

# HUNGRY

# COAL

COAL MINING AND FOOD  
SECURITY IN INDONESIA



WATERKEEPER ALLIANCE



JARINGAN ADVOKASI TAMBANG  
MINING ADVOCACY NETWORK

## EXECUTIVE SUMMARY

Indonesia faces serious land use policy conflicts that may affect the country's ability to feed its growing population. This report examines one of those conflicts; coal mining and the millions of hectares of cultivated and arable land handed over to coal companies. We provide evidence on how coal mining is undermining current farm productivity and quantify coal's impact on current and future rice production. We provide laboratory results of water samples taken at sites affected by operating coal mines and interviews with nearby farmers who are forced to use mine water for irrigation due to the draining of surrounding water resources by coal mines. Using Indonesian Government spatial data, we

map Indonesia's existing cultivated land affected by coal concessions, identify land suitable for new rice cultivation and map the proportion of this land affected by coal concessions. Finally, we quantify the impact coal mining has on existing rice production and Indonesia's future rice production should all these concessions be mined for coal. Indonesia cannot afford to lose valuable food producing land. Nor can it continue to allow its water resources, essential for crops, to be polluted and choked with sediment. If the country is to continue to feed itself, the National Government must radically alter its land use priorities.

### KEY FINDINGS

Coal mining and coal exploration is the largest net industrial land use allocation in Indonesia covering almost 17.5 million hectares.

Contrary to Indonesian regulations most coal companies leave mined land and water resources damaged and useless for food production, which continues long after mining.

Due to the depletion of groundwater and surface water catchment caused by coal mining, villagers surrounding coal mines are forced to use mine pit water for washing, bathing, irrigation of crops and fish farming. Farmers using mine pit water report rice yields down 50 percent and fish production down 80 percent.

All but two of the 17 water samples taken from coal mines and surrounding waterways had concentrations of aluminum, iron, manganese and/or pH likely to have an impact on crop production and fish farming. Indonesia's water quality guidelines do not set maximum allowable concentration for these heavy metals in water used for aquaculture or agriculture.

Coal concessions cover 19 percent of Indonesia's existing mapped rice land and 23 percent of land identified as capable of growing rice. Much of the land identified as capable of rice cultivation is occupied by forestry and oil palm plantations, yet unlike coal mining, these land uses do not exclude its use for future food production.

We estimate that about 1.7 million tonnes of rice per year has been lost due to coal mining and 6 million tonnes per year of rice production is at risk from existing cultivated land.

If coal concessions within the area of land identified as capable of rice cultivation is mined an additional 11 million tonnes of rice per year will be lost. If Indonesia's rice systems are improved with irrigation, better seed varieties and fertilizer, over 50 million tonnes of Indonesia's potential rice production is at risk to coal mining.

## INDONESIA'S HUNGER CHALLENGE

Indonesia is under significant pressure to increase its food production to reduce malnutrition indicators, the most serious of which is the growing prevalence of stunting in one third of children under five.

Indonesia's national government is committed to self-sufficiency for rice. This aim has been achieved in a handful of years over past decades, including, most recently, last year. However, Indonesia has been forced to import rice most years.

Increasingly frequent El Niño events typically lead to delayed rainfall and decreased rice planting, prolonging the hungry season and increasing the annual rice deficit.<sup>4</sup> The areas that often recorded some of the highest rice planting delays during El Niño events includes the main rice growing regions of Java, which account for over half of annual rice output. Analysis of climate change impacts on rice production suggests that Indonesian rice yields could plummet by between 20.3 to 27.1% by 2050.

Indonesia's population has been estimated to grow by almost 30 percent to 366 million people in 2050. If Indonesia is to grow enough food for its people, while weathering expected climate change effects and population growth, rice production must continually increase through increasing yields of existing cultivated land and expanding the area of food cultivation.

Coal concessions cover 19 percent of existing rice cultivation and 23 percent of land capable of new rice

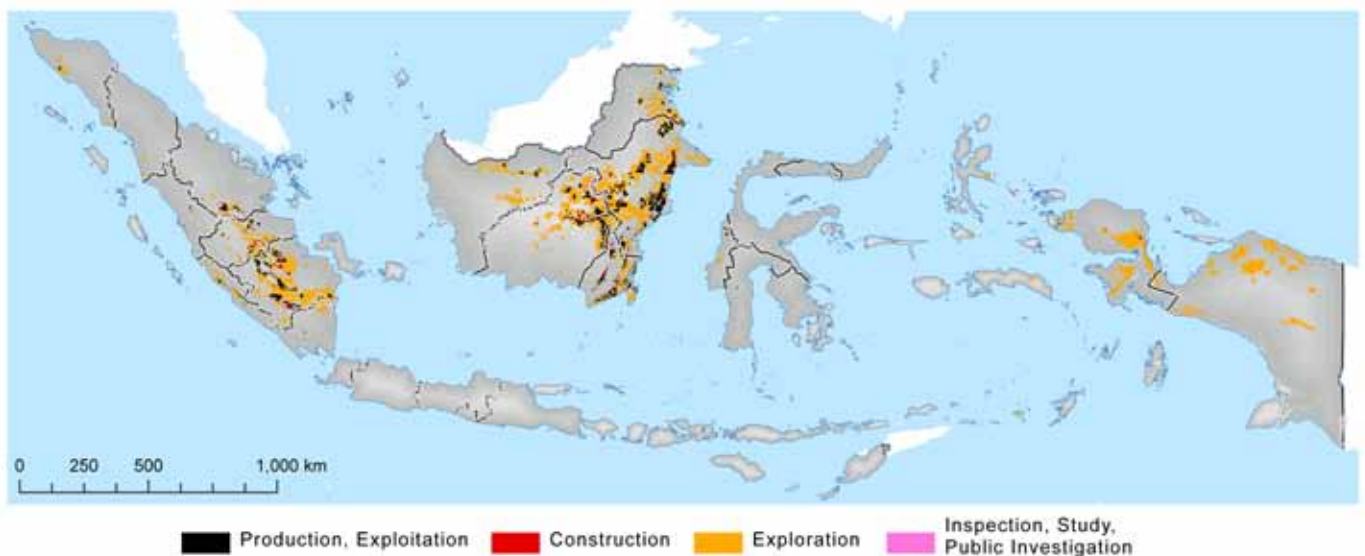
cultivation. Fifteen percent of land allocated for oil palm is also at risk of being stripped and mined for coal.

Land allocated to coal mining covers almost 10 percent of Indonesia, 80 percent of which is under exploration and poses the greatest risk to Indonesia's future food security. Evidence uncovered in this report indicates that coal mining poses a greater potential risk to Indonesia's future food production than any other land use. Indonesia's national government has reined in the expansion of oil palm planting and has promised a similar check of coal's expansion, but as yet these promised reforms remain outstanding.

## COALS IMPACT ON EXISTING RICE PRODUCTION

Operating coal mines occupy almost 4 million hectares in Indonesia and are having a devastating impact. Coal companies are avoiding compliance with Indonesia's meager land rehabilitation and water protection regulations. Coal mining leaves the land scared and barren, water catchments choked and polluted, and groundwater depressed. Coal mining can confidently be assumed to destroy any potential cultivation on the land that it affects.

Coal concessions have been granted in 23 of the 33 Indonesian Provinces, but the largest areas are found in the provinces of South Sumatra, South Kalimantan, and East Kalimantan.





In practice, many companies do not fulfill their regulatory obligations in regards to post-mining activities. The current condition of mined land causes acid mine drainage that currently kills fish in aquaculture operations and reduces rice yields.

