rely on the dirt roads, most of which now cut through oil palm plantations. Transmigrants use these roads to sell their vegetables at the local markets, such as the weekly market in Mantangai, about a 45 minute drive via motorbike from the transmigrant blocks, and some larger markets in Lamunti. These dirt roads connect to the Trans-Kalimantan highway to the south, which continues to Banjarmasin (about a 2-3 hour drive from transmigrant blocks).

As has been typical through Indonesian decentralization, national spending on transportation infrastructure has decreased, leaving road construction to districts. In the Ex-MRP site, oil palm companies have built these semi-paved roads (compacted dirt, not asphalt) through the transmigrant-inhabited blocks where canals are too narrow or shallow to use for transport. Of course, oil palm is cultivated throughout this area so the roads are primarily for transporting company equipment and harvested fruit. Some transmigrants praise the companies for

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saying that "If there were no oil palm companies, there'd be a possibility for farming. Like before, we planted [rice] paddy here." (i 81).

maintaining the roads, because these dirt paths would otherwise become quickly covered with flammable grasses (i 81). Yet one government official I spoke with in Kapuas said that the companies also use publicly built infrastructure, such as the single asphalt road that runs from Kapuas to both Banjarmasin and Palangkaraya (part of the Trans-Kalimantan Highway, which transverses all of Central Kalimantan province). Indeed, traveling on this road is a harrowing experience, with passenger car drivers swerving around trucks carrying mounds of tarp-covered oil palm fruit at 70 miles per hour into oncoming traffic. But the road was not originally constructed to bear the heavy loads of these trucks, the government official explained to me, and they are accelerating damage to the roads. He maintains that the companies should be responsible for road repairs, not the district government (i 44).[168]

Most transmigrants I spoke with in the EMRP site have similarly mixed feelings about oil palm. Some prefer day-to-day contracts with the oil palm companies because it allows for flexibility. Those working as daily contractors are happy to have the steady income, because they can make more per day than they earned from selling vegetables at the local markets. "For people here [the companies] can help… yes… for people who don't have work, who don't have plasma, finally there is work [wage work for companies]" (i 81), explained a Javanese man. None of them seemed fearful that their daily contracts could end abruptly, because oil palm plantations require year-round maintenance work, not just during harvest time. When I asked one

[168] The issue of who is responsible for infrastructure in transmigrant occupied areas came up with multiple informants, both transmigrants and local leaders. Some expressed the need for better irrigation infrastructure so transmigrants can continue to grow rice on shallow peatland. While in a canal near Mantangai, I came across two men from Kapuas's *Dinas Pekerjaan Umum*, the district-level Public Works office, who were speaking with farmers about possible improvements that could be made to the canals used for peatland drainage and transport. They told me that it's less expensive for the district government to pay to maintain the canals for transport than to build or maintain roads that could be used for farmers (i 48). Oil palm companies are also maintaining some of the canals first built by the MRP. I was passing through oil palm company-held land when my friend and driver pointed out two large excavators parked on the side of a large canal. They were dredging illegally to widen the canal, he explained, and got caught by the police so they stopped their activity.

man if he would prefer a monthly or yearly company contract, because it would presumably guarantee him more job security, he told me that he enjoys the freedom of being on a day-to-day contract, because he's not tied to the company. It's a problem, he said, if you're on a monthly contract because you can't take more than three days off in a row. If he wants to visit family in Java (which he does annually, usually around Ramadan), he needs at least one or two weeks off at a time. The daily contract allows him this travel flexibility (i 80).

Transmigrants also spoke favorably about the system of credit that oil palm companies have established for the transmigrants. Prior to the companies' arrival in the area, the most cash transmigrants could borrow from a local *warung* (small stand or shop, usually selling food or basic necessities) was Rp10.000 at a time, less than US$1. I asked a transmigrant man from Java if he cultivates oil palm on his own or through plasma. "If we plant [oil palm] privately, we don't have capital," he explained. "That money is only enough to eat every day. We always borrow from a *warung*, then every payday we have to pay back the *warung*" (i 82). But those who join plasma can borrow several million rupiah at a time from the companies, financing purchases such as televisions and motorbikes, which they cannot afford to pay for in full with cash (i 81). "The companies can help," explained one transmigrant, a Dayak[169] man married to a Javanese woman, "before when there were no companies, we didn't have 'quiet' debt." So while luxuries are more prevalent in the transmigrant blocks than in the Dayak villages—satellite television, smartphones, motorbikes, even herds of livestock—many of these lifestyle upgrades are purchased through credit financed by oil palm companies (figure 34).[170]

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[169] Dayaks from other parts of Kalimantan, or sometimes even nearby villages, could join transmigrant plans as *translokal* migrants.

[170] When I first drove through the transmigrant blocks in early 2013, a research assistant remarked on how much larger and newer the transmigrant houses were than just a few years ago. Though I didn't have the perspective to judge this, she was certain the transmigrants in the Ex-MRP site were doing "very well" by the oil palm companies.

Dayaks from nearby villages are not nearly as involved with the oil palm companies, though some have recently sold their land to companies. Declining and unstable prices for rubber have left the Dayaks out of the latest commodity boom; many are choosing not to tap their rubber trees. Many of the transmigrants had also relied on their rubber gardens for income. Rubber prices have fallen sharply in the past few years, however, from around Rp12.000 per kilo to between Rp3.500 and Rp6.000 (US$.25 to $.50) in late 2014. Though I saw several rubber gardens in Lamunti, many transmigrants said they have far less land planted with rubber trees than they used to, perhaps half a hectare next to their house. Most of the rubber gardens in the transmigrant areas have been converted to oil palm through plasma schemes. Local food prices have increased as a result of expanded oil palm plantings, as fewer Javanese are selling vegetables at the markets in Mantangai, making it more difficult for Dayak families to purchase food at the markets as well.

Because Dayaks rely on fish from the rivers, they are most affected by the fertilizers and pesticides the companies use, which contaminate the rivers and canals. Most Dayak inhabitants of the villages along the rivers rely on meager income from fishing, though fish yields first declined after the MRP canal building and are declining again because oil palm companies use fertilizers and pesticides, contaminating rivers. For the Dayaks, "since the price of rubber fell, they automatically started looking for other work," explained the *kepala desa* of one village along the Kapuas River. The villagers had primarily relied on income from rubber for decades, supplemented by fishing and subsistence agriculture. "Now there is oil palm, gold mining, cutting wood…" he trails off. But not many in his village have gotten involved with oil palm, he says. He is quite critical of the companies, telling me that they have turned up in his village to look for land without his permission (i 51). Oil palm companies are obtaining land in areas inhabited by Dayak communities by working directly with district government leaders. *Bupati* are happy to cooperate with oil palm companies if it means kickbacks and contributions to the government coffers. "As long as the land is suitable, they [the *bupatis*] cooperate with the plantations. But the land isn't sold," explained a former vice *bupati* of Kapuas during an interview (i 71). While the land itself cannot be bought or sold because it legally belongs to the state, land rights can be bought and sold through the exchange of a series of land certificates of varying legitimacy that guarantee user rights.

Though I was unable to interview anyone in the Dayak villages who has actually sold their land rights to an oil palm company[171], both villagers and village leaders are critical of Dayak community members who have opted to sell. Several people mentioned that the villagers were selling their land—a few hectares per family—for absurdly low sums, Rp2 million per hectare (less than US$200), not even enough to cover a family's living expenses for one month. It is astounding that anyone would choose to sell land that has been used by the family for generations for such a small sum of money. But a Dayak friend of mine offered one explanation, having witnessed his relatives being offered money by companies for their land. He explained that the companies will wait to make an offer until families are desperate, when they need to purchase mandatory holiday gifts for relatives or pay school fees. The former vice *bupati* called it a very dangerous trend, the transfer of land rights from Dayak communities to oil palm companies. "If [the land] runs out," he warned me, "the indigenous people could be a stranger in their own country. Just watch, they'll become spectators, foreigners in their own country" (i 71).

[171] After hearing rumors that several families had sold their land in Mantangai to oil palm companies, I tried to find these families for interviews. My research assistant had some tips on where the families lived, but after (supposedly) visiting them and asking if I could interview them, they declined his request. My assistant wouldn't tell me where they lived and no one else in the community seemed to know who they were.

Oil palm corporations in the Ex-MRP site are taking advantage of these socio-ecological landscape changes in order to acquire new land in the area, both directly from Dayak communities and indirectly through transmigrant land holdings. Local awareness of how oil palm companies strategically acquire Dayak and transmigrant land also contrasts with national and/or global narratives justifying land grabs because it is being "wasted." The notion of "wasted land," or "sleeping land" as they call it in Indonesia, has been deployed to justify transfer of ownership or use rights within the global land rush more broadly (Baka 2013). Several recent studies have shown how land can be classified as underutilized and thus rendered suitable for tropical commodity development, despite their incorporation into existing agricultural landscapes (Robbins 2001; Nalepa and Bauer 2012; Eilenberg 2014; McMichael 2014).

Though the Indonesian national government has been working with the World Bank and other NGOs to re-develop land earmarked as "degraded," "empty" (*lahan kosong*) or "sleeping" land (*lahan tidur*) are more commonly used to describe land available for re-development at the local level. Yet 'empty' or 'sleeping' land isn't usually used in reference to forested land that appears uninhabited. It is, rather, land that was once used but is now vacant. For instance, the head of the Dinas Transmigrasi office in Kapuas told me that oil palm companies are seeking out *lahan kosong* in his district. I asked him to explain why the land is empty (in other words, to elaborate on what "empty land" means). "What do you mean," he responded. "It depends on the community, the people. We give them 18 months and they neglect to work on [the land]. The facilities we give them are good, from the province and the district. They get enough seedlings, farm tools. Only their enthusiasm is lacking. If it's empty, certainly it's not being worked on because they are lazy or whatever" (i 73). Yet as I observed, many plots of cleared scrub brush or secondary forest were being utilized for unirrigated rice cultivation, despite appearing barren or empty at certain times of the year.

3. Scientific Consensus, Divergent Expertise, and Environmental Crisis Management

When it comes to the question of Indonesia's peat soil carbon, contention over the land itself is not the only area of difference. While a tenuous scientific consensus has emerged acknowledging the harmful effects of carbon emissions, divergent expertise comes into play when tracing the proximate causes of these emissions. Managing the environmental crisis of massive carbon emissions is a multi-scalar problem linking land-use, scientific research, and multi-level politics. Within a network comprised of international scientists, some affiliated Indonesian scientists, and environmental NGOs, it has become well-founded consensus that Indonesia's peat soil carbon should remain locked underground rather than risk emissions through oil palm development. This understanding emerged out of a historically recent conjuncture of expanding large-scale agriculture, emergent techno-scientific tools, and a political climate in which the Indonesian state sought to avoid responsibility for socioecological disaster at all cost.

A series of extensive forest fires in the 1980s and early 1990s appeared to coincide with El Niño weather patterns, which can induce a prolonged dry season in Indonesia. After each of these fire incidents, smallholder farmers in Sumatra and Kalimantan were especially blamed for using "outdated" swidden techniques, mismanaging fires on their own property, and allowing fire to escape into neighboring forests (Barber and Schweithelm, 2001). But during breaks in smoke plumes in late 1997 and early 1998, academic researchers and local and international NGOs began to analyze the spatial distribution of post-fire burn scars. They used publicly available remote sensing data to determine that many of the fires had actually burned on land held by large companies, most with timber or oil palm concession permits (Barber and Schweithelm, 2001; Harwell, 2000; Page et al, 2002; Tomich et al, 1998), in addition to the government-led MRP scheme in Central Kalimantan.

While many NGOs and at least one government sector—the Ministry of Environment—publicly accused the companies of mismanaging fires used to cheaply clear land before planting, the Ministry of Forestry instructed the media and other state sectors to sidestep or deny those claims. Instead, the government officially blamed the disaster on the droughts wrought by that year's El Niño (Barber and Schweithelm, 2001; Harwell, 2000). The El Niño phenomenon does indeed cause serious drought across Kalimantan and Sumatra (Langner and Seigert, 2009). But this "unnatural" disaster, as Emily Harwell (2000) describes it, couldn't be explained through El Niño conditions alone. The prolonged dry season created the fuel, but the fires still quite literally needed a spark. That spark appeared to come from plantation managers setting fires to clear their land in preparation for planting. Furthermore, in areas where plantation expansion occurred rapidly and without recourse, smallholders were suspected to have started fires as retaliation against land claims made by companies (Dauvergne, 1998; Page et al, 2009; Tomich et al, 1998).

Circulation of this expert knowledge in the years since the mega fires has generated consensus within certain policy networks about how peatlands should be managed. After this study was published, the World Bank and other development agencies began citing Indonesia as the world's third largest carbon emitter, owing to land-based emissions such as these peat fires (Sari et al, 2007). Among the international scientific community and actors who draw on their work, the 1997-98 fires rapidly shifted the ecological scale of the perceived consequences of peat soil fire and oxidation, from local and regional to global. It also solidified the role of large-scale plantation agriculture in enabling these carbon emissions and thus contributing to planetary atmospheric crisis. Through this shift and the peatlands' recapitulation as land suitable for agribusiness investment, experts began to understand tropical peatlands as a hazardous carbon source needing protection and/or rehabilitation. Prior to the late 1990s, biophysical research on Indonesia's tropical peatlands in Kalimantan and Sumatra focused largely on biodiversity, soil composition, hydrological function, and localized impacts of agricultural development (Maltby, 1995; Rieley and Page, 1995). Soil scientists, physical geographers, and ecologists knew that tropical peat soils were composed of a high proportion of carbon (Neuzil, 1991) but prior the 1997-98 fires, there was still considerable debate about whether or not peatlands are net absorbers or emitters of carbon (Rieley and Page, 1995). Yet following these fires, little doubt remained in the international scientific community that Indonesia's peatlands were transformed from a carbon sink to a carbon source under the conditions produced by large-scale cultivation. Draining peat soils, scientists continue to caution, guarantees steady emissions of carbon dioxide via fire and oxidation (Galudra et al, 2010; Sari et al, 2007).

Alongside the well-researched findings of international scientists and their Indonesian affiliates that peatlands contribute significant amounts of carbon dioxide to the atmosphere through oxidation and fire, a subset of scientists working in Indonesia and Malaysia have made alternate claims about the relationship between oil palm, peatlands, and carbon emissions. Though their research circulates along different institutional axes, this divergent knowledge community offers a challenge to the notion of planetary crisis engendered by greenhouse gas emissions from Indonesia's peatlands. Funded in part by oil palm companies and based largely at Indonesian and Malaysian universities, as opposed to overseas universities or international research centers, industry-affiliated scientists are part of an Indonesia's oil palm sector network with close political and economic ties to Singapore and Malaysia (Varkkey, 2012). Some industry-affiliated scientists also work for the Indonesian Ministry of Agriculture while others are funded by the Malaysian Ministry of Science, Technology and Environment; both of these state institutions have been tasked with expanding oil palm production for national economic growth.

To further make peatlands suitable for large-scale mono crop production, the oil palm industry and its associated knowledge communities point out that companies have amassed infrastructure to reduce carbon emissions on plantations, through early-warning hotspot detection and on-plantation local fire brigades, which reduces fire risk. The brigades can both quickly extinguish flames using hoses and trucks to disperse water from the canals and quickly dig ditches to contain flames. Large plantation companies have the capital to protect their agricultural assets and subsequently reduce combustion-related emissions. Yet they also have the capital to continuously dredge and drain their land, thereby creating additional risk for fire crises beyond their plantation boundaries because of the far-reaching hydrological consequences of drainage.