Farmers interviewed for this report indicated that mine pit water is causing rice yields to drop by 50 percent and fish production by 80 percent. All but two of the 17 water samples taken at coal mine sites in East Kalimantan and surrounding waterways had concentrations of aluminum, iron, manganese and/or pH that would be expected to lower crop production and fish farming yields.

Indonesian water quality regulations do not set a maximum allowable concentration for these heavy metals in water used for aquaculture or agriculture, a serious omission. Indeed, the Indonesian Government does not regulate a maximum allowable concentration of soluble aluminum in any of the four classes. Literature reviewed for this report indicates that high levels of soluble aluminum are consistent with declining yields and are harmful to rice production.

### AREA OF LAND AFFECTED

Coal concessions cover 19 percent of Indonesia’s total 44 million hectares of mapped rice land. Of this area of rice land affected by coal concessions, 1.6 million hectares are within operating mine concessions and 6.5 million hectares are within coal exploration concessions.

We estimate that about 1.7 million tons of rice a year has been lost due to coal mining and 6 million tons a year of rice production is at risk, if the exploration concessions are mined for coal.

We further estimate that there are about 18.75 million hectares of additional land capable of cultivation outside of

Java after removing existing cultivated land, primary forest, peatlands and protected areas. The largest areas of land capable of new cultivation is in the coal producing Provinces of East Kalimantan, South Sumatra.

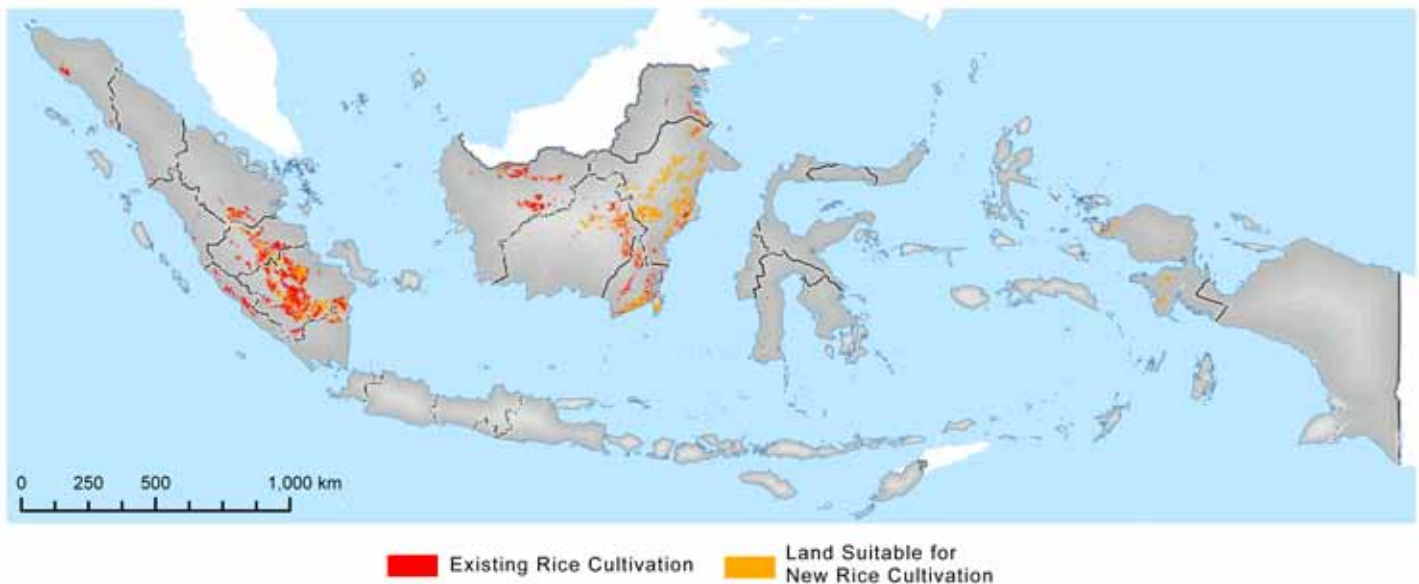
Coal mining concessions occupy 23 percent of land identified as capable of new rice cultivation. Almost 40 percent of these mining concessions are in East Kalimantan.

### COAL’S IMPACT ON FUTURE RICE PRODUCTION

With costly rehabilitation expenses and a high risk of environmental damage, the land occupied by operating mine concessions is unlikely to ever be useful for cultivation. If this area was available for cultivation, even dry land rice production and using a conservative yield of 2.5 tons a hectare, an additional 3 million tons of rice could have been added to Indonesia’s annual rice harvest.

The mining within exploration concessions over land capable of cultivation risks an additional 7.8 million tons of rice a year. Given the severely abject and destructive conditions of mines, if we take for example the exploration concessions for coal in land capable of cultivation, almost 11 million tons of annual rice production potential could be lost. Indeed, if these areas were provided with irrigation and improved seed varieties and fertilizer, the land occupied by coal concessions could produce over 17 million tons of rice a year.

Our calculation suggest that coal’s potential impact on Indonesia’s rice production based on current yields and dry land rice on land suitable for new cultivation is almost 13 million tons a year. If these lands were cultivated with improved rice systems – shifting cultivation to dryland and dryland to irrigated, the potential impact Indonesia’s future rice crop could be as much as 50 million tons a year.





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## INTRODUCTION

Indonesia faces serious land use policy conflicts that may affect the country's ability to feed its growing population. This report examines one of those conflicts; coal mining and the millions of hectares of cultivated and arable land handed over to coal companies. We provide evidence on how coal mining is undermining current farm productivity and quantify coal's impact on current and future rice production.

Indonesia's population is estimated to grow by almost 29 percent, from 260 to 366 million people by 2050.<sup>1</sup> Feeding its people enough food for a healthy and productive life is, therefore, a policy priority. However, the Indonesian national government faces significant hurdles to ensure consistent food and water security for its population.

The Indonesian land mass is about 180 million hectares with most available land either within conservation and moratorium areas or allocated to oil palm, forestry and mining. Government-initiated mega-agricultural projects to alleviate food deficits have therefore been forced into marginal peat lands, causing irreparable social and environmental harm and condemning the projects to failure.

As a consequence of economic and population growth, demands for water and land have increased significantly. The lack of accessible clean water, in both rural and urban areas and the growth of industry, oil palm and mining limits the immediate potential for increasing food production. Environmental issues, such as erosion, land subsidence and the depletion of ground and surface water resources considerably magnify the challenge of growing more food on available arable land.<sup>2</sup>

Compounding the challenge of Indonesia's food security is climate change. In 2015, the World Food Programme warned that, As a highly disaster-prone country, Indonesia faces escalating climate change risks with potential to cause substantial transient, and possibly also chronic, food and nutrition insecurity.<sup>3</sup> As the climate becomes increasingly erratic, altered rainfall patterns, increased frequency and intensity of climate-related events, and increased pest and crop disease will have a mounting impact on food production.<sup>4</sup> Indonesia will be forced to feed an additional 100 million people in 2050, at a time when significant reductions in crop yields are anticipated due to climate change impacts.

If Indonesia is to grow enough food for its people, while experiencing the expected climate change impacts and population

growth, production must continually increase or many Indonesians must do without rice. This will require either a significant cultural transformation, one that appears to be unpalatable for many Indonesians, or an increase in the productivity of existing cultivated land and an expansion of the area of food cultivation.

A major impediment to expanding the area of food cultivation is Indonesia's current land use planning, which is skewed towards industrial export driven agriculture and mining. Coal mining, oil palm and other export orientated commodities dominate potential domestic food growing land in many areas and eat into existing food production.

This report examines how coal mining undermines food and water security in Indonesia by impeding the expansion of food cultivation, destroying cultivated land, depleting and contaminating water resources, and leaving land unusable for growing food, as well as being a major contributor to climate change. Where coal mining proliferates, mine site rehabilitation is largely nonexistent, when rehabilitation does occur, it is poor and unmanaged. In addition, coal mining reduces available groundwater and surface water and contaminates these vital resources with acid mine drainage and heavy metals. Laboratory results of heavy metal contaminated water samples taken at eight coal mine sites in East Kalimantan and surrounding waterways are presented and its impacts identified.

## INDONESIA'S HUNGER CHALLENGE

Despite growth in the Indonesian economy of about 6 percent since 2010, malnutrition persists and continues to confound the country's potential.<sup>5</sup> According to the World Bank Development Indicators database<sup>6</sup> the rate of undernourishment in Indonesia has more than halved in the past decade from 18.6 percent in 2004 to 7.6 percent in 2015. However, data from the National Socio-Economic Survey (SUSENAS) reveals that in 2013, 52 percent of the population failed to meet the daily international threshold of 2,000 kcal per person.<sup>7</sup>

Most troubling is malnourishment in Indonesian children. The World Bank database<sup>8</sup> shows that the proportion of children under five who suffered from wasting in 2013 was 13.5 percent, a mere 0.9 percent improvement since 2004. The incidence of severe wasting in children actually increased from 5 to 7 percent over the same period.<sup>9</sup> The incidence of underweight children also increased slightly, with 20 percent of children under 5 underweight

in 2013, up from 19.7 percent in 2004.<sup>10</sup> The troubling statistic that has received the most attention is the 36.4 percent of Indonesian children under five years of age that were stunted in 2013 - too short for their age - up from 28.4 percent in 2004.<sup>11</sup>

Failure to grow and develop optimally in early life has considerable human and economic costs.<sup>12</sup> Stunting increases the risk of child deaths, adversely affects cognitive and motor development, lowers performance at school, increases the risk of obesity and non-communicable diseases, and reduces productivity in adulthood.<sup>13</sup> Brain development is most affected by childhood stunting<sup>14</sup> and children that experience stunting in their early development are less likely to graduate high school and are expected to earn at least ten per cent less during their lifetime than their food-secure peers.<sup>15</sup> Such high rates of childhood stunting are likely to have considerable impacts upon the Indonesian economy. For example, these cumulative effects have been estimated to cost African and Asian countries up to 11 percent of their gross national product.<sup>16</sup>

## FOOD SECURITY

Food security is defined as “a condition when all people at all times have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preference for an active and healthy life” (World Food Summit, 1996). Indonesia’s national government has restated its commitment to achieving self-sufficiency in five key staples - rice, maize, soybeans, sugar and beef - and has committed to a revised timeframe for achieving self-sufficiency by the end of 2017 for rice, maize and soybeans and the end of 2019 for beef and sugar.<sup>17</sup> In the 2016 calendar year, Indonesian achieved self-sufficiency in rice for the first time since 2009, producing 79.2 million tons of unmilled rice (between 54 and 57 million tons of white rice when milled), up from 74 million tons in 2015.<sup>18</sup> However, in May 2016 the FAO tentatively forecast the 2017 aggregate Indonesian rice production at 71.9 million tons, 2 percent below last year’s level and further forecast that Indonesia will require total cereal imports of 13 million tons in the 2017 financial year.<sup>19</sup>

The Indonesian Government’s National Mid-Term Development Plan (RPJMN) 2015-2019 seeks to strengthen food sovereignty through five major strategies:

1. Increase food availability by enhancing domestic production of

key crops including rice, maize, soybean, meat, sugar, chili and onion.

2. Improve the quality of food distribution and the accessibility of food.

3. Improve the overall quality and nutritional value of the Indonesian diet.

4. Protect food security through preparedness for natural disasters, mitigating the impact of climate change, and preventing pest infections and the spread of diseases in animals.

5. Improve the livelihoods and welfare of farmers, fishermen and other food producers.<sup>20</sup>

## RICE

While many local forms of food staples such as sago and tubers are relied on in areas of Indonesia, the vast majority of Indonesians rely on rice as a primary food source.

In 2009, each Indonesian on average consumed 127 kilograms of milled rice.<sup>21</sup> This is the highest per capita rice consumption in the world. In 2009, rice provided 47.6 percent (1,259 kcal per day) of per capita caloric intake and 39.6 percent of per capita daily protein requirement.<sup>22</sup> The country is the world’s third-largest rice consumer and despite being the third largest producer, is said to be the largest rice importer in the world.<sup>23</sup> Indonesia has only produced enough rice for its own needs in the mid-1980s, 2008-2009 and 2016.<sup>24</sup> The Indonesian Government attempted to reduce rice consumption through its One Day No Rice campaign<sup>25</sup> The campaign failed due to Indonesian’s strong cultural connection and preference for rice.<sup>26</sup>

In 2015, the domestic price of medium quality rice in Indonesia hit a record high of over IDR 10 million per ton (USD 750).<sup>27</sup> As the international rice supply originates from just three rice-exporting countries: Thailand, India and Vietnam, and global trade accounts for just 5 percent of consumption, countries that are not self-sufficient face increased price volatility in times of production shortfalls.<sup>28</sup>

Low-income families in Indonesia spend an estimated 27 percent of their salaries each month buying rice subsidized by the government.<sup>29</sup> Under the RASKIN program, the government sells rice of a lower quality at IDR 1,600 per kilogram (USD 0.12),

allowing each family to purchase up to 15 kilograms a month<sup>30</sup> In 2013, about 3.7 million tons of rice was distributed to about 16 million families.<sup>31</sup> However, the program has been criticized for not targeting the poor,<sup>32</sup> for being marred by corruption,<sup>33</sup> and for pushing up the price for rice, which is estimated at 60 percent above international prices.<sup>34</sup>

The weather also plays a factor. El Niño events typically lead to delayed rainfall and decreased rice planting, prolonging the hungry season and increasing the annual rice deficit.<sup>35</sup> The FAO reports that the mostly irrigated, main season paddy crop for 2016 was delayed by up to eight weeks in several areas due to the late onset of the rainy season and erratic precipitation through January, under the influence of an El Niño event.<sup>36</sup> The areas that recorded the highest delays include parts of West and East Java, West Nusa Tenggara and South Sulawesi, which together account for the bulk of main season rice output.<sup>37</sup>

With the increasing number of climate-change-linked harvest deficits, and fluctuating availability of rice on global markets, the rice issue provokes national anxiety.<sup>38</sup> Suharto's resignation in 1998 and the uprising that preceded it, has been blamed, in part, on a tripling of the rice price which forced 89 million Indonesians to subsist on just one meal a day.<sup>39</sup> Suharto's successor, B.J. Habibie, was compelled to import 5.1 million tons of rice, a quarter of the world's trade at the time, to quell the unrest.<sup>40</sup>

Indonesia's long history of annual rice deficits is predicted to worsen. Analysis of climate change impacts on rice production suggests that in 2025 rice production in Java is likely to be 1.8 million tons lower than current levels and in 2050 3.6 million tons lower.<sup>41</sup> Other predictions of the impact of climate change suggests that Indonesian rice yields could plummet by an average of 11.1 and 14.4 percent for every degree (C) of temperature increase, for irrigated and rain fed rice respectively.<sup>42</sup> A further study predicts Indonesian rice production will decline by between 20.3 to 27.1 percent by 2050.<sup>43</sup>