Countering expert claims that tropical peatlands only release greenhouse gasses when they are drained for large-scale agricultural production, industry-affiliated scientists have argued that peatlands' greenhouse gas emissions are naturally high regardless of land use (GAPKI, 2013; Melling et al, 2005). Oil palm development, the logic follows, does not increase emissions from this elevated baseline and even has the potential to lower emissions through proper land management (Sabiham et al, 2012). For example, a recent Indonesian Oil Palm Association report states that "Even without human intervention (e.g. used for agriculture land/plantation) peatlands will produce CO_2 emissions from microorganism decomposition and respiration"

(GAPKI 2013: 29) in reference to an unpublished Indonesian agricultural department study. The report and associated citations do not discount the relationship between peatlands and carbon emissions but instead downplay Indonesia's role in peatland-based emissions. They argue that high rates of agricultural conversion in Russia's boreal peatlands and the proportionally small surface area of tropical peat in comparison to sub-tropical and temperate peatlands is evidence that the majority of peatland-based carbon emissions occur outside of Indonesia. Furthermore, rather than publishing in internationally recognized science journals, such as *Nature* or *Proceedings of the National Academy of Sciences*, as foreign scientists and their Indonesian affiliates working in peatlands often do, Indonesian scientists based at the country's technical universities tend to publish in Indonesian language journals or in business-funded trade publications, limiting the reach of their knowledge claims as well as their international credibility. These publication outlets nevertheless enable industry-aligned scientists to publicly publish their findings and provide officials with citable data to reference so they can strategically support their claims.

This industry-aligned knowledge network is far from a cohesive scientific body. While they do present in some of the same venues and appear at the same working groups as international scientists, their calculated emissions values are generally dismissed by foreign scientists as being incorrect or contradictory. The latter network attests that they use faulty methodologies or erroneous baseline measurements to attempt to prove that peatland emissions are comparatively lower under oil palm cultivation than in intact peat forests. Citing mainly non-peer reviewed scientific research, Indonesia's Oil Palm Association argues they can best manage peatlands' greenhouse emissions, as they would soil acidity or pest infestations. While other scientists have made substantial claims about dry peat soil's ongoing carbon emissions through oxidation, research presented by the Indonesia Peat Association at conferences and in Indonesian language reports offers evidence that carbon emissions can be reduced through techno-fixes, such as planting cover crops. These researchers further claim that management strategies can successfully reduce emissions on plantations to rates lower than those of secondary peat forests (Sabiham et al, 2013), though several prominent papers present evidence to the contrary (Carlson et al, 2012; Hooijer et al, 2010; Koh et al, 2011; Paoli et al, 2011).

While scientific consensus can form “a kind of operational common sense,” as David Bond (2013) shows in relation to managing the effects of the 2008 BP oil spill, science is also complicit in generating ignorance and doubt (Proctor, 2008). If scientific expertise is deployed to determine what land is suitable for investment, divergent expertise can stake a claim in countering consensus about how land should be managed. In the tobacco industry for example, industry-funded research deliberately diverted public and legislative opinion through decoy research findings, which were used to elicit doubt over the validity of scientists’ research linking smoking to disease (Oreskes and Conway, 2010; Proctor, 2008). The value of such research is not, then, in the advancement of scientific knowledge. Much as tobacco industry-funded scientists sought to counter beliefs that smoking causes lung cancer by conducting basic research showing otherwise, the value of such knowledge production is political. The very fact that such research is funded and disseminated at all can generate enough doubt to sway legislative agendas. For Indonesia’s oil palm industry, as I argue here, the objective of oil palm industry-affiliated research is not to advance scientific knowledge of peatlands. It is rather to manipulate policy agendas through which they can continue to expand their land control by maintaining claims of land suitability for expanded investment.

These alternate claims to peat carbon knowledge do not necessarily challenge the validity of the claims made by other experts. But that might not be the purpose of generating alternate scientific research (Proctor, 2008). The ends of such knowledge claims are perhaps more significant than the data itself, if it can justify certain land management practices over others. By creating scientific divergence through alternative expertise, oil palm industry actors can divert attention from land classification practices—such as those that enroll certain lands into conservation regimes—that threaten agricultural expansion. The political obfuscation that occurs through lack of scientific consensus (Whatmore, 2009) also drives more knowledge production within each scientific network, as politicians and planners can postpone or resist alternatives to peatland development on the basis of needing more scientific evidence.

These are, of course, not tactics particular to Indonesia or agrarian development. When scientific knowledge threatens to upend economic growth or political norms, expertise can quickly become contentious. Similar processes of divergent knowledge have played out more broadly in climate change "debates," for example, where climate change skeptics have deployed fossil fuel-funded decoy science to stir up controversy in order to stall regulation of greenhouse gas emissions. As Oreskes and Conway (2010) show, such skeptics manipulate scientific knowledge to push back against experts—who often come bearing bad news about the harmful effects of tobacco, acid rain, pesticides, and so on—and enforce the status quo, allowing unregulated business as usual. By maintaining controversy just as expert consensus was forming and most scientists would consider any debate to be over, Indonesia's oil palm industry-funded scientists are similarly able to slow regulatory change that might threaten corporate land acquisition.

4. Land Suitability and the Uncertain Underground

Despite producing research that most international scientists and their affiliates do not take seriously, there is growing indication that the divergent expertise surrounding peatlands' emissions is swaying legislative agendas in Indonesia in favor of corporate land grabbing. In 2014, a national peatlands protection and management law was passed that mandated rehabilitation of damaged (e.g. drained) peatland and conservation of undeveloped peatland greater than three meters deep. One of the law's articles stipulates that peatland is considered degraded or damaged, and thus in need of rehabilitation, if the water table falls to more than 40 centimeters (1.3 feet) below the surface and/or the mineral soil beneath the peat layer is exposed (Indonesian Government Regulation no.71/2014, article 23). While international groups heralded the law's passing, they drew attention to the fact that—based on existing scientific data—if even 40 centimeters of peat is drained, it will emit carbon emissions through oxidation. Conservation groups claim that this stipulation was not based on "sound" science to begin with, but on existing plantation management strategies that keep water tables at or below 40 centimeters to optimize crop yields (*Mongabay,* 8 January 2015). Pressure from oil palm and pulpwood producer lobbying groups, however, successfully fought to have the law's article changed to state that only peatlands with water tables lower than 100 centimeters be considered for rehabilitation. Even with water tables at 40 centimeters below the surface, they argued, several million hectares of cultivated peatland would flood, killing the oil palm crop (*Jakarta Post*, 31 December 2014). This ruling by the Ministry of Forestry and Environment advances the notion that peatland of any depth can be suitably managed by plantations, a notion which relies on industry-supported counter-science to protect existing peatland-based oil palm plantations so long as the companies monitor their water tables.

Mapping peat depth and volume has therefore taken on a sense of urgency among international scientists, who are anxious to prove that much of the peatland remaining outside oil palm concessions is more than three meters deep and thus can be protected through existing regulation. Such regulation effectively cedes already developed peatland to indefinite corporate management, but uncultivated peatland remains up for grabs. For most peat scientists and internationally-funded research centers, protecting remaining peatland with peat soil depths over three meters from agricultural development is a priority. The means of doing so, they believe, is by demonstrating the land's unsuitability for mono-crop agriculture through depth measurements. Until recently, the Indonesian government's singular objective in peatland mapping was to determine which areas were suitable for agriculture. Peat soil less than two meters deep was considered suitable for agriculture; this has now expanded to three meters in official regulations. Only areas of shallow peat were therefore mapped with any degree of accuracy.

Mapping peat depth and volume has therefore taken on a sense of urgency among international scientists, who are anxious to prove that much of the peatland remaining outside oil palm concessions is more than three meters deep and thus can be protected through existing regulation. The difference between four meters and 15 meters of peat was insignificant to government officials paving the way for agricultural development. Scientists, on the other hand, argue that peat of such depth is capable of producing the most carbon emissions. But while experts consider the surface area of Indonesia's peatlands relatively consistent across existing maps, peat depth is more difficult to calculate than peat area and thus less accurately mapped (Hooijer, 2012). Field workers sampling peat depth must contend with muddy areas, water transportation, and deep, heavy soils that contain large rocks and tree stumps that are difficult, if not impossible, to cut with soil-coring equipment (Page et al, 2011). Some peatland scientists believe that existing maps of Indonesian peatlands underestimate peat depth 25 to 400 percent in many areas of Sumatra and Kalimantan, indicating that the volume of peat—and the quantity of potential carbon emissions—could be twice as large as indicated by previous maps (Hooijer, 2012; Sari, 2013). This underestimation includes a frequently cited 2008 peat map published by the Netherlands-based NGO Wetlands International discussed in chapter 3, which at the time had recorded deeper peat depths than any previous maps (Wahyunto et al, 2008). Scientists point to this unknown underground as justification for further data collection and urge that peat depth mapping methods, like "quick and targeted, surgical, peat thickness field surveys," be used to generate additional peat depth certainty within a year (Hooijer, 2012; Sari, 2013).

Part of international scientists' and their affiliates' peatland mapping agenda is to use soil depth data to demonstrate that most remaining peatland is too deep to be cultivated by oil palm companies without risking massive carbon emissions and thus can be protected by existing government regulation. Yet because of government regulations rendering peatland less than three meters deep available for investment, scientists have been put on the defensive, having to generate more of their own research to show the unsuitability of peatlands for land claims, and prove that existing maps used by the national government are incorrect. Many scientists and policymakers argue that what is at stake in mapping this underground is conservation of existing carbon stores in peatland areas that are still relatively intact.

Yet the data itself may be less significant than the claims it enables among those seeking to prevent agricultural expansion. In this context, peat depth and subsequent carbon stock calculations underscore support for land claims made through environmental conservation projects, particularly those that involve rehabilitating degraded peatlands through hydrological restoration, including re-flooding large swaths of drained peatland (Joosten et al, 2012). Within scientific communities in which the connection between peatland development and carbon emissions is no longer merely expert knowledge but operational common sense (cf. Bond, 2013), these proposed conservation projects offer an alternative strategy for land management to corporate land acquisition.

5. Conclusions

Scientific knowledge can be mobilized to create contestations, not simply settle them (Whatmore, 2009). When the contestations are ultimately over land use and control, scientific consensus legitimates certain management practices and, in the process of doing so, delegitimates others. The ecological stakes of forming scientific consensus around the depths and carbon content of Indonesia's peatlands are high. Within a climate change paradigm in which concern for the planetary atmosphere is paramount in many scientific communities, oil palm development in peatlands has been well-established by the scientific mainstream as a risk, contributing to carbon emissions and global atmospheric change. The land use strategy that logically follows from this research agenda encourages peatland protection and/or rehabilitation, and requires curbing large-scale oil palm expansion.

Yet as I have shown here, industry-affiliated science can also conjure doubt and ambiguity through what I have called "divergent expertise" in support of continued agricultural development. Because mainstream scientific expertise has framed the dangers of peatland development as a problem for planetary carbon emissions, industry-affiliated actors have been able to produce counter-scientific knowledge purporting to show that carbon emissions can be reduced through land management practices. Despite not being taken seriously by most scientific experts, this data is nevertheless successful in persuading a broader political community about the potential suitability of peatlands for mono-crop agriculture. There is a predominant assumption among many scientists that if they generate more knowledge about peatland area and depth, these peatlands will be deemed unsuitable for development, leading to protection and/or rehabilitation rather than allocation for agriculture. The international scientific community, therefore, continues to operate under the assumption that the knowledge they produce will be taken as "truth."

But they don't take seriously the possibility that competing knowledge claims—divergent expertise—may be marshaled to generate scientific ambiguity that can then be used to support oil palm development. The lack of knowledge that matters is thus not a lack of knowledge about peatlands' precise carbon content but an ignorance about how counter-scientific claims may undermine "mainstream" scientific research in order to serve political-economic ends. For agribusiness, whose profitability model relies on seeking new land for expansion, creating uncertainty through the production of counter-science—a kind of deliberately engineered alternative knowledge—remains one strategy to sway legislative and public opinion away from mainstream scientific consensus. Such counter-scientific narratives remain significant for land contestation outcomes so long as they remain in circulation.

While much scientific expertise surrounding global atmospheric change is still produced in the Global North, the ways in which that expertise is deployed, contested, and remade throughout the Global South warrants further empirical and conceptual attention. To be sure, scientific expertise doesn't arrive in the Global South pre-packaged and ready for application, as several scholars have pointed out (Goldman and Turner, 2011; Lahsen, 2009; Mahony, 2014). In newly democratic countries such as Indonesia, a plurality of environmental knowledge producers—in and beyond the academy—have a voice in shaping land policies and practices far more than in decades past, when land use decisions were made autocratically. But there is no guarantee that the emergence of "horizontal knowledge" (Lave, 2015) outside the academy, in industry groups or public forums, will necessarily support broadly laudable environmental objectives, such as carbon emissions reductions from tropical peatlands. While horizontal knowledge points optimistically towards a dismantling of scientific hegemony by intellectual elites alongside the emergence of new knowledge producers, it also provides an opening for economic elites to bolster their land claims. Still, these shifts may indeed be more democratic. In the case of Indonesian peatland management, a wider base of knowledge production allows opportunity for actors to challenge scientific consensus, and use the resultant ambiguity to challenge policy objectives that originate with scientific elites in the Global North.

Chapter 6: Peat Fires and the Southeast Asian Haze Crisis

While the 1997-98 fires highlighted the impact of the MRP drainage on Kalimantan's peatlands, peat fires throughout Indonesia have become a reoccurring, peculiar feature of Southeast Asia's socio-ecological landscape. They occur only if a peat swamp is drained for development, they spread uncontrollably, and can smolder undetected for months. While forest fire smoke was once largely confined to rural areas, noxious smoke from Indonesia's peat fires now frequently reaches Singapore, the Malaysian peninsula, and beyond. As I discuss further in Chapter 7, 2015 is likely to go on record as the worst year for Indonesian peat fires since 1997. Central Kalimantan province, particularly around the Ex-MRP site, has been among the hardest hit areas.

Originating in Sumatra and Kalimantan, the fires' smoke—innocuously called "haze"—is associated with unhealthy particulate matter across the region. The smoke-haze has also sparked international tension over who, and what, is to blame for the pollution and who should be held responsible for managing these fires. Though the Association of Southeast Asian Nations (ASEAN) has called for legislation to mitigate the haze, the origins, causes, and trajectories of Indonesia's peat fires remain murky. Historically, forest fires in Indonesia were blamed on quotidian practices of smallholder farmers such as small-scale land clearing, cooking over open fires, and tossing cigarette butts. Yet, as the peat fires have become more frequent and their consequences farther reaching, these localized causal explanations no longer seem adequate.

Thus far, I have focused on carbon dioxide as the primary, scientific problem-defining consequence of peatland degradation. Here, however, I call attention to the other major consequence, or externality, of peatland degradation: airborne smoke-haze. Though this does not focus specifically on the Ex-MRP site, that area remains a literal hotspot for peat fires. This chapter analyzes the structure of blame for the trans-territorial haze and shows how the political economy of agrarian development in Southeast Asia and the biophysical materiality of peat fires complicate efforts to determine precise causes of the fires. This analysis builds on the discussion in chapter 5 regarding expanding land acquisitions for oil palm development. It also highlights the ambiguity and uncertainty of scientific understanding of peat fires—and the strange nature of the fires themselves—which problematizes the responsibility for the fires.

Within the conceptual framework of knowledge regimes, this chapter also forms another case study that shows the ways in which techno-scientific practices and the politics of blame have been mutually reinforcing in locating the causes of the peat fires. The knowledge regime in this context points to the significance of satellite-based surveillance technology in shaping the political discourse between Indonesia and its neighboring countries. There has been a remarkable lack of questioning of the role these technologies play in determining the cause of the fires. Yet as this chapter shows, they have been consistently been called on to settle claims of responsibility for the fires. The 'regime' in this sense is thus the emergence of this techno-scientific practice (inclusive of the reliance on technology) in defining the terms of the debate over fire causality and responsibility.

1. Spatializing Air Pollution

Geological materials are increasingly recast as problematic in the Anthropocene (E. Johnson et al. 2014).[172] The fine particulate matter comprising Southeast Asian haze is one example, as it is biogeochemically transformed from stable surface material—peat soil and forest

[172] The "Anthropocene" refers to the proposed present geological epoch in which humans are having a visible effect on the Earth's geology, and is the subject of much critical debate.

vegetation—to an unruly, transboundary airborne hazard through co-produced social-biophysical processes (Lave, Barron, and Carey 2014). As this occurs, states, corporations, and individual actors fight to assign blame, while relieving themselves of responsibility, for the fires. From a territorial perspective, fires in rural Indonesia are disproportionately the locational source of haze that periodically blankets parts of Southeast Asia.