Nevertheless, a steady annual increase of 3.2 percent in rice production and 6.1 percent in maize production has been achieved over the last ten years.<sup>44</sup> Most rice production, however, is concentrated in Java, where 100,000 hectares of rice lands is said to be converted to other uses each year.<sup>45</sup>

While concentrated high yield irrigated rice paddy production in Java has enabled increased overall food production in Indonesia given the limited availability of agricultural land, continuing to rely

on Java for the bulk of the country's rice production risks future food security. Data from the Ministry of Agriculture shows Java Island to be the most affected by the drought influencing El Niño, and suffers the most prevalent and intense droughts in the country, which are being experienced with increasing frequency.<sup>46</sup>

Such concentrated rice production also results in problems with distributing rice to rural areas outside Java. Local food production to meet local demand is an important food security safeguard, but has not been achieved. Indeed the number of rural districts experiencing food production deficits has increased. For example, 22.6 percent of rural districts studied for the 2015 Food Security and Vulnerability Atlas of Indonesia experienced deficits in the production of cereals and tubers, a 2 percent increase since 2009.<sup>47</sup> Provincial level deficits are also experienced. In a recent study of East and West Kalimantan between 2013 and 2014 significant numbers of households identified as facing temporary food insecurity during an annual hunger season (paceklik).<sup>48</sup> In 2013, total rice production of East Kalimantan was 573,381 tons,<sup>49</sup> just 87 percent of provincial demand.<sup>50</sup>

However, expanding Indonesia's cultivated land has its challenges. Plans to increase rice harvest area have continually been stymied by the over-allocation of land to export commodities such as palm oil and coal.<sup>51</sup> Poorly-conceived attempts at mega rice projects of the past have, as a result, been squeezed into marginal land and reaped dismal results. Indonesia's first mega rice project aimed at converting one million hectares of unproductive low land Central Kalimantan peatland into rice paddy ended in environmental and social ruin.<sup>52</sup> With 75 percent of arable land already under cereal production<sup>53</sup> increasing food production means increasing crop productivity and/or cultivating food on land set aside for oil palm and coal.

## COAL MINING

More than a decade and a half of growth in Indonesia's coal-mining sector has positioned the country as the world's fourth-largest coal producer and the largest exporter of thermal coal. Indonesia now accounts for 8 percent of the world's thermal coal production and despite a 9.8 percent decline from 2014, still accounts for over 36 percent of global thermal coal exports.<sup>54</sup> Indonesia, therefore, has a major role in greenhouse gas emissions from coal-fired power plants.

In 2015, Indonesia produced almost 469.3 million tons (Mt) of





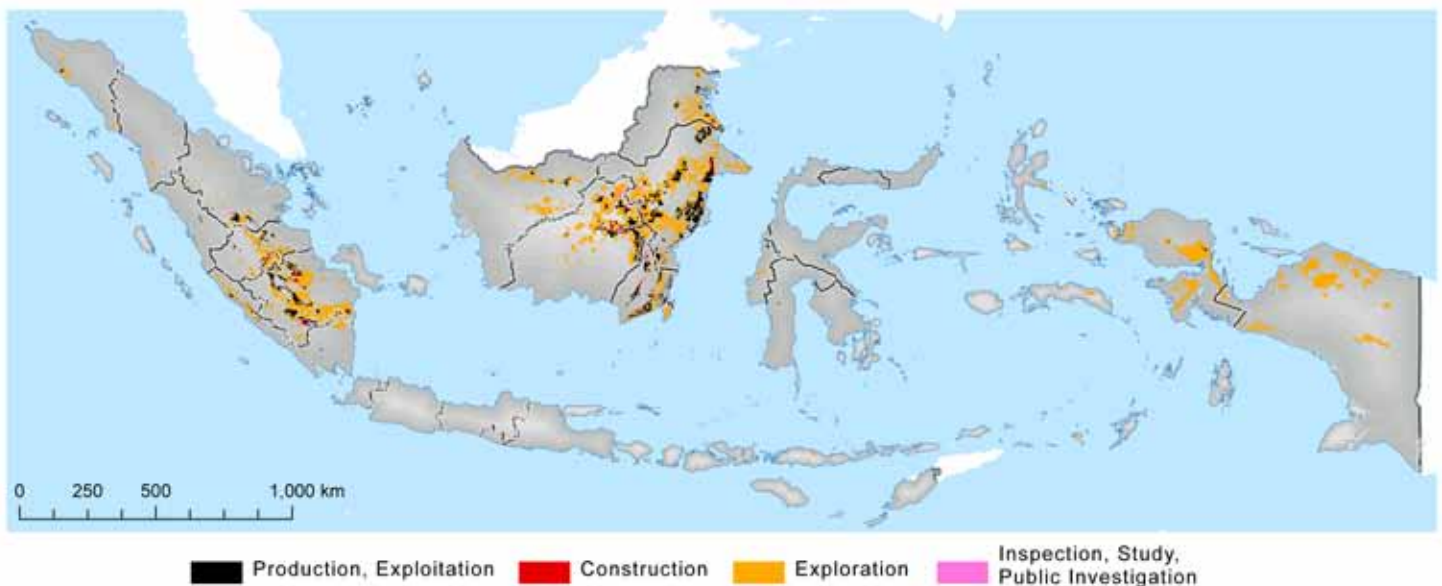
coal, 99.4 percent of which was steaming coal, the fourth highest production after China, USA and India. Indonesia exported 78.5 percent of its total coal production, making it the world's largest exporter of steaming coal.

Domestic coal consumption is also planned to increase. To cope with electricity shortages and to reduce the country's dependence on fossil fuels, the President of Indonesia launched a program in 2015 to provide an additional 35 Gigawatts (GW) of domestic power capacity by 2019.<sup>55</sup> The program included the construction of 20 GW of coal-fired power capacity that would increase domestic coal consumption by 80-90 Mt a year, 40% of which was expected to be supplied domestically.<sup>56</sup> At the time, Indonesians electricity demand was expected to grow by 8.7 percent a year, on the back of an expected economic growth rate of 7 percent. In late 2016, the National Energy Board (DEN) announced that only 56.28 percent of the targeted 19.7GW of electricity, would be added into the grid by 2019.<sup>57</sup> Lower-than-expected economic growth of just 5.1 percent now raises questions about the feasibility of the program.<sup>58</sup> To date only 232 MW of the total 35,000 MW target are in commercial operation.<sup>59</sup>

Map 1 below has been developed from Indonesian Government spatial data<sup>60</sup> and shows that coal reserves are found in all the five major islands with coal concessions having been granted in 23 of the 33 Indonesian Provinces, but the largest reserves are found in the provinces of South Sumatra, South Kalimantan, and East Kalimantan (see table 1).

Coal mining and coal exploration is the largest net industrial land use allocation in Indonesia. Indonesian Government spatial data<sup>61</sup> shows that coal mining concessions cover almost 10 percent of the country or just under 17.5 million hectares; 9.8 million hectares in Kalimantan (Indonesian Borneo); 4.3 million hectares in Sumatra; and 3.1 million hectares in Papua/West Papua. While only about 20 percent of these concessions are currently mined (3.4 million hectares) or under construction (0.24 million hectares), another 78 percent (13.6 million hectares) is under exploration. While oil palm concessions cover a net area of 19.1 million hectares, included in this is 2.8 million hectares of coal concessions. Indonesia will eventually exhaust its coal reserves, and unless mine site rehabilitation dramatically improves large tracks of potentially productive farmland will be left unusable for growing food, waterways polluted and groundwater depleted. In 2014, Indonesian coal reserves were estimated at 32.3 billion tons. However, declining strip-ratios and profitability have led to a drop in economically retrievable coal reserves. PricewaterhouseCoopers now suggests that if current production is maintained and if domestic consumption increases as predicted, Indonesia's economically retrievable coal reserves could be depleted by 2033 to 2036.<sup>62</sup>

A moratorium on new coal mine concession areas was to be implemented after the announcement of a similar five-year ban on new palm oil plantations, announced in April 2016. A moratorium would not, however, halt new mine expansions or developments



Map 1: Coal concession in Indonesia (2013)



Table 1: Indonesian coal mining concessions – all number in hectares

Region	Province	Production/ Exploitation	Construction	Exploration	Feasibility	Total
Java/Nusa Tenggara/Bali	Banten	2,125		5,800		7,925
	West Java	11		1,317		1,328
	East Nusa Tenggara	9,806				9,806
<b>Totals</b>		<b>11,942</b>		<b>7,117</b>		<b>19,059</b>
Sumatra	Aceh	12,722		116,844		129,566
	Bengkulu	35,483		187,589		223,072
	Jambi	129,033	38,173	674,462	405	842,073
	Lampung	190,662				190,662
	Riau	88,172		208,265	18,832	315,269
	West Sumatra	12,869		40,140		53,009
	South Sumatra	509,468	64,203	1,901,504	34,922	2,510,097
	North Sumatra	1,092		42,895		43,987
<b>Totals</b>		<b>979,501</b>	<b>102,376</b>	<b>3,171,699</b>	<b>54,159</b>	<b>4,307,735</b>
Kalimantan	West Kalimantan	47,691		794,655	4,423	846,769
	South Kalimantan	387,091	37,263	541,379	22,964	988,697
	Central Kalimantan	544,751	24,352	2,054,513	5,381	2,628,997
	East Kalimantan	1,242,856	55,212	3,148,398	56,669	4,503,135
	North Kalimantan	74,989	19,927	701,696		796,612
<b>Totals</b>		<b>2,297,378</b>	<b>136,754</b>	<b>7,240,641</b>	<b>89,437</b>	<b>9,764,210</b>
Sulawesi/Maluku	North Maluku/Maluku	60,062		49,518		109,580
	West Sulawesi	10,397		49,761	60,158	120,316
	South/Southeast Sulawesi	4,740		9,339	12,624	26,703
	Central Sulawesi			9,751		9,751
<b>Totals</b>		<b>75,199</b>		<b>118,369</b>	<b>72,782</b>	<b>266,350</b>
Papua	Papua			1,778,941		1,778,941
	West Papua	10,303		1,307,950		1,318,253
<b>Totals</b>		<b>10,303</b>		<b>3,086,891</b>		<b>3,097,194</b>
<b>Grand Totals</b>		<b>3,374,323</b>	<b>239,130</b>	<b>13,624,717</b>	<b>216,378</b>	<b>17,454,548</b>

by companies that already hold mining concessions.

The Indonesian Government is trying to grapple with the vast areas of land handed over to coal companies during previous regimes. Local governments (kabupaten) in coal-rich areas have issued many thousands of Mining Business Permits (Izin Usaha Pertambangan, or IUPs) often corruptly, without maintaining administrative oversight.<sup>63</sup> As a consequence many mining companies now lack the mandatory Clean and Clear certification (CnC). Clean and Clear certification was introduced in 2014 to identify miners that have outstanding royalty obligations and other tax debts, unfulfilled exploration and environmental commitments and property delineation issues. As a result of the CnC process the Director General for Coal and Minerals at the Energy Ministry,

had identified 4,023 of the 10,388 IUP-holders, which should be revoked.<sup>64</sup> It remains to be seen how many coal concessions will eventually be overturned. It is essential for Indonesia’s food security objectives that the vast area of existing coal concessions are not allowed to be mined. To do so would leave waterways silted up, contaminate with heavy metals, depleted groundwater and make millions of hectares of productive land barren and unsuitable for food production.

## POOR MINE SITE REHABILITATION

Over 99 percent of coal mining in Indonesia is open cut or strip mining.<sup>65</sup> To allow for strip mining, concession areas are stripped of



*Ibu Dewi lives within 100 meters of the PT Cahaya Energi Mandiri coal mine in Mugirejo near Samarinda, East Kalimantan. Her well water has been unusable since the mine started in 2009 and mudslides regularly cover her rice paddies. Before the mine was developed there were 83 families growing rice in the area. Since the mine started and the mud slides began, rice growing families moved away and the number of rice growing families in Mugirejo fell to just 20. Ibu Dewi complains that there are so many mud slides now that families can't produce as much rice as they once did. Mud slides cover the rice plants with increasing frequency and need to be replanted.*

*Flooding events are reported as being more common and widespread since coal mining arrived in East Kalimantan, with the city of Samarinda experiencing floods on 150 occasions between 2009 and 2014. Coal mines denude topsoil on hills. Rapid runoff of torrential rains into waterways leads to mudslides that now routinely decimate rice fields and wash out neighbourhoods.*

*The soil characteristics of East Kalimantan and the hilly topography with relatively steep slopes favour soil erosion as soon as the vegetative cover is broken. Poor water quality is a consequence of vegetation removal which causes river siltation, suspended solids, as well as mineral and metal contamination of surface water. This is in addition to reduced soil fertility. Damage to natural soil conditions occurs very fast and is sometimes irreversible.*

vegetation and soil is removed and piled to allow access to the coal seam. The process has a significant impact on agricultural production, as well as local communities, soil stabilization, hydrological cycling, carbon sequestration, and habitat for biodiversity. Downstream communities are also impacted through landslides, sedimentation, depleted groundwater and the discharge of acid mine drainage and toxic heavy metals.

In practice, many companies do not fulfill their regulatory obligations on post-mining activities leaving land and water resources damaged. Companies lack the technical capacity to conduct rehabilitation on heavily-degraded, and sometimes toxic sites. The limited technical capacity and often unwillingness of government regulators to impose and monitor rehabilitation obligations means that the impacts of coal mining in Indonesia is severe and does not stop when mining ceases.<sup>66</sup>

Recent reports of thousands of coal mines closing in Indonesia's coal belt with very few companies having paid their share of billions of dollars owed to repair the badly scarred landscape they have left behind,<sup>67</sup> underline the rehabilitation challenge Indonesia faces. Indonesia's Corruption Eradication Commission (KPK) estimates that 90 percent of the more than 10,000 mining license holders have not paid the reclamation funds they owe by law. One-third are for coal.<sup>68</sup>

## COAL DEPLETES GROUNDWATER AND SURFACE WATER

Almost all Indonesian coal is mined by open cut or strip mining.<sup>69</sup> Such mining has a significant impact on surface and groundwater, essential for successful food production.

Strip mining requires groundwater to be pumped from the mine pit to allow mining to proceed. This draws down the level of groundwater surrounding the mine pit. Depending on the depth of the mine, this groundwater "depressio" may extend for several kilometers.<sup>70</sup>

Unless mine pits are filled with earth when mining ceases and dewatering of the mine pit stops, mine pits fill with groundwater, rainfall and runoff. This creates a permanent lake to form in the abandoned mine pit. The relationship between groundwater and pit lakes is two-way. Pit lakes influence and are influenced by groundwater.<sup>71</sup> In other words, not only can abandoned pits be a source of acid mine drainage and heavy metals into groundwater, pit lakes can also draw down groundwater after mining ceases due



to evaporation.