Though fire has been a feature of tropical forest landscapes for hundreds of years (Dennis et al. 2005), 'haze crises' have only begun occurring with regular frequency for the past several decades. The largest recorded haze crisis was in 1997 and 1998, when massive peat and forest fires sent plumes of particulates from Sumatra and Kalimantan in Indonesia across Southeast Asia. The fires were estimated to have covered three million square kilometers[173] and affected over 70 million people, leading Brunei Darussalam, Malaysia, and Singapore to declare states of emergency (Frankenberg, McKee, and D. Thomas 2005; Nguitragool 2011).

Since then, there have been at least half a dozen similar episodes of varying intensity, alarming scientists and sickening residents across Southeast Asia. Though scientists assumed the largest haze event occurred during prolonged drought years associated with El Niño events such as that of 1997-98, the 2013 haze occurred in the absence of regional climate anomalies (Gaveau et al. 2014). The arrival of a specific haze crisis is thus difficult to predict. Fire frequency and intensity are almost certain to increase, however, as climate change induces irregular weather patterns, including prolonged drought. Urban and rural inhabitants of Southeast Asia now experience poor air quality as a common unnatural disaster, rather than the uncommon natural disaster it was once assumed to be.

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[173] Estimates of land burned during the 1997-98 fires vary widely, from Indonesian government estimates of 700,000 hectares to researchers' estimates of over 7 million hectares (Frankenberg et al. 2005, Harwell 2002, Barber and Schweithelm 2000).

Air pollution is often cited in social science literature as an externality of industrial processes or other forms of urban-based development at relatively small scales (Bickerstaff and G. Walker 2003; Véron 2006; Whitehead 2009). Scholars are right to point out that the heterogeneous dispersal of air pollutants and their effects unfold unevenly across local populations. Despite privatization and commoditization of environmental resources including land, forests, and water, air and air quality remains almost universally as a public good and as a universal right to access (Véron 2006). As such, analyses of air and air quality can "enroll different sets of power relations" than access to land or water (Véron 2006: 2095). Bryant (1998) similarly called for more attention to air as a means to moving beyond political ecology's "land-centrism" and deftly notes that "unequal power relations are as likely to be 'inscribed' in the air … as they are to be 'embedded' in the land" (1998: 89).

Yet Bryant and others do not explain how unequal power relations unfold differently in the air than they do on land. But a comprehensive analysis of the haze reveals messy urban-rural connections that are more complicated than air pollution produced by urban industry. Southeast Asian haze is similarly defined in relation to urban centers, as it only becomes defined as an environmental crisis once the fires' particulate matter escapes rural areas and infiltrates cities such as Singapore and Kuala Lumpur. Only when the particulate matter crosses international borders does it become a "transboundary haze crisis."

'Haze' specifically refers to airborne particulate matter, which obscures visibility both close to the burn site and wherever the wind-circulating plume carries it. The term is intentionally apolitical, however, indicating a vague dispersal of particulate matter without a clearly defined origin (Varkkey 2013; Tim Forsyth 2014; L. Jones and Hameiri 2015).[174] The Transboundary Haze Pollution Bill passed by Singapore in 2014 defines haze as deteriorating air quality in Singapore over a continuous 24 hour period, and that during those 24 or more hours, satellite imagery and meteorological information show smoke plumes moving in the direction of Singapore. While this definition does not necessarily help pinpoint precise origins of the haze, it sets up the conditions for claims that center blame on activities occurring on Indonesian land. Yet, while entire urban and rural populations are exposed to poor air quality during a haze episode, residents of Singapore, with air filtration systems, are exposed to far less particulate matter than rural inhabitants, especially in less developed parts of Indonesia. So while Southeast-Asian haze "blankets" the region in one sense, its consequences for health are uneven across and within communities, cities, and countries.

Though commonly referred to as "transboundary" air pollution, I suggest that the haze be considered trans-territorial as well. While boundaries suggest the possibility of inclusion or exclusion along geopolitical lines, airborne particulate matter refuses to be kept in or out "up there." Trans-territoriality, meanwhile, draws attention to the fact that Southeast Asian haze originates in the land itself. Unlike a watershed or a forest, it's difficult to define a precise boundary around an airshed, as air and the molecules it contains—both innocuous and noxious—exist at multiple scales simultaneously. In addition to spreading laterally across political boundaries and vertically from surface to stratosphere, a regional haze plume also infiltrates bodies at an alveolar level, as the finest particulates infiltrate human lungs.

[174] The Association of Southeast Asian Nations (ASEAN) adopted the term after the 1997-98 conflagrations to avoid criminalizing Indonesia by implying that the particulate matter originated in fires on Indonesian land (Harwell 2000, Nguitrahool 2011).

These dynamic atmospheric processes (including regional haze and planetary climate change) also challenge notions of territory as a fixed political object or static land form. As Martin Mahony argues towards this end, “climate change as a global risk issue poses distinct challenges to the territorial logic of the modern nation-state” (2014: 120; Jasanoff 2010). Recent work by Luke Bergmann (2013) on the dispersal of carbon emissions shows that while emissions are typically associated with the nation-states in which they are generated, a spatialized analysis can link emissions with their places of associated consumption and capital accumulation. By linking emissions to capital accumulation, he argues, carbon accounting can better account for differences in trade, development, and technological change. This relational accounting shows that much of the world’s carbon emissions—such as those produced by China—are in fact associated with capital accumulation in the United States. Southeast Asian haze similarly provokes new challenges to notions of scale and territory in assessing the origin of environmental problems and thus assigning blame.

Such an analysis may also better articulate how atmospheric processes associated with the Anthropocene are connected to—or implicated in—mundane, everyday practices. Similarly, spatially unpacking haze’s causality locates the fires in a broader scalar framework than attributing them to a single ignition location and source. The haze is neither neatly localized, nor is it a fully global phenomenon, like carbon emissions dispersed throughout the planetary atmosphere. Linking fires to national territory as a means to blame Indonesia for the haze therefore becomes problematic, if territory is not simply land within the boundaries of a nation-state but a means to achieving political and economic goals (Elden 2013). Because fires burn through land that has undergone massive ecological transformation due to international investment, the concept of *trans-territorial* haze better attends to the complex geopolitical relations surrounding the political economy of agricultural development that ultimately enables the haze. It also reveals the ways in which mundane, everyday practices on the land respond to and disrupt that political economy.

Southeast Asian haze can largely be traced to burning forests and peatlands in Sumatra and in Kalimantan, on the Indonesian side of the island of Borneo. As discussed in previous chapters, Kalimantan and eastern Sumatra have some of the country's deepest peat soils, reaching over ten meters in depth. When these soils are drained for large-scale, monocrop agriculture, they become flammable. Between 1997 and 2006, the highest average fire emissions, including particulate matter and gases, were measured in the peatlands of Central Kalimantan and in Riau and Jambi provinces in eastern Sumatra (Frankenberg, McKee, and D. Thomas 2005; Marlier et al. 2012). These provinces also have among the highest concentrations of plantation agriculture production in Indonesia, for oil palm and pulpwood. Peat fires release a cocktail of aerosols, ozone, carbon dioxide, and particulate matter. The latter of these can be regionally dispersed and has the most immediate effect on human health, economic activity, and local ecosystem function.

Over the past two decades, two dominant explanations have assigned blame for the haze. These are reflected in the ways that Southeast Asian states have responded to poor air quality. One discourse, perpetuated by government and media in Singapore, Malaysia, and other Association of Southeast Asian Nation (ASEAN) countries, centers blame on Indonesia, as a nation-state, for activities that occur on its sovereign territory. While the fires themselves do burn on and through Indonesian land, such an explanation ignores Singapore’s role as the transnational Southeast Asian capital in creating the conditions for the fires through extensive plantation agriculture. The other discourse assigns blame to either communities or companies for illegally using fire to clear land. This reflects a simplified understanding of the nature of the fires themselves, and of the broader ecological change across Indonesia's peatlands, where many fires originate. In this chapter, I show that these explanations draw on overly simplistic notions of causality that emphasize linking remotely detected 'hotspots' with their ignition sources, thereby blaming actors already assumed to be responsible for setting specific fires. Such explanations also reveal the limits of remote spatial mapping technology, upon which policymakers, NGOs, and companies increasingly rely to determine fire causality.

Though the direction of blame varies, the actors most likely to be blamed are landless rural inhabitants, careless local elites, farmers acting in retaliation against large companies, or corporations mismanaging their agricultural plantation land. I argue that these causal explanations perpetuated by the media, government officials, NGOs, and local land users do not align with the biophysical materiality of the fires that contribute to the haze, nor with the broader political-economic dynamics that enable the fires. They rely heavily, however, on satellite-based surveillance technologies that many of these actors believe to be a-political or objective in determining causality. While quotidian rural practices are implicated in far-reaching haze "crises" that threaten to become "the new normal" in Southeast Asia, the uncertainty and complexity surrounding the causes of Southeast Asian haze reinforce the challenges of governing multi-scalar socio-ecological problems.

2. Communities of Fire

Haze, as a reoccurring macro-level environmental disaster, has renewed attention to the quotidian practices of rural forest and peatland inhabitants in Indonesia. Intentionally burning vegetation, often associated with shifting cultivation, or swidden, has been a common practice among rural smallholders in Sumatra and Kalimantan for centuries (Aiken 2004; Dennis et al.

2005). Though few smallholders in Sumatra and Kalimantan still cultivate crops within a traditionally nomadic swidden system because of increasing pressure on land for mono-crop production (van Vliet et al. 2012), fire remains a necessary tool. It is inexpensive, effective at removing dense brush, and provides ash fertilizer for acidic and nutrient-poor soils. Additionally, in the absence of clear land tenure and written documentation, many smallholders maintain the practice of burning land to demonstrate ownership as burning indicates the land is in use. Every smallholder I interviewed in the Ex-MRP site who said they still use fire in their fields emphasized their use of controlled burning, a swidden practice they have been practicing for generations.[175] One Dayak farmer explained that he follows customary indigenous practices when he burns on his land, including only setting a fire before the start of the rainy season and always in the later part of the day when temperatures have decreased. He checks for wind direction, digs fire buffers around his field, and readies buckets of water in case flames threaten to spread. Another farmer, when I asked him if there are “big fires” in his area, the type that produces a lot of smoke, told me that there are frequently big fires but they are not particularly dangerous unless they threaten his crops. Smallholders like him, he said, will sleep in their fields (often several kilometers away from their permanent residence) to ensure neighboring fires do not reach his land (i 55, 56).

Blaming smallholders for these swidden-based land clearing practices is an inadequate explanation for the conflagrations, however, given that fires have gotten larger and more frequent only in recent decades. Some scholars have hypothesized that farmers might also set fire to plantation land as retaliation against land grabbing or illegal land occupation by other actors

[175] The smallholders I refer to here are primarily indigenous Dayak, who have traditionally practiced shifting cultivation that includes fire use. Not all smallholders in Sumatra and Kalimantan are Dayak; smallholders from Java or other islands who have settled in Kalimantan use agricultural fire less frequently.

(Harwell 2000, Sizer et al. 2014). One Indonesian fire researcher explained that, additionally, companies sometimes pay local farmers to set fires in concession land so the company can benefit from land clearing but still point fingers at local farmers (i 65). Discourses that center blame on rural communities *writ large* also overlook the heterogeneity across groups of smallholders, migrant workers, and landless peasants. Smallholders with established landholdings, for instance, are quick to blame landless workers who have to travel deeper into the forest to cobble together livelihoods from gold mining, fishing, and logging. Tossing cigarette butts into the forest is an especially commonly cited culprit.[176] "Communities who work [in the forest] aren't careful with fire. They use cookstoves, they throw out cigarettes… because the dry season is long, just tossing a cigarette can start a fire," explained one smallholder with several hectares of his own to farm (i 57). Pointing fingers at these forest inhabitants for fire ignition, and by extension for the regional haze, is problematic, however, in the context of structural economic change that has forced many former smallholders from their homes in search of other income opportunities.

Implicating smallholders for regional air pollution as a result of their 'pyromaniac' agricultural practices also overlooks an important, underlying issue: Indonesian farmers are no longer free to use fire, because forest landscapes in Sumatra and Kalimantan have undergone massive ecological transformation. Large-scale plantation agriculture has contributed to millions of hectares of deforestation and peatland drainage, both of which lay the environmental groundwork for haze. Within a radically transformed forest landscape—in which peatlands are no longer waterlogged and forest canopies are no longer standing—mundane actions such as clearing fields or lighting cookstoves have higher stakes. Yet many of the political mechanisms

[176] Several fire scientists told me that there is no scientific evidence that cigarette butts ignite fires in peatlands. Accidents involving gas cookstoves can, however, ignite fires that spread out of control.

used to prevent fires, such as no-burn agricultural policies in some Indonesian provinces, increase financial burden on smallholders as they are forced to switch to pesticides or chemical fertilizers. It also renders a traditional resource management tool illegal, forcing farmers to choose whether to obey the law or maintain their fields (Kull 2002).

Both transmigrants and Dayaks use fire to produce ash, which is used as fertilizer to raise the soil acidity in shallow peat areas used for cultivation. Javanese and Balinese transmigrants will burn grasses and other collected vegetation to amass enough ash to spread in their fields, while Dayaks have always used controlled burns to raise the pH levels within swidden practice. This traditional practice adheres to several long-established guidelines that prevent fires from spreading beyond the intended area, including clearing borders for fire breaks around the land plot. Traditional Dayak practice also stipulates setting fires against wind direction and only in the late afternoon, when temperatures decrease. Yet because of broader changes in the landscape, following these protocols is no longer enough to keep fires from spreading beyond the intended areas. When the peat forest was intact, overall humidity levels were higher when surrounding forest had a closed canopy, preventing fires from spreading to intact forest. Now that there is little standing forest, it is much easier for fires to spread to surrounding scrub brush or grass land cover.

3. The Peculiarity of Peat Fires

Scientific knowledge of fire and haze, and particularly of peat fires, challenges certain normative discourses that render specific actors culpable for fire ignition. Much of the policy response to the fires and haze has relied on simplistic notions of fire ignition and causality, advancing policies and legal mechanisms that target either large plantation companies with evidence of fire in their land concessions, or ignorant and/or vengeful local farmers. In unpacking blame for haze, my aim is not to absolve the range of actors involved, but to show that the ways in which the haze is being conceptualized do not always reflect the complexity of the biophysical matter or the political-economic dynamics within which the fires are enabled. In this section, I outline the crucial differences between tropical forest and peat fires in relation to particulate drift and describe how peat fire often spreads undetected, making it difficult for both local land users and research scientists equipped with spatial mapping technology to determine the point of ignition. I also show how the technologies predominantly used to detect peat fire do not necessarily clarify connections between the location of Indonesia's rural fires and the haze that settles in urban Singapore and Malaysia, further complicating efforts to assign blame.

Peat soil becomes flammable if peatlands are drained through hydrological manipulation, as is necessary for large-scale agricultural cultivation. Though intact peat forests are typically submerged in water and thus have little risk of catching on fire, if the peatlands' water table is sufficiently lowered the peat soil can smolder unabated, emitting white smoke. These subterranean fires do not produce visible flames and thus can burn largely undetected. Along with carbon dioxide, they release large amounts of particulate matter and aerosols suspended in the white smoke, which is prone to drift far from the fires' origin (figure 43). These smoldering peat fires produce larger amounts of greenhouse gasses and particulate matter than flaming wood fires.[177] From a fire-fighting perspective, a fire is usually considered extinguished if it is no longer producing visible flames. But subterranean flame-less peat fires can only be extinguished by prolonged, deeply penetrating rain that sufficiently raises the subsurface water table. They can also burn without alarming rural inhabitants living nearby, who might not see occasional smoke

[177] Workshop presentation by Kevin Ryan, Palangkaraya, Central Kalimantan, August 2014.

rising from the ground as dangerous, since burning rubbish and cut grasses is also a common practice.