Indonesia regularly faces periods of no rain in the dry season and droughts are becoming increasingly common.<sup>72</sup> During these dry periods, groundwater has long been relied upon for the water needs of communities and farms. When mine pits are abandoned, evaporation of the mine lake causes groundwater to be drawn into the pit, depleting groundwater and depressing the water table. As such, many wells in areas of production and abandoned coal mines face dry periods with water tables significantly depressed.

Greenpeace reported in March 2016 that the groundwater of the village of Kertabuana near Samarinda, East Kalimantan, has been affected by the Banpu mine. Since the mine started the community has experienced dry wells and some are now forced to dig up to 20 meters before they find groundwater to pump.<sup>73</sup>

Interviews undertaken with farming families for this report revealed similar experiences. Villagers surrounding the KPC mine in East Kalimantan, as well as several farming communities surrounding production and abandoned coal mine sites near the East Kalimantan capital of Samarinda have been forced in some cases to utilize the water in the mine pits for washing, bathing, irrigation of crops and fish farming due to the depletion of groundwater by coal mining (see laboratory results from water testing carried out on these farmers mine pit water below).

Indeed, in the heaviest mining Province of East Kalimantan the number of open cut coal mines has led to open pits butting up against villages, cutting into community land and depleting water resources essential for crops.

The expansion in coal mining has not seen a proportional increase in the government resources allocated to manage the industry. It has been reported that Samarinda has only five government mining inspectors responsible for ensuring adherence to regulatory obligations by mine companies.<sup>74</sup> Indeed little or no consideration or planning has preceded the rush to mine coal in East Kalimantan. "Poor governance, control of resources by powerful elites, a permit process that doesn't adequately consider the environmental or social impacts of mining, and lack of monitoring, oversight, and clear requirements for post-mining clean-up has allowed coal mining to operate largely unchecked with a high environmental, social, and economic cost to local communities"<sup>75</sup>

The recent downturn in coal's fortunes brought on by China's reduced demand, has hit the meagre benefits from coal mining, with many of the coal companies now insolvent or divested of

assets with little recourse for governments to demand rehabilitation obligations be fulfilled.<sup>76</sup>

In 2015, around 200 coal mining companies ceased operations in East Kalimantan. Some of these were temporary, as miners waited for coal prices to rise, others were permanent and bankrupt. This saw around 5,000 people lose their jobs as Indonesian coal exports fell 18 percent.<sup>77</sup>

Abandoned mine pits dot the bare, treeless hillsides in Samarinda, the capital of East Kalimantan. Indonesia has tried, mostly in vain, to get mining companies to keep their promises to clean up the ravaged landscape.

Samarinda is scarred by a growing number of abandoned open cut coal pits and piles of topsoil and mine overburden leaving vast areas prone to flooding and contamination of surrounding waterways with toxic cocktails of heavy metals and sediment.<sup>78</sup> The increasing number of abandoned mine pits pose a significant risk to the environment and human health and safety.

The devastating human toll that abandoned mine pits have had increases with each passing year. In the last five years 24 local children have drowned in the deep aqua water of the coal pits, a legacy of the high heavy metal concentrations.<sup>79</sup>

In addition to the human tragedy that abandoned coal pits have caused, the local population must suffer the ongoing loss of surface and groundwater through evaporation from the abandoned pits. Operating open-cut coal mines drain water tables to access the coal and use large amounts of water in the mining process, but unless rehabilitated and backfilled with the mine spoil and overburden, these pits fill with groundwater and continue the increased water loss through evaporation. Thus an ongoing impact is foisted onto the local populations with lost surface water harvesting and groundwater leading to dry wells and empty dams. Backfilling of mine pits can mitigate their social and environmental risks, and presents the opportunity to return land to a form that supports food production and conservation.<sup>80</sup> In the United States, filling in coal mine pits has been required by law since the 1970s.<sup>81</sup>

## COAL'S TOXIC LEGACY

A major impact of coal mining is its pollution of available freshwater with acid mine drainage (AMD).

Contamination of waterways by coal mining is well documented and metal release leading to the formation of AMD has been



*Ibu Rahma at the mine pit that killed her son, Samarinda East Kailimantan (JATAM).*

*Ibu Rahma di tambang yang membunuh anaknya, Sempaja Samarinda (JATAM).*

extensively reported,<sup>82</sup> as has the development of AMD from coal mining.<sup>83</sup> Acid mine drainage is one of the most serious localized environmental problems that the coal mining industry faces.<sup>84</sup> AMD causes acidification and metal contamination of surface and ground water bodies and requires high-cost, long-term remediation and treatment measures to mitigate its impact.

When mine materials and overburden-containing metal sulfides are exposed to air and water, the sulfide bearing rocks oxidize to produce sulfates and acid. Under such acidic conditions a wide range of metals become more soluble. In coal mining operations, AMD is predominantly caused when sulfide minerals that are present in coal beds or in strata overlying and underlying the coal are exposed to oxidation.<sup>85</sup>

Some of the effects of AMD include fish kills and the loss of other aquatic species, and impacts on vegetation such as killing crops or reduced or impaired yields.<sup>86</sup> The formation of AMD can be a long-term source of water contamination. Once a mining operation has ceased, poor water quality may continue to impact on the environment, human health and livelihood for decades or even centuries. A well-known mine site in the Iberian Pyrite Belt in Spain, for example, has been generating AMD for well over 2000 years.<sup>87</sup>

A 2014 Greenpeace study analyzed collected surface and wastewater samples in and near mine sites in the Province of South Kalimantan and reported levels of iron and manganese consistently above Indonesia's legal limit. The report noted that 7 of 29 samples had pH readings below 3 — a level of acidity found in vinegar.<sup>88</sup>

Acid mine drainage across Kalimantan has killed fish in aquaculture operations and reduced rice yields.<sup>89</sup> Laboratory results from water samples we took from mine sites and surrounding waterways in East Kalimantan revealed heavy metal concentrations and acidity above acceptable limits for food production systems. Indeed, farmers interviewed complain that wastewater from coal mining activities entering rice paddies damage their harvests and devastating food production. Since using mine pit water these farmers stated that rice yields were down 50 percent and fish production was down 80 percent from what it was before mine pit water was used. Heavy metal contamination Heavy metals are significant environmental pollutants, and their toxicity is a problem of increasing significance for ecological, nutritional and environmental reasons.<sup>90</sup> Because of their high solubility in aquatic

environments, heavy metals can be absorbed by living organisms. Once they enter the food chain, concentrations of heavy metals can magnify as they accumulate in organisms and ecosystems. If the metals are ingested beyond the permitted concentration, they can cause serious health disorders.<sup>91</sup> Heavy metal toxicity is also one of the major non-biological stresses affecting plants.<sup>92</sup> Due to acid mine drainage, accumulated overburden and wastewater created by coal mining, a range of heavy metals are released. Significant concentrations of aluminum, iron and manganese are commonly discharged. These heavy metals can have a negative impacts on living organisms, particularly aquatic life and crops. The impacts of heavy metals on crops increase in acid soils. Heavy tropical rainfall decreases the soil pH (increasing acidity) <sup>93</sup> Acid soils cover 661,153km<sup>2</sup> or about 35 percent of Indonesia. The pH of these soils ranges from 4 to 5.<sup>94</sup> Rice paddy farming also has a tendency towards acidity. Studies of rice paddy soils occupying Indonesian hills and lowlands revealed soil pH between 4.3 and 6.75.<sup>95</sup>