While it has become clear to research scientists[178] that there is a relationship between surface fires and peat fires, much remains unknown about how surface fire can ignite subsurface fire, or vice versa. Surface fires burning long or hot enough have the potential to ignite subterranean peat soil, through which combustion can spread largely undetected through vast areas of dry peatland. The subsurface fire can sometimes re-ignite surface vegetation far from the original surface fire location, though researchers are still unclear how or why this happens.[179] When it does occur, especially during dry seasons in degraded peatlands in Kalimantan and Sumatra, fire origin and causality is particularly perplexing. If a farmer uses fire to clear his land and extinguishes any remaining visible flames, the fire can still spread undetected underground and then "jump" to the surface in another location. If flames from a secondary surface fire are detected by officials looking for a culprit, farmers in the vicinity of the secondary fire risk being targeted and victimized by local law enforcement.

While many NGOs and at least one government sector—the Ministry of Environment—publicly accused the companies of mismanaging fires used to cheaply clear land before planting in 1997, the Ministry of Forestry instructed the media and other state sectors to sidestep or deny those claims. Instead, the government officially blamed the disaster on the droughts wrought by that year's El Niño (Barber and Schweithelm, 2001; Harwell, 2000). The El Niño phenomenon does indeed cause serious drought across Kalimantan and Sumatra (Langner and Siegert 2009).

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[178] Here I refer to both foreign and Indonesian scientists associated with and funded by major research institutions, such as NASA and the Center for International Forestry Research, whose research is seen as credible in international circles. For more on the rhetoric used by industry-aligned Indonesian and Malaysian scientists see Goldstein, 2015.
[179] Workshop presentation by Mark Cochrane, Palangkaraya, Central Kalimantan, August 2014.

But this “unnatural” disaster, as Emily Harwell (2000) describes it, could not be explained through El Niño conditions alone. The prolonged dry season created the fuel, but the fires still quite literally needed a spark. That spark appeared to come from plantation managers setting fires to clear their land in preparation for planting. Furthermore, in areas where plantation expansion occurred rapidly and without recourse, smallholders were suspected to have started fires as retaliation against land claims made by companies (Dauvergne 1997; Tomich et al. 1998; Page et al. 2009).

Despite increasingly precise satellite-derived remote detection of fire hotspots, it remains difficult to connect a haze episode in Singapore or Malaysia to a specific village or an agricultural plantation in Indonesia. Most research on fire occurrence in peat soil is conducted remotely using data from NASA’s MODIS satellites. Hotspots are defined by a temperature differential between one location and its immediate surroundings, indicating the likelihood of fire. Hotspot data is published every two weeks by NASA, allowing researchers to monitor fires in near-realtime and send field workers to confirm fire occurrence by checking for flames or “burn scars,” land or vegetation that appears recently burned. In analyses following the most recent and severe haze episodes, researchers found that a majority of hotspots were concentrated in company planation land on deep peat soil with little forest cover (Ekadinata et al. 2013).

Much of this land had been legally designated for plantation crops, including oil palm and pulpwood, although government-published concession maps in Indonesia are notoriously obscure, out of date, or inaccurate (Murdiyarso et al. 2004), complicating efforts to precisely match fires to land control. Furthermore, the biophysical dynamics of peat fires further complicates hotspot detection as a useful device for determining fire causality. Because peat fires burn under the surface and do not emit hot flames, they often remain invisible to satellite detection that relies on temperature differentiation. Yet, despite its inaccuracies in detecting peat fires, satellite imagery remains the predominant technology for determining causes of haze-generating fires. Legal scholars writing on Singapore's trans-boundary haze pollution bill, passed in 2014, noted, "Since proving what happens abroad is difficult, presumptions are introduced to allow reliance on satellite imagery, meteorological information, and maps" (Tay and Wei 2014).[180]

Not all land-based fires in Indonesia produce smoke-haze that travels north or eastward to Singapore and Malaysia. Fine particulate matter drift is highly dependent on daily, and even hourly, weather patterns and is thus directionally inconsistent. Nigel Sizer and colleagues at the World Resources Institute note that media coverage of land-based fires increases dramatically when winds carry particulates into Singapore, as they did during June 2013 and March 2014, the most acute recent smoke-haze crises. There are considerably fewer media reports calling attention to the smoke-haze when particulate matter drifts westward over Sumatra or north over rural Kalimantan (Sizer et al. 2014). While Singapore is indeed a frequent destination of smoke-haze originating in Indonesia, recent research found that the highest average concentrations of particulate matter are contained in a band stretching across southern Sumatra and southern Borneo, closest to the fires' origin. Singapore and southern peninsular Malaysia are within a zone containing the second-highest average annual levels of particulate and ozone concentrations (Marlier et al. 2012, see also Aiken 2004 on 1997-98 smoke-haze plumes).

Furthermore, according to Marlier et al. (2012), landscape fire occurrence in Southeast Asia correlates strongly with ENSO phases, but there is no indication that the arrival of El Niño *causes* fires directly. In addition to enabling dry conditions, ENSO cycles also create

[180] These quotes were obtained from news articles published online and thus do not have page numbers.

atmospheric inversion conditions that suspend particulate matter over Southeast Asia for longer periods of time, when it would normally be quickly dispersed (Murdiyarso et al. 2004). This indicates that not only does El Niño exacerbate conditions leading to fire but also that inhabitants of Singapore and peninsular Malaysia bodily *experience* poor air quality more than they would during a non-El Niño year, even if fires burn in Indonesia.

While the direct effects of climate change on human health are often difficult to study, research on smoke-haze resulting from land-based fires clearly connects poor air quality in rural and urban areas to the serious detriment of human health (Frankenberg, McKee, and D. Thomas 2005). If the smoke-haze lingers in densely populated areas, such as Southeast Asia's major cities, air particulate matter can quickly exceed levels considered safe for human health by the World Health Organization (WHO). The WHO considers particulate matter in the air below 50 $\mu m/m^3$ to be healthy for human inhalation. During the 1997 fires, air quality monitors detected particulate matter in Singapore up to 450 $\mu m/m^3$ and over 200 $\mu m/m^3$ in southern Thailand. In eastern Sumatra, however, particulate matter levels exceeded 1,800 $\mu m/m^3$, three times what the US Environmental Protection Agency considers as necessary to wear a respirator during outdoor activities (Frankenberg et al. 2005). In Southeast Asia, the WHO's upper limit of air particulate matter considered "safe" was never exceeded in years between 1997 and 2006 without land-based fire emissions. Low concentrations of fine particulate matter are most dangerous for human health and correlate strongly with high rates of respiratory and cardiovascular diseases, and early mortality (Marlier et al. 2012).

Parts of Sumatra and Kalimantan closest to the fires' origin now experience over 100 days annually in which air particulate matter is above levels considered safe for humans (Marlier et al. 2012). In March 2014, enormous fires in Riau province caused over 50,000 people to suffer from respiratory infections (Genie and Mattangkilang 2014). Haze in Indonesia often causes immediate economic losses as flights into regional airports are cancelled and fishermen and farmers are unable to work in poor visibility conditions. The economic effects of smoke-haze further ripple through the Malaysian, Singaporean, and Thai economies as losses in tourism, transportation, and aviation (Murdiyarso et al. 2004). By quantifying smoke-haze's detrimental effects on both human health and economies, national governments seek to recoup losses from those they claim to be responsible for the smoke-haze, thereby advancing blame for the fires as well.

4. Shifting Blame

Remote satellite imagery first played a significant role in shifting blame away from apolitical environmental causes after the 1997-98 conflagrations. Prior to 1997, agriculture-related land clearing and land fires in agricultural areas were rarely linked to trans-boundary haze (Barber and Schweithelm 2000). As fires raged across Sumatra and Kalimantan in 1997 and into 1998, government officials perpetuated the belief that ENSO (the El Niño Southern Oscillation) had caused the fires and thus couldn’t have been prevented (Murdiyarso et al. 2004). President Suharto publicly apologized to neighboring countries in late 1997, but along with Indonesia’s National Disaster Management Agency, reiterated that the fires were a “natural disaster” (Harwell 2000, Nguitrahool 2011). However, naturalizing disaster in this way overlooks the cultural and political contexts out of which “envirotechnical” disasters emerge (Pritchard 2012). Research following the 1997-98 fires revealed that in addition to the prolonged drought, the haze crisis emerged amid shifting land access in which plantation companies were increasingly claiming and cultivating land. Following milder haze episodes in 1991 and 1994, Indonesia acknowledged that drought might cause future fires to spread out of control on agricultural plantations and, as a result, attempted to ban burning by plantation companies. This regulation was hardly enforced, however, and by mid-1998 a majority of burned land appeared to be within plantation concessions (Barber and Schweithelm 2000, Harwell 2000). Remote sensing imagery, overlaid with concession maps, was sufficient visual evidence for some Indonesian officials to determine that many of the 1997-98 fires were, in fact, on plantation land. Providing this information publicly also advanced discourses that companies were to blame for the fires and the haze (Murdiyarso et al. 2004).

Yet the availability of satellite-based monitoring of fire hotspots has encouraged the media, scientific communities, and officials to speculate further on the culprits responsible for haze crises. Despite evidence blaming corporate entities for fires since the late 1990s, individual suspects—including local farmers—have been singled out as culprits following the 2013 and 2014 haze crises, perpetuating the discursive dichotomy that either local communities or large corporations were to blame for the haze. Tim Forsyth (2014), in an analysis of Indonesian, Singaporean, and Malaysian media reports of haze blame, shows that since 1997 there has been an increase in articles that blame each state government for failing to enforce fire prevention and control among domestic companies. While there were no references in *The Jakarta Post* newspaper to corporate plantations vis-á-vis haze in 1997 or 2005, media-based criticism of commercial entities increased sharply after 2005. Government authorities in Singapore were also quick to blame plantation enterprises in 2013 and 2014, relying on visual data from overlaid cadastral maps and analyses of fire hotspots (Gaveau 2014). In response to a 2013 haze episode the Minister of Environment and Water Resources in Singapore declared that "the root cause is commercial. It is not the weather or the environment" (Leong 2014), referring to fires he believed were deliberately set for corporate gain. Additional research seemed to support this, showing that the most recent haze crises in 2013 and 2014 occurred without El Niño weather patterns present (Gaveau et al. 2014).

Indonesian officials have been less forthright in assigning blame to plantation companies following the 2013 and 2014 fires. Some prominent officials, such as the Indonesian Minister of Forestry, publicly announced their uncertainty of whether the fires were caused by companies or communities. Near burning sites in Kalimantan and Sumatra, local and national law enforcement singled out individuals accused of setting fires to clear land (Cochrane 2013). One field monitor working for the World Wildlife Foundation was quoted as saying "the fires here were started by small farmers who are encroaching on the land." In March 2014, the Indonesian Minister of Forestry told the media that "The instructions by the National Police chief and the chief of the military that those found burning forests should be shot on the spot are very strict. If [the suspects] resist arrest, just shoot them." While the Minister went on to point fingers at business owners for fires, he did not clarify whether business owners were actually suspected of starting fires and should also be shot (*The Jakarta Globe* 2014).[181]

According to Global Forest Watch, a project of mapped data published by the World Resources Institute, over one third of fires in Sumatra during the March 2014 fire episode occurred in plantation concessions owned by the two largest pulpwood conglomerates, Asia Pacific Resources International Limited (APRIL) and Asia Pulp and Paper (Sizer et al. 2014). Companies regularly argue that it is not in their financial interest to allow fire to burn on their land, because they have to divert staff to fight the fires. Moreover, they say they risk losing planted land, and thus profits, to fire. Some of the largest pulpwood and oil palm plantation

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[181] The perversity of such a demand was also highlighted in October 2015, when Global Forest Watch data showed that over the course of two months, there were over 100,000 fire hotspots in Sumatra and Kalimantan.

companies have been quick to defend themselves against accusations that they have contributed to haze crises. In one instance, the president of APRIL argued that the fires were "the fault of smallholders using slash and burn methods, and fires in APRIL's concessions were in areas overlapping or disputed with local communities" (Taylor 2014). Because fires on plantation-owned land have destroyed valuable crops, some companies declared themselves victims of the fires rather than perpetrators (Taylor 2014). Companies have also argued that fires wouldn't occur if companies managed land beyond their concessions, thereby justifying further corporate expansion (Azhari 2014).

Indonesia's fires have never remained exclusively a domestic matter because of foreign capital investment in lands where fires occur, however (Nguitrahool 2011). Some of the largest plantation company operators in Indonesia have parent companies based in Singapore, such as Golden Agri-Resources and Wilmar International, and Malaysia, such as Darby Bhd and Cargill (Taylor 2014). By some estimates, Malaysian investments control two-thirds of Indonesia's oil palm sector (Varkkey 2013). These connections have resulted in vague finger-pointing at corporations, including many that have connections to Singaporean and Malaysian capital, but few corporations claiming responsibility for the haze.

Over the past 15 years, Malaysian and Singaporean investment in Indonesia's plantation sector has rapidly increased (McCarthy et al. 2012). While Malaysia once boasted the largest oil palm production in the world, it has since been surpassed by Indonesia. Yet this reflects oil palm produced on Indonesian land, not the nature of the company ownership. Malaysia has offered incentives for domestic companies to invest abroad since the late 1990s. These economic policies reflect a tightening labor market, perceived land scarcity for increased production, and forest protection commitments that have made it difficult for plantation companies to clear land for agriculture in Malaysia (Varkkey 2013). Seeking higher economic returns, Malaysian investors have looked to their southern neighbor for cheap labor, large tracts of available land, and a market-oriented economic policy that welcomed foreign investment following the collapse of the Indonesian economy during the Asian Financial Crisis in 1997 (L. Jones and Hameiri 2015). Malaysian interests in Indonesia's oil palm sector are well protected by lobby groups, including the Association of Palm Oil Plantation Investors of Malaysia in Indonesia (APIMI). In addition to providing bureaucratic help and market knowledge, the group has pushed for special agreements on trans-boundary haze pollution, ensuring that no legal action would be taken against Malaysian-operated plantation companies if fires occurred on their land (Varkkey 2013). These measures have directly contradicted existing Indonesian law that vowed to prosecute companies responsible for plantation-based fire. But more significantly, they present serious obstacles to successful implementation of the most recent Singaporean transboundary pollution law.

Singapore's government has arguably been the most forceful in advancing legislation intended to curb the haze, by making companies operating on Indonesian territory responsible for fires in their concessions. The 2014 Transboundary Haze Law passed by Singapore establishes parameters for determining haze causality and culpability. In targeting corporations operating in Indonesia, the Singaporean law implicitly acknowledges that the Indonesian government has failed to prevent fires on their territory. But in addition to the difficulty of connecting haze to specific fires on certain lands, plantation agriculture companies operating on Indonesian land are entangled with Singaporean and Malaysian capital, making it unclear who the law is really targeting: operators and workers on Indonesian territory, or foreign investors. Though it is still unclear how the law will be enforced and implemented, it nevertheless seems to reinforce existing discourses: blame for the haze is associated with land-based territory, rather than a notion of territory as de-territorialized flows of capital (Elden 2013). It also fails to acknowledge the difficulty in determining the origin of a peat fire. The trans-boundary haze pollution bill also requires evidence that haze pollution “at least partly” came from a specific fire on a company’s land (Leong 2014). In court, meanwhile, the defendant is able to argue that the “haze pollution was caused solely by a grave natural disaster or phenomenon” or was caused by actors not under their control, such as farmers working in nearby areas (Tay and Wei 2014). These stipulations recall the measures the Indonesian government took following the 1997-98 fires to publicly reinforce ideas that the haze was a “natural disaster” and that smallholders are responsible for the largest conflagrations.

Indonesia lacks a strong record of enforcing environmental laws; the most recent Singaporean law intends to punitively fine or arrest suspects outside of Indonesian territory for fires set on Indonesian land that cause haze in Singapore. Indonesia lacks a strong record of enforcing environmental laws (Murdiyarso and Tacconi 2013). It was the last ASEAN country to ratify the Transboundary Haze Pollution Bill enacted in 2002,[182] and many scientists and policymakers in Indonesia and Singapore remain sceptical that the ASEAN bill has been effective in enforcing measures that stop haze (Murdiyarso et al. 2004; Chin 2014). Provincial-level laws against fire use for land clearing in Indonesia, meanwhile, have rarely brought accused companies to court. In 2013, for example, eight companies were accused of unlawfully setting fires in Riau province but only one was ever tried. Meanwhile, the police continue to arrest local farmers suspected of setting fires. In Riau in 2013, 44 people were arrested; only one was an active employee of a company, while the rest were locals without company affiliation (*The*

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[182] Indonesia ratified the 2002 bill in September 2014.

Jakarta Globe, 18 March 2014). Though the most recent Singaporean law intends to punitively fine or arrest suspects outside of Indonesian territory, it remains unclear whether or how the law will be enforced on Indonesian land. Furthermore, the measure does little to encourage Indonesian officials to bring corporate suspects to trial, or to support fire prevention measures on the ground. As such, while the Singaporean law is a show of government action amid public criticism that ASEAN has done little to stop the haze crises, it circumvents many of the issues at stake in this trans-territorial environmental disaster.

The June 2013 and March 2014 episodes highlighted the ways that emerging scientific knowledge adds complexity to existing discourses about who is to blame for the fires. Every new haze crisis brings new data that adds uncertainty about responsibility for haze. The June 2013 and March 2014 episodes highlighted the ways that emerging scientific knowledge adds complexity to existing discourses about who is to blame for the fires. Recent research looking at the directions of burned areas put forth an alternative claim: that mid-level entrepreneurs, neither local smallholders nor the largest companies, were responsible for the fires. Because many of the largest companies have reached limits on how much land they are allowed to hold under Indonesian law, they have sub-contracted agricultural production to laborers (often migrants) willing to work on behalf of the company. Because this land is not officially within the bounds of plantation companies, it allows companies to evade responsibility for practices outside their concessions (Ekadinata et al. 2013). A more thorough analysis of the March 2014 fires showed that many of the fires started outside plantation concession areas, on land claimed by smallholders or contract workers. But fire culpability can't be determined through concession maps and hotspot data alone, despite the fact that it is the predominant method used to present evidence of fires (Gaveau et al. 2014). Land indicated on concession maps as leased by a specific company is not necessarily controlled by that company, a point that companies themselves use to evade responsibility for land practices.

5. Conclusions

During and after each haze episode, the discourses analyzed here are reinforced by the media, government officials, and communities of experts. It is no doubt easier to cite oft-repeated lines blaming companies, or scapegoating local farmers, for the fires that seem to connect linearly to haze affecting urban residents. Yet by reinforcing these discourses through public declarations and reinforcing them through policy measures, such as the recent Singaporean law, the fires and related haze crises risk becoming a normalized, inevitable disaster. As I have suggested here, illuminating the biophysical materiality of the fires can disrupt this understanding, raising the possibility that new configurations of actors—and the complex relations between them—are to blame for the haze. Christian Kull (2002) argues that there is political opportunity in the ambiguity over whether fire is a tool of resistance or a tool of resource management. The peat fires that contribute to regional air pollution only add to the biophysical ambiguity; actors can exploit this ambiguity for their own ends. The ways in which they are able to do that, of course, lie not in the spectacular but in the quotidian.

The Southeast Asian haze crisis, and its proximate biophysical cause, the peat fires, exemplify the far-reaching consequences of peatland degradation. Earth smolders, entangled with *homo Capitali,* and flares up to wreck havoc on economies, livelihoods, and human health. The near-annual haze episodes are characterized by widespread uncertainty about their origins and causes; yet they are becoming a normalized series of unnatural disasters. Subterranean combustion generates trans-territorial plumes of particulate matter that cross boundaries and penetrate bodies, traversing scales from hectares to nations to alveoli. Along with the plumes, risk, injury, and responsibility remain dispersed, shrouded in hazy uncertainty. Regardless of the accusers or the target of blame, few question the assumption that it is, in principle, possible to assign simple responsibility for this complex, trans-territorial crisis. Likewise, few question the assumption that it is, in principle, possible to police the problem through technological means.

Yet the account presented in this chapter questions both of these assumptions: it might *not* be possible to identify a single, unambiguous cause or perpetrator, especially through the omniscient view of satellites. Since 1997's fires, a knowledge regime has emerged through the political reliance on techno-scientific means to surveil and police those believed to be responsible for the fires. Using such technologies to determine blame and responsibility appears to, on the surface, cast both national and local-level politics aside. But this is where the framework of a knowledge regime is particularly useful: it reveals the ways in which techno-scientific practices and beliefs are couched in existing political relations in addition to shaping the political climate in which the structure of blame and responsibility emerges.

Chapter 7: Conclusions

Indonesia's 2015 peat fires are shaping up to be comparable to those in 1997-98, and might end up as the worst on record. Comparisons to Europe's total annual emissions are once again making headlines; the World Resources Institute published data showing that on most days in October 2015, Indonesia's daily carbon emissions from peat fires have exceeded average daily emissions from the entire United States economy. As in 1997, the worst-hit provinces are those in southern and western Kalimantan and in southeastern Sumatra. In particular, the Ex-MRP site appears shrouded in thick smoke in NASA photographs. While Singapore's media and government reported the city's daily pollution standard index (PSI) readings as up to 300 on many days, accompanying warnings to stay indoors and limit physical activity. Yet for all of the alarmist news headlines Singapore's air pollution generated over these months, the air quality in Central Kalimantan and other parts of Indonesia was far worse. By some accounts, Palangkaraya and the area around the Ex-MRP site had the worst air quality on the planet on certain days, with the PSI reaching 1900 (over 100 is considered detrimental to human health by the World Health Organization). Schools were closed for several weeks at a time, families with small children were evacuated to naval ships outside of the affected areas, and farmers started reporting crop losses as a result of both prolonged drought and lack of sunlight due to haze.

As they did in 1997, 2013, and 2014, this year's fires once again drew attention to the land use practices of large-scale agricultural plantation developers, migrant workers, and smallholder farmers, as the media, NGOs, and government officials alternated between naming them each as culprits responsible for igniting the out-of-control conflagrations. The underlying causal factors remain the same as they did following the demise of the Mega Rice Project in 1998: peatlands drained and deforested become exceedingly flammable during drought brought on by El Niño.

But while this year's fires have revealed peatland degradation across even larger parts of Indonesia, the history of the Mega Rice Project as discussed in chapter 2 remains illuminating.

In some respects, history appears to be repeating itself. In 2014, Indonesia elected Joko Widodo, a political outsider, for President, who ran on a populist platform and promised governance free from corruption and patronage that has plagued Indonesia for decades. Yet ironically, one of the first promises he made after elected to office was to return the country to food self-sufficiency by opening up new land in Papua for rice production (see figure 44). While this particular promise has yet to be fulfilled through action on the ground, these "mega" agricultural estates remain a favorite prerogative of politicians hoping to appeal to the electorate's most basic need: more rice. Meanwhile, areas such as the Ex-MRP site continue to rapidly lose their own capacity to produce rice for local consumption. Dayaks and transmigrants have been able to grow rice on shallow, burned peatland in the past, but this land increasingly marked as degraded and then slated for re-development through smallholder oil palm and plasma contract farming. Furthermore, as the history of the MRP showed, these mega projects are designed with more objectives than simply producing more rice. In the case of the MRP, the authoritarian government's interest in developing the area was driven by political desire to meet the country's rice consumption needs. Yet the project satisfied other political and economic goals for the Suharto-led government, including feeding the country's newly constructed sawmills and providing well-financed contracts to Suharto's cronies. The project also served as a last attempt to bolster Suharto's image as the "father of development" in what turned out to be the waning days of his presidency.

A history of peatland development in this particular site also reveals contentious connections between scientific knowledge and the Indonesian state. Though some Indonesian scientists who had been working locally to the site that would become the Mega Rice Project quietly objected to plans for the project, the government silenced critics who dared use scientific knowledge to object to the government's plans. Retroactively, scientists in and beyond Indonesia see draining and deforesting the peatlands over such a vast area of deep peat soil as the height of arrogance and stupidity on the part of the Suharto regime. But the Suharto regime's ignorance might not have been predicated on a lack of available knowledge as much as an active suppression of scientific knowledge of the impacts of such large-scale development. Ignorance in this case was productive. The political regime was thus able to select experts and expertise that supported already-formed plans, rather than rely on experts to contribute to the land development process.

While the MRP site indeed has a unique history, as shown in chapter 2, the scope of socio-environmental problems that arose in this area following the project's demise have broader consequences and relevance. As chapter 3 discussed, the scientific knowledge that was produced in and from this site was unencumbered by a post-Suharto political climate, which in turn stimulated further—and farther-reaching—knowledge within international scientific communities. The emergence of a carbon-centric knowledge regime in the wake of the 1997-98 fires has proven durable, both in its discursive and material effects on peatlands. In Indonesia, published data on the relationship between degraded peat and climate change advanced this knowledge regime and began to re-organize conservation and rehabilitation activities on the ground. The attempt, and ultimate failure, to tie mega fauna-driven forest conservation (orangutan habitat) to carbon emissions mitigation mechanisms is instructive here, as is the rise and fall of the REDD+ project, which had more explicit carbon emissions-reducing aims.

Yet while this year's images of charred peatlands across Central Kalimantan might appear as the history of the Mega Rice Project repeating itself, some things have changed since 1997-98. The composition of the Indonesian state has changed dramatically, with spending and decision making power largely devolved to the district level. Contestations surrounding scientific knowledge and the inability of the national government to 'make good' on many of their land use promises (a moratorium on peatland development being one) have been hindered by this decentralization process in many ways. Though local-scale decision making—as decentralization seemingly enables—has been favored by many scholars as the best opportunity for indigenous people and peasants to be included in natural resource management. In the case of large-scale ecosystem rehabilitation, however, activities at the local scale have not been effective in undoing the damage of centralized state-led development.

While forest conservation might be possible at local scales, through REDD+ or more traditional pathways, forest rehabilitation is proving to be more complex. Repairing the hydrological systems in a landscape as large as the Ex-MRP site might *not* be possible through small-scale efforts, such as small dam building. Furthermore, dam building and canal blocking will not advance forest re-growth so long as livelihood options in the Dayak villages are so few that many inhabitants practice illegal logging, thereby dismantling the dams. And while the KFCP project hoped to shift the economic conditions at the local scale in favor of rehabilitation activities that could be funded through international climate financing, the project was eventually ended by politics operating at the national level in Australia. Much scientific debate over how to intervene—or not—in such degraded landscapes stems in large part from these questions over whether human-led interventions are even necessary to restore some semblance of forest to these places, as chapter 4 discusses.

Political decentralization, and the formation of various knowledge regimes, has also enabled a broader array of actors to have a stake in determining land use outcomes in this particular site. In the Ex-MRP site, chapter 5 shows that decentralization is likely enabling more companies to lease land in smaller parcels with approval from district heads. These land transfers often fly under the radar of national-level regulations or stipulations against agrarian development on peatland. Regardless, oil palm—or mono-crop, corporate-led agrarian development in the tropics more generally—is clearly playing a significant role in the management of biophysical risk and climate disaster through land use practices. While government officials and the media are quick to blame oil palm companies for starting the peat fires that rage out of control in dry years like 2015, the story is indeed more complicated. Some of the largest conglomerates overseeing oil palm production (and to a lesser extent on peatlands, pulpwood), such as Wilmar, Nestle, and Asia Pulp and Paper, have publicly announced "zero deforestation" policies, renounced cultivation of peatlands, and even pledged to restore degraded peatlands in some of their concession areas. Whether one believes this is a hopeful sign of environmental responsibility or mere corporate greenwashing, the economic structure of commercial agrarian production in Indonesia has fractured in recent years. Alongside political decentralization, smaller companies and intermediaries acting opaquely on behalf of larger firms might be driving much of the increased development on peatland. *Plasma* schemes have also proliferated, which further fractures responsibility for preventing fire: within such a plantation structure, responsibility for land management is even less clear than in traditional plantation structures (employing contract labor exclusively) or through smallholder production.

Since the MRP, science has had an ambivalent, evolving role in shaping land use strategies and land management in degraded peatlands. Scientific knowledge can be generated by a surprising range of actors with varying objectives. Traditionally trained experts, lay people, industry-funded researchers: all of these groups have produced scientific knowledge regarding the relationship between degraded peatlands and carbon emissions. The practices, tools, and actors that contribute to such knowledge production both contribute and respond to shifting political climates. Sheila Jasanoff (2004) argues that the co-production of science and politics occurs along four pathways: making identities, institutions, discourses, and representations. In this dissertation, I have focused on the emergence of the co-production of science and politics along institutional and discursive lines in particular. As Jasanoff continues, "When environmental knowledge changes, for example, new institutions emerge to provide the web of social and normative understandings within which new characterizations of nature — whether climate change, endangered elephants or agricultural science—can be recognized and given political effect" (Jasanoff 2004: 40). In the case of Indonesia's degraded peatlands, new institutions have indeed arisen in response to epistemic shifts in scientific knowledge surrounding carbon emissions and as chapter 6 shows, the role of techno-science in shaping political discourse around fire causality. Most significantly, the political role of scientific knowledge in this case illuminates the range of actors with a stake in remaking degraded land.

Appendix A: Methodology

The scope of the Mega Rice Project, both temporally and spatially, made semi-structured, in-depth interviews the best method for obtaining as broad a history of the project and current developments in the area as possible. As such, I sought to interview individuals that were representative of most of the groups of actors involved with or affected by the project, and those currently living in the area, including local government officials (village and district level), Dayak inhabitants of the site, transmigrants, foreign and Indonesian NGO workers, and foreign and Indonesian scientists. Though I obtained contacts for three government officials who worked for national level ministries at the time of the project, all turned down my requests for interviews.

It probably goes without saying that all fieldwork-based research encounters practical challenges that end up shaping the theoretical and empirical work. I had more than a few such obstacles, only a few of which are worth mentioning here for the sake of explaining the limitations of the project. The biggest challenge was obtaining archival data on the Mega Rice Project itself. Early on, several informants assured me I would never find plans, papers, or other written information on the MRP because the government would have destroyed everything when Suharto stepped down. Some Indonesian researchers said they have also looked for detailed information about the project for years but have found nothing. I visited several district government offices in Kuala Kapuas, believing that the local Ministries of Forestry, Agriculture, or Transmigration would have kept documentation on the project. People at each office all said that they have no written records from the 1990s, because they don't keep documentation from the "old" government. They also emphasized that the project "came from the center," This is, undoubtedly, a historian's nightmare, but reflective of the lack of reliance on written documentation across Indonesia more generally.[183]

Given the relative lack of archival material on the MRP, I rely heavily on interviews with people who were directly or indirectly involved with the project and/or who were living in the area during the late 1990s to inform chapters 2, 3, and 4. Fortunately, the Mega Rice Project was long enough ago that no one hesitated to discuss it for fear of it being too sensitive of an issue but recent enough that it is still clear in peoples' memories. *The Jakarta Post* and *Kompas*, two of the most respected newspapers in Indonesia, were publishing a surprising amount of detail, as well as some criticism, of the MRP between 1995 and late 1998. Both publications were considered relatively independent during the New Order, though there is an obvious lack of criticism of President Suharto directly. I was thus able to use newspaper articles to fill in details of the project construction in chapter 2. Finally, WALHI's national office in Jakarta provided me with access to their library and archives, where I was able to obtain newspaper clippings pertaining to the project as well as letters WALHI had written in protest of the project.