## HEAVY METAL CONTAMINATION

Heavy metals are significant environmental pollutants, and their toxicity is a problem of increasing significance for ecological, nutritional and environmental reasons.<sup>90</sup> Because of their high solubility in aquatic environments, heavy metals can be absorbed by living organisms. Once they enter the food chain, concentrations of heavy metals can magnify as they accumulate in organisms and ecosystems. If the metals are ingested beyond the permitted concentration, they can cause serious health disorders.<sup>91</sup> Heavy metal toxicity is also one of the major non-biological stresses affecting plants.<sup>92</sup>

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*KPC Mine, East Kalimantan.  
Tambang KPC, Kalimantan Timur.*



KPC MAY 2016								
	Surrounding waterways			Mine pits and sediment ponds				
Sample ID	1	2	14	9	10	11	12	13
Parameter	Down-stream pit B: Kraitan River tributary	Down-stream pit B: Kraitan River a	Down-stream pit B: Kraitan Riverb	Kenya-makan sediment pond	Pit Hatan Pond	Pit Hatan Sungi	Sedi-ment pond	Pit B: Karaiton Mawar Pond
Temp ©	29	29.2	26	31.2	34.3	30.6	32.9	32
pH	<b>4.21</b>	7.2	6.5	6.53	7.46	7.17	7.83	5
Aluminum ppm	0.224	<b>1.33</b>	<b>1.23</b>	0.04	<b>0.562</b>	0.127	0.256	<b>3.86</b>
Iron ppm	0.268	<b>1.46</b>	<b>1.05</b>	0.24	<b>1.21</b>	0.159	0.136	0.906
Manganese ppm	1.04	0.434	0.544	<b>3.4</b>	0.139	0.222	0.086	<b>8.85</b>

Table 2: Water testing results of samples taken in and around the KPC coal mine in East Kalimantan in May 2016

Parameter results in bold indicate concentrations are above acceptable limits

Sample ID	Sediment ponds and mine pits						Irrigation canals	
	3	4	5	6	7	8	15	17
Description	PT Transisi Energi Satunama, mine pit	PT Panca Bara Sejahtera, Mine pit	PT Cahaya Energi Mandiri, mine pit	CV Arjuna: mine pit	CV Arjuna: sediment pond	PT Graha Benua Etam, mine pit	CV Limbuh: irrigation canal	PT Kitadin: irrigation canal
Temp ©	34.1	32.1	31.7	34.3	36.8	32.7	31.6	27.4
pH	5.4	6.9	4.1	7.5	6.9	9.2	4.74	7.78
Aluminum ppb	<b>0.701</b>	0.102	<b>3.03</b>	<b>0.872</b>	<b>0.703</b>	<b>1.57</b>	0.078	<b>16.1</b>
Iron ppb	0.23	0.436	0.311	<b>1.58</b>	<b>2.68</b>	0.203	2.24	<b>119</b>
Manganese ppb	<b>2.38</b>	<b>2.91</b>	<b>5.84</b>	0.56	0.151	0.032	<b>1.4</b>	<b>1.33</b>

Table 3: Results of water samples taken at mine sites and irrigation canals fed by mine sites around Samarinda. Parameter

results in bold indicate concentrations above acceptable limits

hills and lowlands revealed soil pH between 4.3 and 6.75.<sup>95</sup>

## HEAVY METALS FOUND IN COAL MINE WATER

In 2015 and 2016, in preparation for this report, 17 water samples were taken at eight coal mine sites in East Kalimantan and surrounding waterways. All water samples were taken using US EPA Method 1669.<sup>96</sup> These samples were analyzed by certified testing laboratories in Indonesia for heavy metals using ICPMS (Inductively coupled plasma mass spectrometry).

All but two of the water samples analyzed had concentrations of aluminum, iron, manganese and/or pH that is likely to have an impact on crop production and fish farming. Indonesia’s water quality guidelines set out in Regulation 82 of 2001 does not set a maximum allowable concentration for aluminum, iron or manganese in water used for aquaculture or agriculture, a serious omission.

Indeed, the Indonesian Government does not regulate a maximum allowable concentration of soluble aluminum in any of the four classes of water use. Aluminum toxicity has been linked to multiple neurological diseases such as Parkinson’s disease, amyotrophic lateral sclerosis and Alzheimer disease.<sup>97</sup> High concentration of aluminum in water, particularly in low pH water can lead to accumulation in fish

organs causing nervous system disorders,<sup>98</sup> and reduces mucous cells of the skin and gills leading to the inability to regulate salt.<sup>99</sup>

Substantial research has been undertaken into the impact of aluminum, at relatively low concentrations, on agriculture.<sup>100</sup> Aluminum is one of the major factors that limit plant growth and development in acid soils.<sup>101</sup> Specifically, aluminum toxicity in plants reduces root systems, induces a variety of nutrient-deficiency symptoms and decreases yield.<sup>102</sup> Many plant species are sensitive to very low concentrations of soluble aluminum, and can begin to inhibit root growth within 60 minutes.<sup>103</sup> In soils of pH lower than 5.5, soluble aluminum is toxic to many plants when the concentration is greater than 2–3 ppm.<sup>104</sup> However, aluminum appears to be lethal to young rice plants at concentrations as low as 0.5 ppm.<sup>105</sup>

Although iron is an essential nutrient for plants, its accumulation within cells can be toxic. Iron toxicity is a major disorder in irrigated and rain fed rice.<sup>106</sup> High soluble iron causes poor growth and severe yield reductions at concentrations above 10 ppm.<sup>107</sup> Average reported yield losses due to iron toxicity are in the range of 12%–35%.<sup>108</sup> However, toxicity at seedling and early vegetative stages can strongly affect plant growth and result in a complete crop failure.<sup>109</sup> Iron has also been found to be toxic to some aquatic life at concentrations as low as 1ppm.<sup>110</sup>



*Pak Baharudin, a 58 year old originally from South Sulawesi, has been farming fish, rice and chilies near Samarinda in East Kalimantan since 2000. Before 2008, he produced fish worth about 150 million Rupiah a year. However, after 2008 the CV Arjuna Makroman coal mine started drying up his dams and groundwater, and he has since been forced to use mine pit water for his fish ponds. Now his fish ponds provide him with only 20 million Rupiah a year. He receives all his water from the Macroman coal mine operated by CV Arjuna to grow Gurami, Nilla, Bututu, Emas and Kai in about 50 fish ponds. He said the fish don't grow well anymore. Rice production is also down. Pak Baharudin once produced about 7 tons of rice a year, but since irrigating with mine water rice production is down to about 4 tons a year.*

Similarly, manganese toxicity is nearly always associated with acid soils and waterlogging may induce or exacerbate the toxicity.<sup>111</sup> Manganese toxicity in plants is often not a clearly identifiable disorder with symptoms and the concentration that causes toxicity varying widely among plant species and varieties within species.<sup>112</sup> In potatoes, stem streak necrosis has been linked to manganese toxicity watered with manganese concentration as low as 2 ppm.<sup>113</sup> The plant dies prematurely and tuber yields are seriously reduced. Lowering the pH of the soil below 5 increased the severity.<sup>114</sup> Rice is known as a manganese tolerant plant species, but has been found to accumulate manganese in roots and shoots causing damage to membranes.<sup>115</sup>

Table 2 shows the results of water samples collected at the Kaltim Prima Coal mine (KPC). The KPC mine is the largest coal mine in Indonesia and one of the largest in the world,<sup>116</sup> producing around 50 million tons a year.<sup>117</sup> The KPC concession areas cover 90,000 hectares in three districts, encompassing several villages.