During trips to Indonesia in 2011, 2013, and 2014 I conducted 99 interviews that were recorded and transcribed, plus others that were more informal and not recorded. Nearly all of the interviews were conducted in Jakarta and Central Kalimantan, though a handful were conducted in Bali. Preliminary research in Jakarta/Bogor through the Center for International Forestry Research (CIROR) and the World Agroforestry Center (ICRAF) in 2011 led to additional contacts with consultants, investors, and researchers familiar with REDD+ projects and other carbon market mechanisms for conservation in Indonesia. These interviews inform part of chapter 4. I also first learned about the Mega Rice Project through these early contacts, because

[183] BAPPEDA, the district planning office in Kuala Kapuas, was able to provide me with some maps and transmigration statistics from the project area because of ongoing spatial planning efforts in the EMPR site.

of CIFOR's involvement with the EMRP site through the KFCP project. When I returned to Indonesia in early 2013 with the intent to conduct dissertation research on the history of the MRP and the recent trajectories of socio-ecological land use change in the site, several contacts in Jakarta gave me substantial background information on the project. An invitation to the Indonesia Climate Change Center's second annual peatland conference in Bandung in February 2013 turned out to be a crucial point of introduction to the scientific debates over peat emissions that laid the ground work for parts of chapters three, four, and five. It also put me in contact with many of the scientists whose work I have cited and discussed throughout the dissertation.

In the MRP area, I made Mantangai the center of my village-level research for several practical reasons. Mantangai is actually three villages abutting one another—Mantangai Hilir, Mantangai Hulu, and Mantangai Tengah. Though they appear to be one village connected along a main compacted dirt road running parallel to the Kapuas River, each has its own *kepala desa* (village head). Together they have a population of roughly 5,000, nearly all of which are Nguju Dayak. Taken together, Mantangai is the largest in a string of about 10 villages along the Kapuas River, which bisects the MRP site. It is also situated next to the most elaborate series of primary and secondary canals, making it easy to access the canals by small boat from the village. From Mantangai I was also able to spend several nights/days at two field camps run by the Borneo Orangutan Society (BOS), both of which are located in Block E, which is largely intact peat forest. Though there are no villages in this area per se, inhabitants of the river villages often spend several days or weeks at a time in work huts throughout this forest for fishing and logging. While based at these camps, I was able travel throughout the small rivers in my assistant's motorized canoe to interview people doing these activities—both legally and illegally—which otherwise would have been too far from the river villages for a day trip.

Mantangai was also the *de facto* field center of the Kalimantan Forest Climate Partnership (KFCP) REDD+ project. Though the main project office was located in Kuala Kapuas, the district capital, project managers maintained a small office in Mantangai, which they used for field site visits and coordination for field teams. Though the project had ended when I arrived in Mantangai for fieldwork, village inhabitants were somewhat used to foreigners staying in their village and also had a lot of familiarity with the KFCP project. My research assistant in Mantangai, who had done fieldwork for the KFCP project, was a crucial liaison. Though I have no way of knowing precisely how he (a married, 23 year old Dayak man) was perceived by others in the villages, friends of mine that put me in touch with him assured me he was right for the job. I started by interviewing some of his older family members, who were living in Mantangai during the project (his grandfather was a former village head). Several of them suggested other people for me to interview regarding the history of the project and the area (snowball sampling). His familiarity with the surrounding canals and rivers made it possible to travel for us to interview people working in the forest and along the canals. He knew many of the people we encountered, which made interviews both with loggers (always men, usually working illegally) and fishermen/women (all Dayak, both men and women). To interview transmigrants, we travelled by motorbike to Lamunti, about a 90 minute drive from Mantangai.[184]

[184] Though my assistant had no prior contacts in the transmigrant areas, we asked people we encountered for directions to the village heads' houses, introduced ourselves there, and asked these men for permission and recommendations to interview families in their "blocks," as the transmigrant areas are divided.

Appendix B: Plant Species Names

Local (Indonesian) name	Latin name (Family)
Gemur	*Alseodaphne coriacea* (Lauraceae)
Rottan (rattan)	*Calamus sp.* (Palmae)
Terentang	*Campnosperma coriaseum* (Anacardiaceae)
Tumi	*Combretocarpus rotundatus* (Anisophylleaceae)
Jelutong	*Dyera costulata* (Apocynaceae)
Jambu jambu (guava)	*Eugenia havilandii* (Myrtaceae)
Ramin	*Gonystylus bancanus* (Thymelaeaceae)
Pisang pisang (banana)	*Mezzetia leptopoda* (Annonaceae)
Meranti	*Shorea platycarpa* (Dipterocarpaceae)
Sedge	*Thorachostachyum bancanum*

Appendix C: Table of Formal Interviews

Year	ID	Location	Language	Category
2011	1	Bogor, Java	English	Scientist
2011	2	Bogor, Java	English	Scientist
2011	3	Denpasar, Bali	English	Consultant-private
2011	4	Denpasar, Bali	English	Consultant-private
2011	5	Denpasar, Bali	English	Consultant-private
2011	6	Denpasar, Bali	English	Consultant-NGO
2011	7	Denpasar, Bali	English	Consultant-NGO
2011	8	Bogor, Java	English	Consultant-NGO
2011	9	Bogor, Java	English	Scientist
2011	10	Bogor, Java	English	Scientist
2011	11	Bogor, Java	English	Scientist
2011	12	Bogor, Java	English	Scientist
2011	13	Bogor, Java	English	Scientist
2011	14	Bogor, Java	English	Consultant-private
2011	15	Jakarta, Java	English	Consultant-NGO
2011	16	Jakarta, Java	English	Consultant-NGO
2013	17	Bogor, Java	English	Scientist
2013	18	Jakarta, Java	English	Consultant-NGO
2013	19	Jakarta, Java	English	Consultant-NGO
2013	20	Jakarta, Java	English	Consultant-NGO
2013	21	Jakarta, Java	English	Consultant-private
2013	22	Bandung, Java	English	Consultant-NGO
2013	23	Bandung, Java	English	Scientist
2013	24	Bandung, Java	English	Scientist
2013	25	Bandung, Java	English	Consultant-private
2013	26	Bandung, Java	English	Scientist
2013	27	Palangkaraya, Central Kalimantan	English	Consultant-NGO
2013	28	Palangkaraya, Central Kalimantan	English	Consultant-private
2013	29	Bogor, Java	English	Scientist
2013	30	Bogor, Java	English	Scientist
2014	31	Jakarta, Java	English	Consultant-private
2014	32	Jakarta, Java	English	Consultant-private
2014	33	Jakarta, Java	English	Scientist
2014	34	Jakarta, Java	English	Scientist
2014	35	Jakarta, Java	English	Consultant-NGO
2014	36	Jakarta, Java	English	Scientist
2014	37	Jakarta, Java	English	Consultant-NGO
2014	38	Jakarta, Java	English	Consultant-NGO

2014	39	Jakarta, Java	English	Scientist
2014	40	Ex-MRP, Central Kalimantan	Indonesian	Dayak/villager
2014	41	Ex-MRP, Central Kalimantan	Indonesian	Dayak/villager
2014	42	Ex-MRP, Central Kalimantan	Indonesian	Dayak/villager
2014	43	Ex-MRP, Central Kalimantan	Indonesian	Dayak/villager
2014	44	Ex-MRP, Central Kalimantan	Indonesian	Dayak/villager
2014	45	Ex-MRP, Central Kalimantan	Indonesian	Dayak/villager
2014	46	Ex-MRP, Central Kalimantan	Indonesian	Dayak/villager
2014	47	Ex-MRP, Central Kalimantan	Indonesian	Dayak/villager
2014	48	Ex-MRP, Central Kalimantan	Indonesian	Local Government (Kapuas)
2014	49	Ex-MRP, Central Kalimantan	Indonesian	Dayak/villager
2014	50	Ex-MRP, Central Kalimantan	Indonesian	Dayak/Govt
2014	51	Ex-MRP, Central Kalimantan	Indonesian	Dayak/Govt
2014	52	Ex-MRP, Central Kalimantan	Indonesian	Transmigrant
2014	53	Palangkaraya, Central Kalimantan	Indonesian	Consultant-NGO
2014	54	Palangkaraya, Central Kalimantan	Indonesian	Consultant-NGO
2014	55	Palangkaraya, Central Kalimantan	Indonesian	Dayak/villager
2014	56	Palangkaraya, Central Kalimantan	Indonesian	Dayak/villager
2014	57	Palangkaraya, Central Kalimantan	Indonesian	Dayak/villager
2014	58	Palangkaraya, Central Kalimantan	English	European/villager
2014	59	Kuala Kapuas, Central Kalimantan	Indonesian	Government official
2014	60	Kuala Kapuas, Central Kalimantan	Indonesian	Government official
2014	61	Palangkaraya, Central Kalimantan	Indonesian	Scientist

2014	62	Ubud, Bali	Indonesian	Transmigrant
2014	63	Jakarta	Indonesian	Consultant-NGO
2014	64	Bogor	English	Scientist
2014	65	Bogor	English	Scientist
2014	66	Bogor	Indonesian	Scientist
2014	67	Jakarta	English	Consultant-private
2014	68	Palangkaraya	Indonesian	Scientist
2014	69	Palangkaraya	Indonesian	Scientist
2014	70	Palangkaraya	English	Consultant-private
2014	71	Kuala Kapuas	Indonesian	Government official
2014	72	Kuala Kapuas	Indonesian	Government official
2014	73	Kuala Kapuas	Indonesian	Government official
2014	74	Kuala Kapuas	Indonesian	Government official
2014	75	Kuala Kapuas	Indonesian	Government official
2014	76	Ex-MRP	Indonesian	Dayak/villager
2014	77	Ex-MRP	Indonesian	Transmigrants
2014	78	Ex-MRP	Indonesian	Dayak/villager
2014	79	Ex-MRP	Indonesian	Transmigrant/Govt
2014	80	Ex-MRP	Indonesian	Transmigrant
2014	81	Ex-MRP	Indonesian	Transmigrant
2014	82	Ex-MRP	Indonesian	Transmigrant
2014	83	Ex-MRP	Indonesian	Dayak/Govt
2014	84	Ex-MRP	Indonesian	Transmigrant
2014	85	Ex-MRP	Indonesian	Transmigrant
2014	86	Ex-MRP	Indonesian	Transmigrant
2014	87	Ex-MRP	Indonesian	Transmigrant/Govt
2014	88	Ex-MRP	Indonesian	Transmigrant
2014	89	Ex-MRP	Indonesian	Transmigrant
2014	90	Ex-MRP	Indonesian	Transmigrant/Govt
2014	91	Ex-MRP	Indonesian	Transmigrant
2014	92	Ex-MRP	Indonesian	Transmigrant
2014	93	Ex-MRP	Indonesian	Transmigrant
2014	94	Ex-MRP	Indonesian	Transmigrant
2014	95	Ex-MRP	Indonesian	Dayak/Govt
2014	96	Ex-MRP	Indonesian	Dayak/Govt
2014	97	Palangkaraya	Indonesian	Consultant-private
2014	98	Palangkaraya	English	NGO

Appendix D: List of Newspaper Articles

6 January 1977. “Transmigran Kuala Kapuas Panen Cengkeh.” *Kompas.*

14 September 1984. “Potensi Tanah Gambut akan Dimanfaatkan.” *Kompas*.

19 February 1985. “Pertanian di Lahan Gambut Perlu Didahului Penelitian.” *Kompas*

29 June 1987. “Wapres Tinjau Proyek Pembangunan di Kalteng.” *Kompas.*

21 August 1995. “Diversify diet to regain rice self-sufficiency.” *The Jakarta Post*, Archipelago, p10

1 December 1995. “Soeharto says RI can maintain rice self-sufficiency.” *Jakarta Post,* p1

5 December 1995. “New joint venture for oil palm plantation.” *Jakarta Post*, Archipelago, p8

5 January 1996. “Soeharto unveils 1996-1997 draft state budget.” *The Jakarta Post*, Business, p5

26 January 1996. “Subcontractors asked to join rice project.” *Jakarta Post*, Business, p8

30 January 1996. “Irian Jaya forests to help overcome timber shortage.” *Jakarta Post*, Business, p8

4 April 1996. “Estate project teaches farmers to adapt to new methods.” *Jakarta Post*, Business, p5

9 July 1996. “Rethink peat-area project, Walhi says.” *Jakarta Post*, National news, p2

2 October 1996. “Peat land project faces housing crisis.” *Jakarta Post*, National news, p2

5 October 1996. “Peat land project facing irrigation problems.” *Jakarta Post*, National news, p2

10 October 1996. “Rain prevents Soeharto inaugurating Ciamis plant.” *Jakarta Post*, Business, p1

8 January 1997. “Timber supply shortage may threaten forests, says NGO.” *Jakarta Post*, Business, p10

2 March 1997. “Effects of transmigration policy questioned.” *Jakarta Post*. Features, p3

24 April 1997. “Soeharto denounces critics on Kalimantan peat project.” *Jakarta Post*, National news, p1

2 July 1997. “Maintaining rice self-sufficiency vital: Minister.” *Jakarta Post*. Business, p12

8 July 1997. “Drought hits rice farmers in two provinces.” *Jakarta Post.* National news, p2.

26 September 1997. “Moments before Indonesian crash, pilot blinded by haze.” CNN World News. http://www.cnn.com/WORLD/9709/26/indonesia.crash.pm/index.html?eref=sitesearch, retrieved 22 October 2015

21 November 1997. “Forest fires may be over but other threats to come: Minister.” *Jakarta Post*. National news, p2

27 January 1998. “Government warns of possible return of forest fires.” *Jakarta Post*. National news, p2

18 March 1998. “Indonesian fires could cost US$6 billion, experts say.” *Jakarta Post*. Business, p1

20 December 1999. “Former minister to be named suspect in peat land saga.” *Jakarta Post*. National news, p2

Appendix E: Figures

Photos by author unless otherwise indicated.

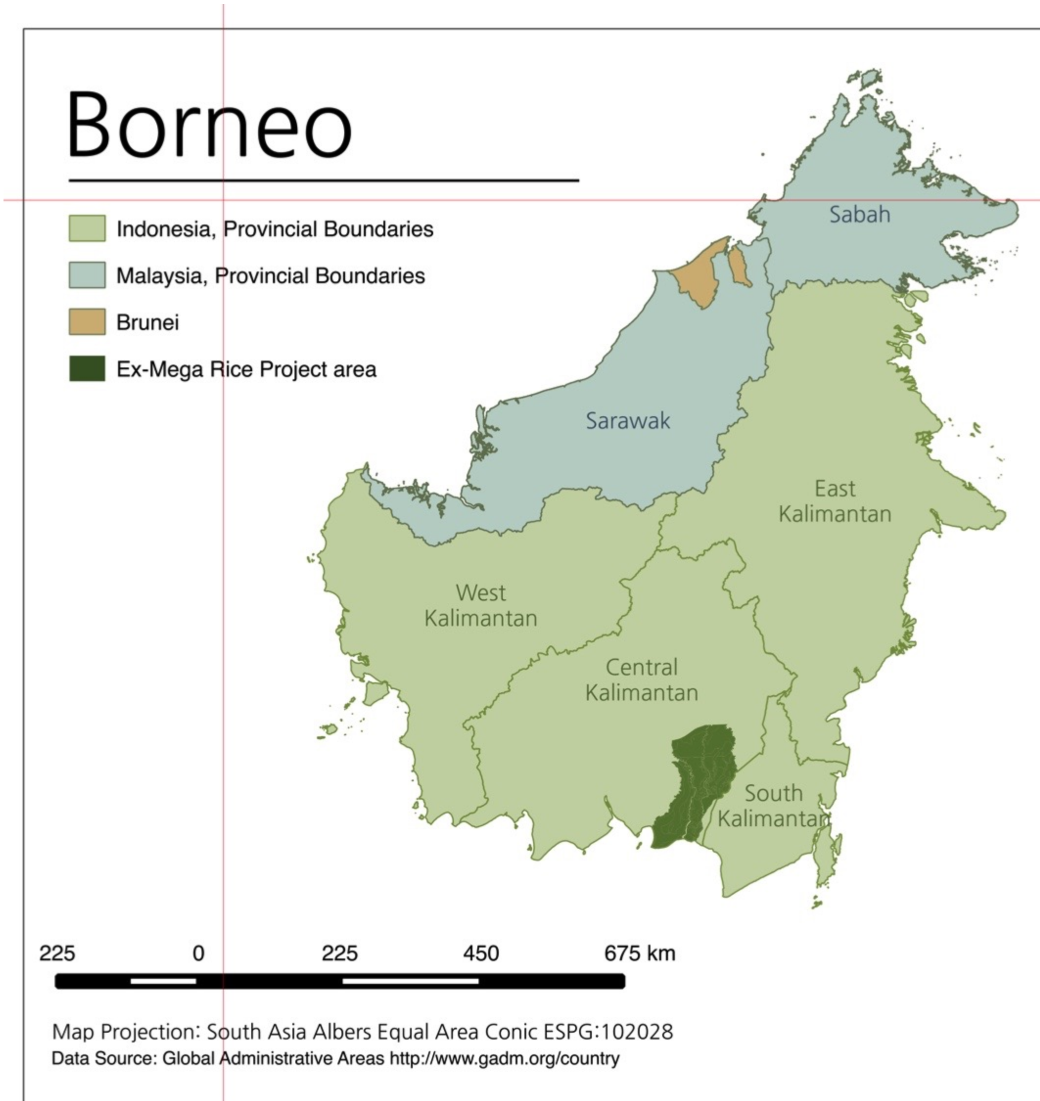

Figure 1: Map of Borneo with political borders and location of Mega Rice Project

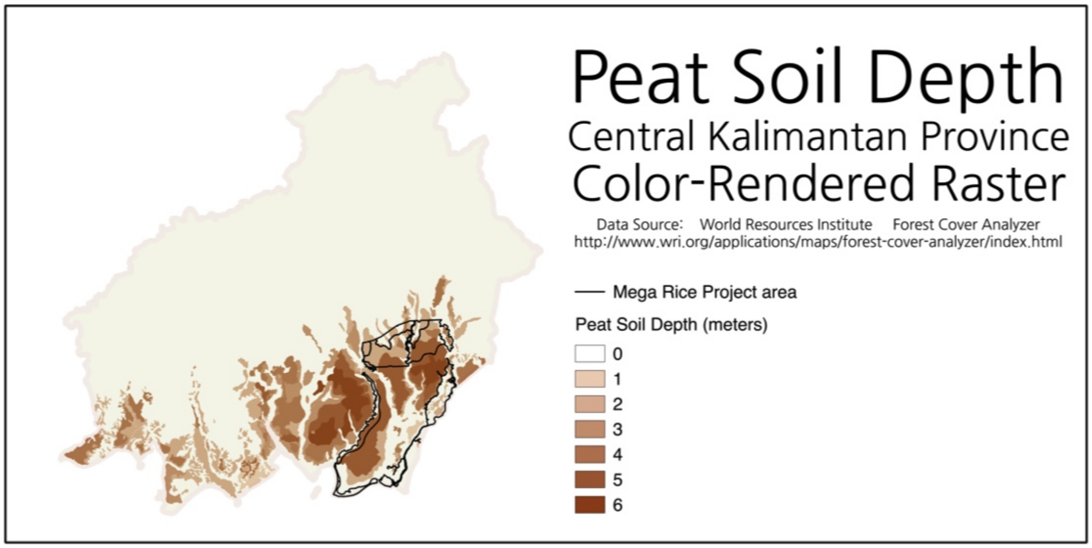

Figure 2: Map of peatland distribution in Central Kalimantan (areas indicating 6 meters range from 6-20 meters)

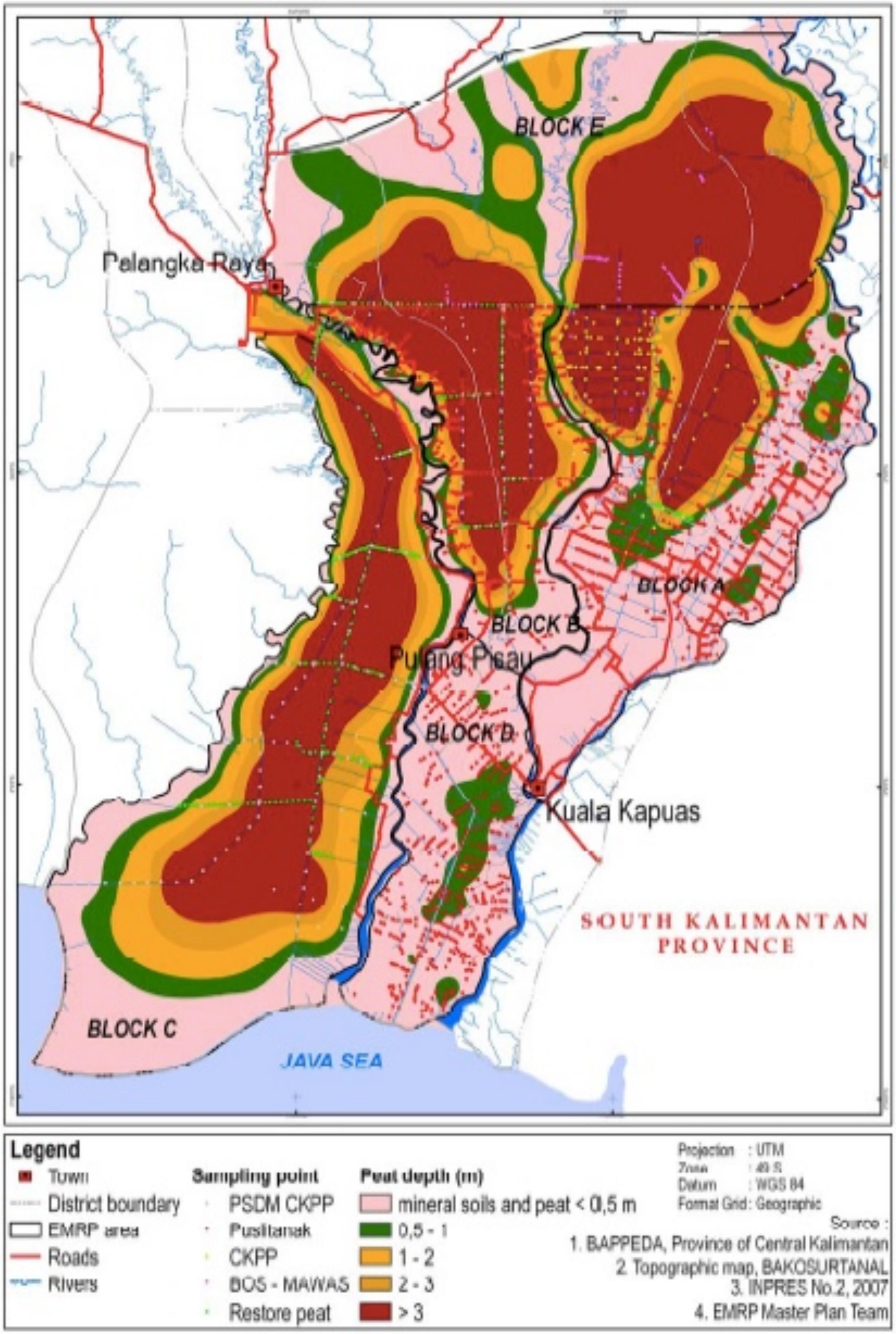

Figure 3. Map of peat distribution, MRP site, Master Plan for Rehabilitation, 2008

Figure 4. Aerial view of Central Kalimantan peatlands

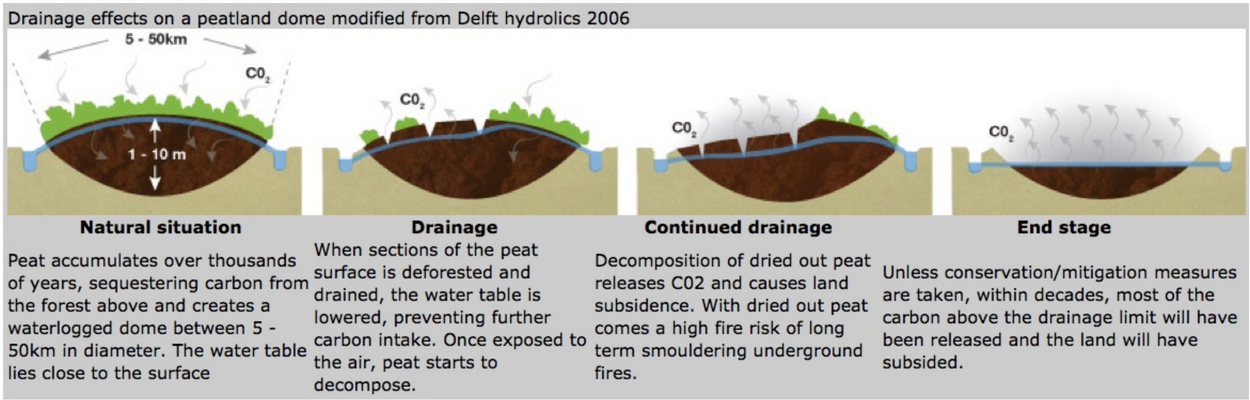

Figure 5.. Schematic illustration of tropical peat domes. Source: http://www.greenpeace. org/seasia/stop-the-haze/

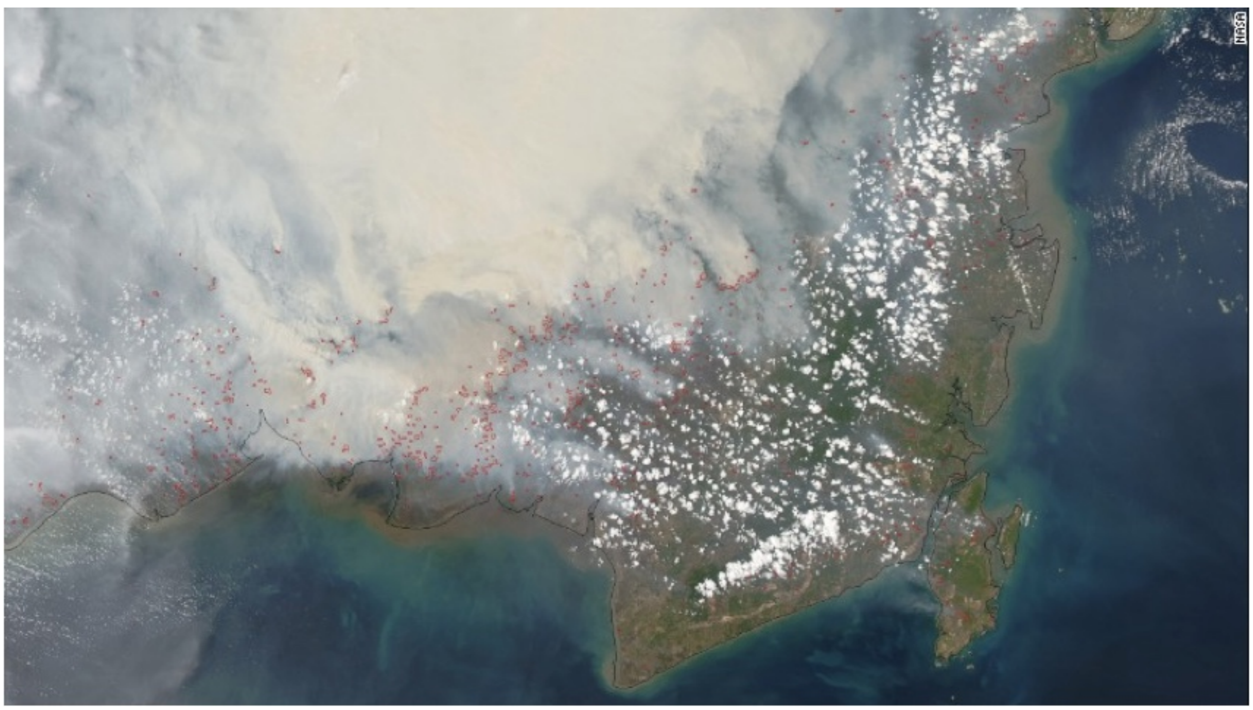

Figure 6.. NASA MODIS satellite image of peat fire smoke, Central Kalimantan, October 19, 2015

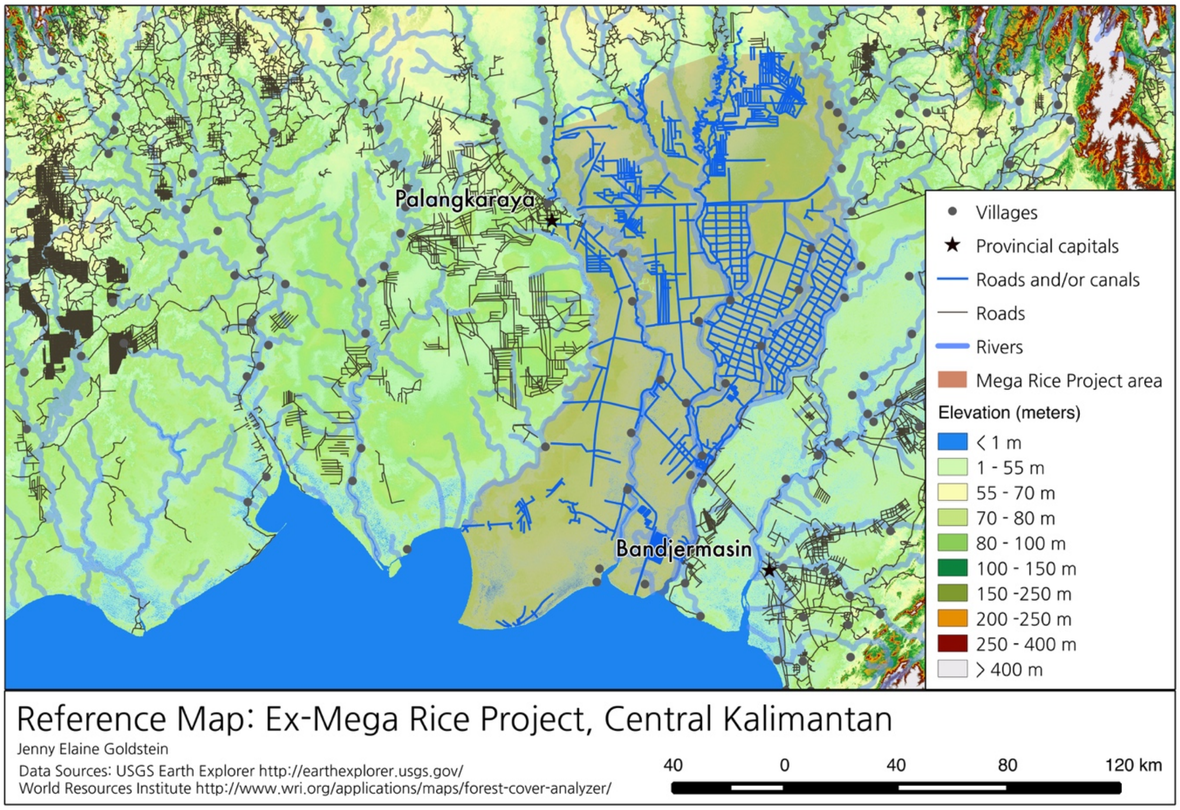

Figure 7. Map of Mega Rice Project showing canals and blocks

Figure 8. Map of Mega Rice Project, Master Plan for Rehabilitation, 2008

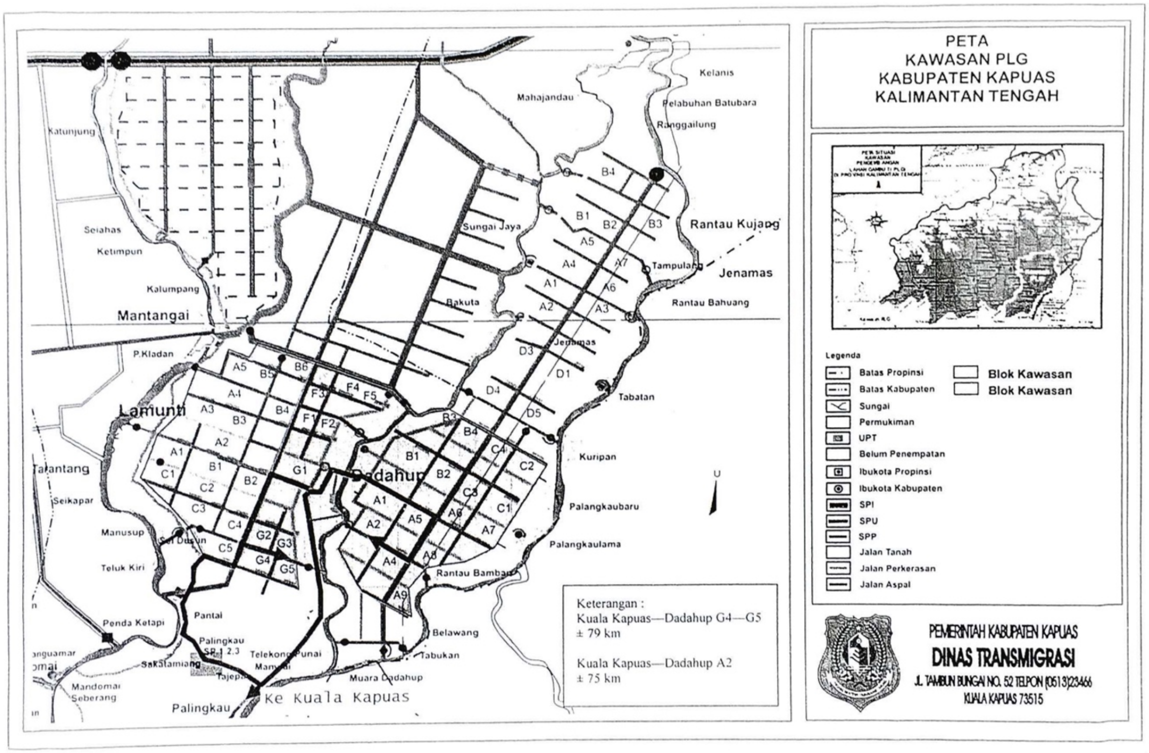

Figure 9. Map of Mega Rice Project, detail of Block A showing transmigrant blocks, current

Figure 10. Photo of transmigrant houses, 1997, photo by PT Wijaya

Figure 11. Photo of canals being dug in transmigrant area, Lamunti, 1997, photo by PT Wijaya

Figure 12. Photo of government officials from Jakarta and company managers in canal, 1997, photo by PT Wijaya

Figure 13. Aerial photo of canals in transmigrant area, Block A, 1997, photo by Patrice Levang

Figure 14. Photo of transmigrant farming, 1997, photo by Patrice Levang

Figure 15. Secondary canal and transmigrant farming, Lamunti, 1997, photo by PT Wijaya

Figure 16. Photo of test rice plots, 1997, photo by Patrice Levang


Figure 17. Photo of pavilion constructed for President Suharto, 1997, photo by Patrice Levang

Figure 18. Photo of President Suharto arrival with group of officials, 1997, photo by PT Wijaya

Figure 19. Photo of congratulatory rice harvest by government officials, 1997, photo by PT Wijaya

Figure 20. Photo of transmigrant house in swamp, 1997, photo by Patrice Levang

Figure 21. Photo of plastic barrier to keep rats out of fields, 1997, photo by PT Wijaya

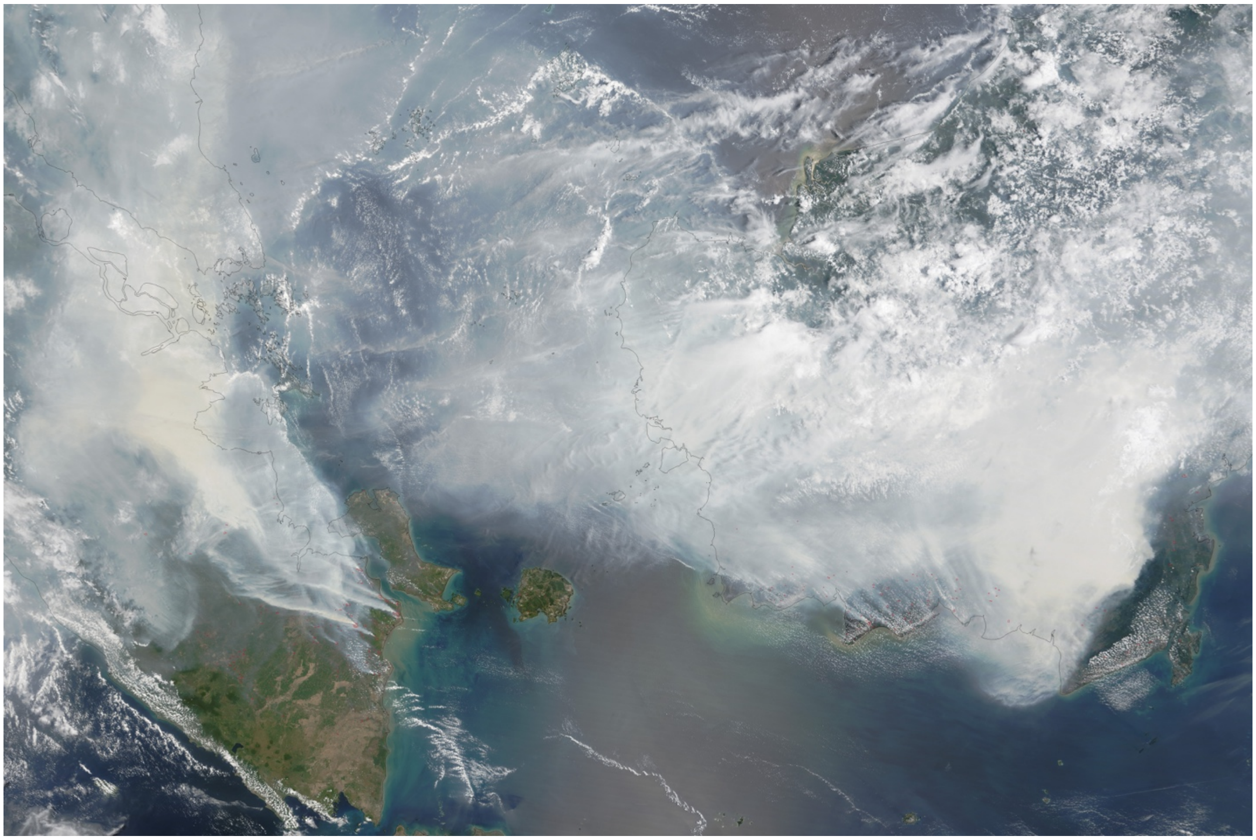
Figure 22. NASA MODIS satellite photo of Indonesia (Sumatra, Kalimantan) smoke-haze, September, 24 2015

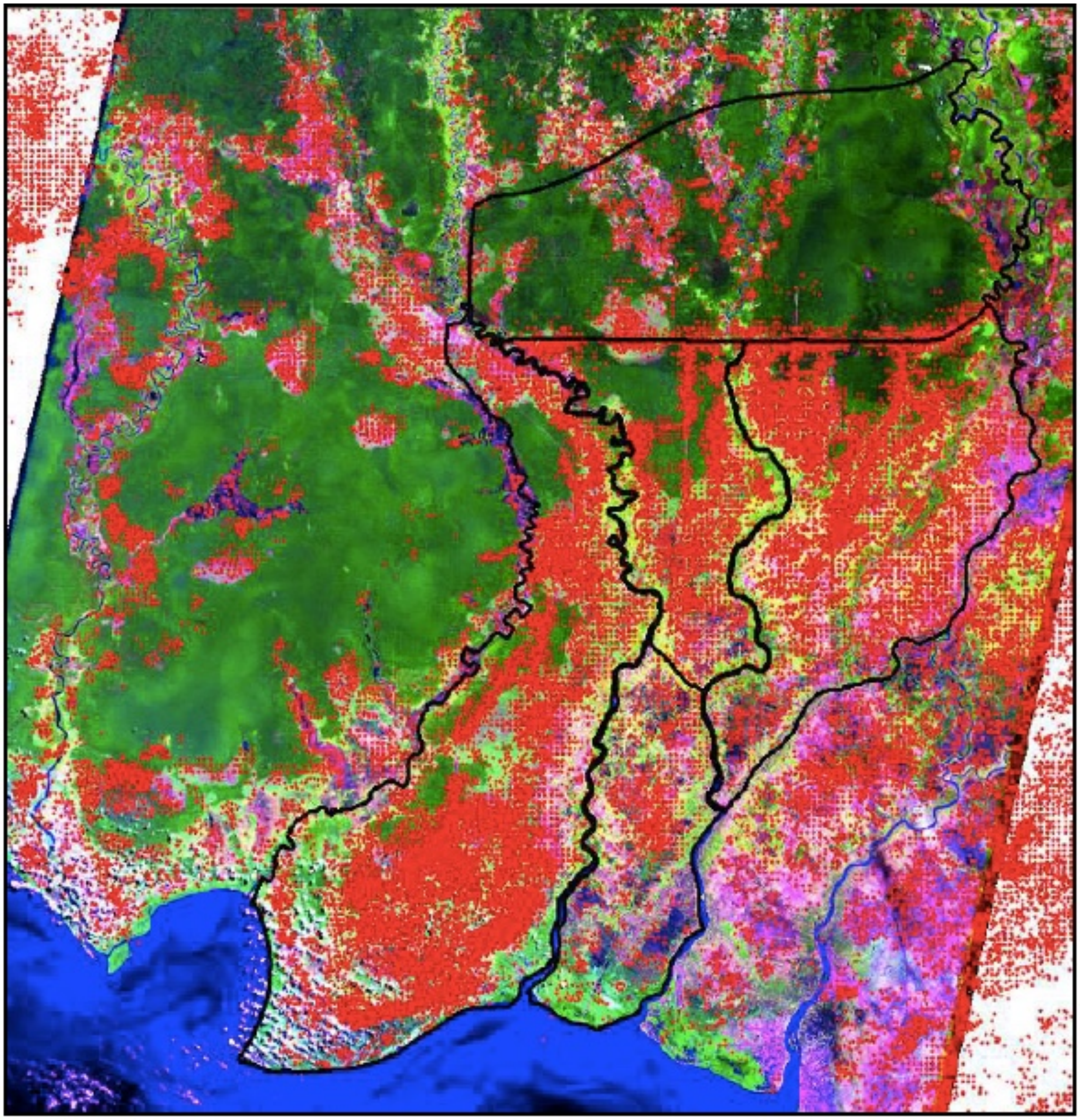

Figure 23. Landsat composite image of fire hotspots in EMRP, 1997-2007, Master Plan for Rehabilitation, 2008


Figure 24. Photo of canal, Block A, 2014

Figure 25. Overgrown canal, Block C, 2014


Figure 26. Photo of sawmill outside Mantangai, Block A, 2014


Figure 27. Photo of loggers nailing together logs for transport, Block E, 2014

Figure 28. Photo of padi gunung rice planted on cleared and burned land, Block A, 2014


Figure 29. Photo of rice, Block D, 2013


Figure 30. Photo of Dayak work huts for loggers, Block E, 2014


Figure 31. Photo of Dayak work huts for fishing, Block A, 2014

Figure 32. Photo of Javanese woman at market, Mantangai, 2014

Figure 33. Photo of vegetable farm in transmigrant area, Lamunti, 2014


Figure 34. Photo of rubber garden, Lamunti, 2014


Figure 35. Photo of oil palm plantation in Lamunti, 2014


Figure 36. Photo of cleared peatland, Block A, 2013


Figure 37. Photo of dam blocking a tatas canal in intact peat forest, 2014

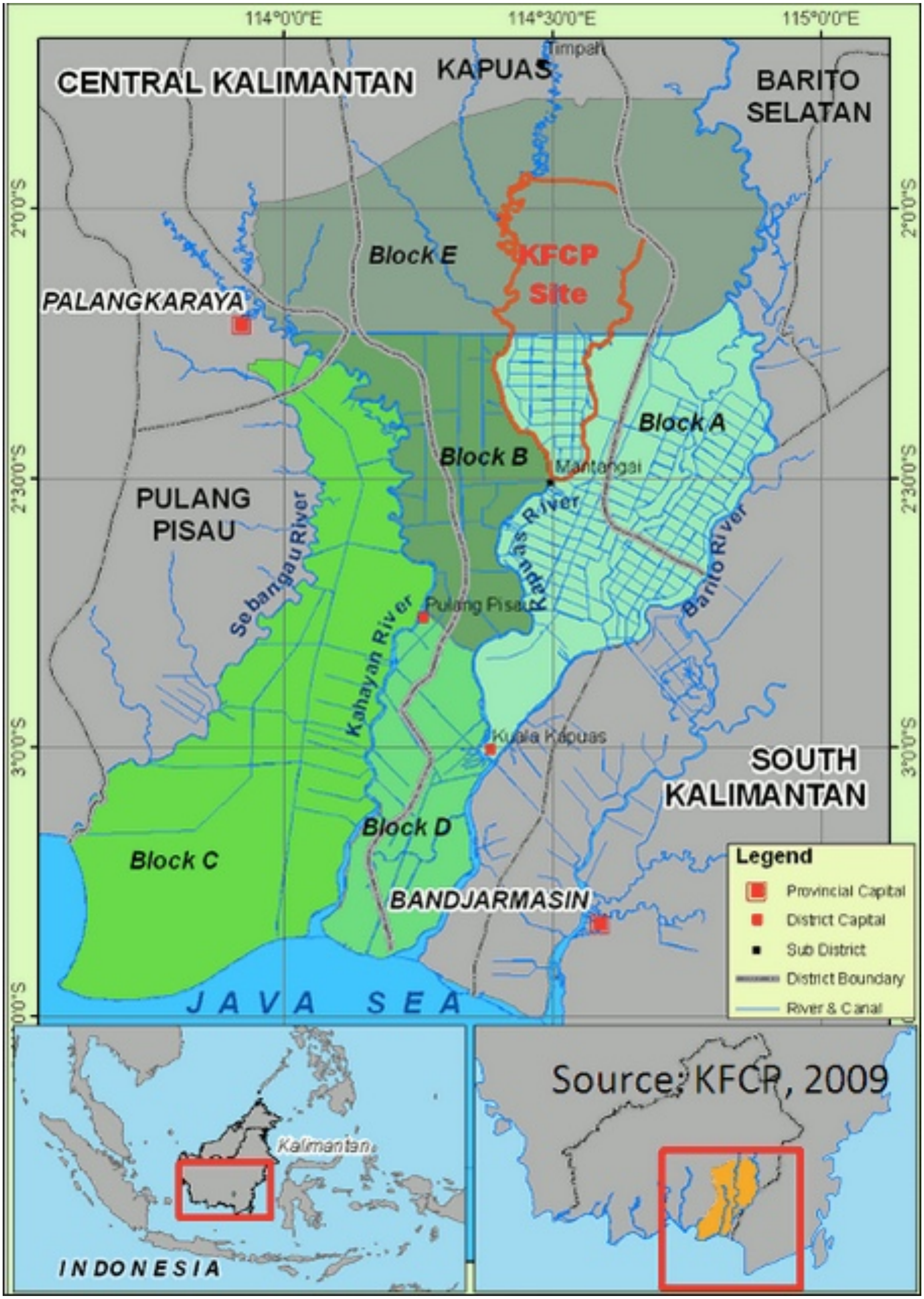
114°0'0"E
114°30'0"E
115°0'0"E
2°0'0"S
2°30'0"S
3°0'0"S
CENTRAL KALIMANTAN
KAPUAS
Timpah
BARITO SELATAN
Block E
KFCP Site
PALANGKARAYA
Block A
Block B
Mantangai
PULANG PISAU
Sebangau River
Kapuas River
Barito River
Kahayan River
Pulang Pisau
Kuala Kapuas
SOUTH KALIMANTAN
Block D
Block C
BANDJARMASIN
JAVA SEA
Legend
Provincial Capital
District Capital
Sub District
District Boundary
River & Canal
Kalimantan
INDONESIA
Source: KFCP, 2009

Figure 39. Panoramic photo of cleared land for oil palm, Mantangai, 2014

Figure 40. Photo of oil palm fruit, Central Kalimantan, 2014

Figure 41. Transmigrants from Java, Lamunti, 2014

Figure 42. Photo of rice planted in cleared land, Mantangai


Figure 43. Photo of peat fire, 2014

Figure 44: Political cartoon of President Jokowi declaring one million hectares of new land open for rice production. Tempo Magazine, October 26, 2014.

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