All the three water samples taken from waterways surrounding the KPC mine (samples 1, 2 and 14) would breach the US EPA recommended maximum water quantity criteria for aluminum. Two (samples 2 and 14) are in breach of the Indonesian water quality criteria for drinking water for iron and one (sample 1) is in breach of Indonesian drinking water criteria for manganese. Sample 1 also breaches all 4 classes of Indonesian water quality criteria for pH.

Water samples were also taken at operating and abandoned coal mines and irrigation canals fed by mines around Samarinda, East Kalimantan.

The results set out in table 3 show extreme concentrations of both aluminum and iron for sample 17, taken from an irrigation canal used for rice paddy production. Water containing such concentrations of aluminum would severely reduce rice crops and likely kill young rice plants. The canal was fed from the PT Kitadin mine north of Samarinda. Aluminum concentrations in the sampled water were over 21 times and iron 119 times the respective US EPA maximum and continuous recommended concentrations for freshwater aquatic life.

The CV Arjuna mine also feeds water through an irrigation canal to rice paddies and fish farms. Iron concentrations were found to be 1.58ppm and 2.68ppm in water samples taken from the mine pit and a sediment pond of CV Arjuna mine. Seven of the 17 water samples taken had iron concentrations above 1ppm and likely to be detrimental to rice crops and fish farms, and one was found as high as 119ppm.

Sample 15 was taken from an irrigation canal used to water rice and fish farms. The irrigation canal was fed by an abandoned mine pit of CV Limbuh. Samples from irrigation canals (sample 15 and 17) were many times over the Indonesian drinking water quality criteria for iron (7 and 400 times respectively), and manganese (14 and 13 times respectively). Sample 15 was also in breach of Indonesian water quality criteria for pH. Manganese can affect crops at concentrations higher than 2ppm. Five of the 16 water samples taken shows manganese concentrations higher than 2ppm. One sample showed a concentration of 8.5ppm.

All but two of the water sample results shows concentrations of heavy metals or pH that would be expected to be detrimental on food production in agricultural systems. Farmers interviewed



*Pak Abba, a 60 year old Samarinda farmer who has been growing rice on his 1.5 hectare plot for 25 years, produces less than 2 tons of rice a year since the Limbuh mine began operating upstream in 2010, down from about 4 tons before the mine began. The Limbuh mine pit drains into an irrigation dam built in 1985, during the Suharto regime, to feed water to rice paddies farmed by about 100 small holders. Pak Abba said all the rice growers in the irrigation system are experiencing similar rice production deficits. He said that before the mine started, there were 4 families producing fish, now there was only one, and that farm produced few fish.*

during the water sampling confirmed these fears.

## **‘TOXIC’ LAW IN MINISTERIAL REGULATION ON RECLAMATION**

ATAM (Jaringan Advokasi Tambang or Mining Advocacy Network) finds that the Indonesian government, specifically in this case the Ministry of Energy and Mineral Resources, is responsible for the contamination of soil used for agriculture and fish farming.

Article 12 of Regulation of the Minister of Energy and Mineral Resources No. 7 of 2014 on the Implementation of Reclamation and Post-Mining Activities in Mineral and Coal Businesses stipulates that reclamation programs can be carried out through revegetation or other forms.

In more detail, Article 5 of this regulation provides four options regarding the use of abandoned mine pits for other activities, namely

for housing, tourism, water, and cultivation. These options are new and are not stipulated in Regulation of the Minister of Energy and Mineral Resources No. 18 of 2008 on Reclamation and Mine Closure, which predates the 2014 Regulation.

JATAM East Kalimantan has recorded that since 2014 there have been 2,896 mine pits in East Kalimantan, including 232 mine pits in Samarinda, East Kalimantan’s capital. As many as 197 mine pits have been declared inactive, measuring at 1,389 hectares. In comparison, the Soekarno-Hatta International Airport in Jakarta measures 1,740 hectares. Therefore, the combined area of these abandoned mine pits is almost equivalent to that of the main airport of Indonesia’s capital. One often used option is the use of mine pits for fish farming. There are currently 11 mine pits with a total area of 283.8 hectares that have been converted into fish farms.

Another option is the use of mine pits for sources of water. Mining





company PT Mahakam Sumber Jaya uses this option, and has converted the 61.33-hectare Ex-Pit L0 and the 7.4-hectare Ex-Pit S-7 South as reservoirs for the Regional Drinking Water Company (PDAM). Data from the Environmental Agency of

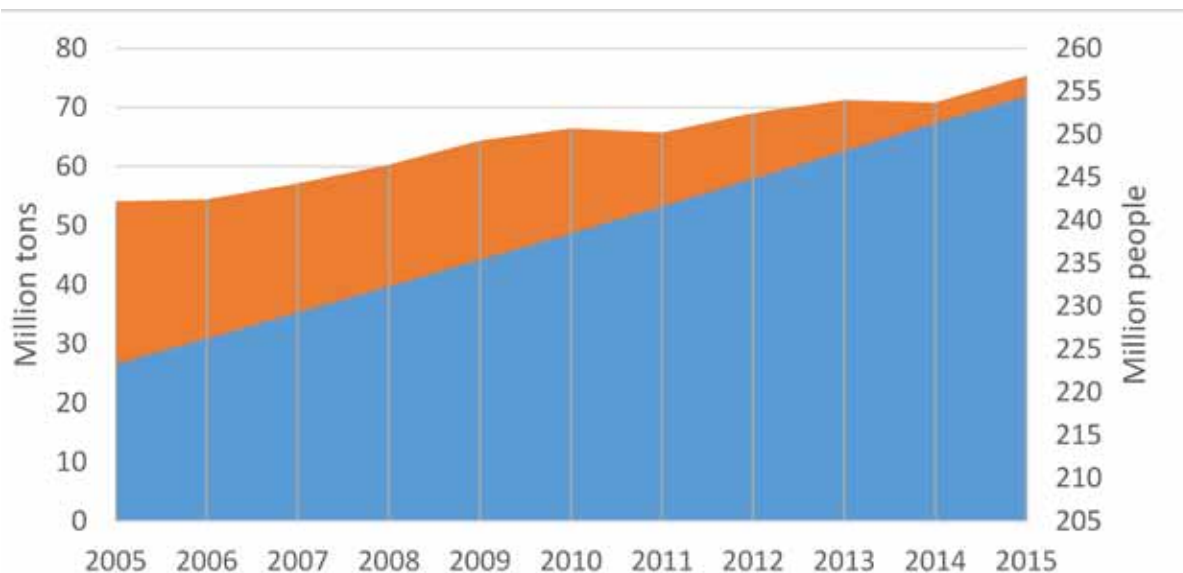
## INDONESIA'S STRUGGLE TO PRODUCE ITS OWN FOOD

Indonesia's agricultural industry is divided between a smallholder sector focused on staple commodity production and an export oriented agro-industrial sector.

Rice farming is one of the most important commodities in the agricultural sector, as it produces rice as a staple food for most Indonesians and is still the main occupation in the rural areas.<sup>118</sup> Smallholder farmers account for around 90 percent of Indonesia's rice production on an average land area of less than 0.8 hectares.<sup>119</sup> Rice is grown by about 26 million Indonesian farmers, which is 77 percent of the country's farmers, under predominantly subsistence conditions.<sup>120</sup> About 70 percent of the lowland rice area in Indonesia produces two crops per year. The rainy season crop is planted in November-December and harvested in January-February. The dry season crop is planted in February-March and harvested in May - June. A very good irrigation system may permit a third lowland (flooded) rice crop to be grown.<sup>121</sup>

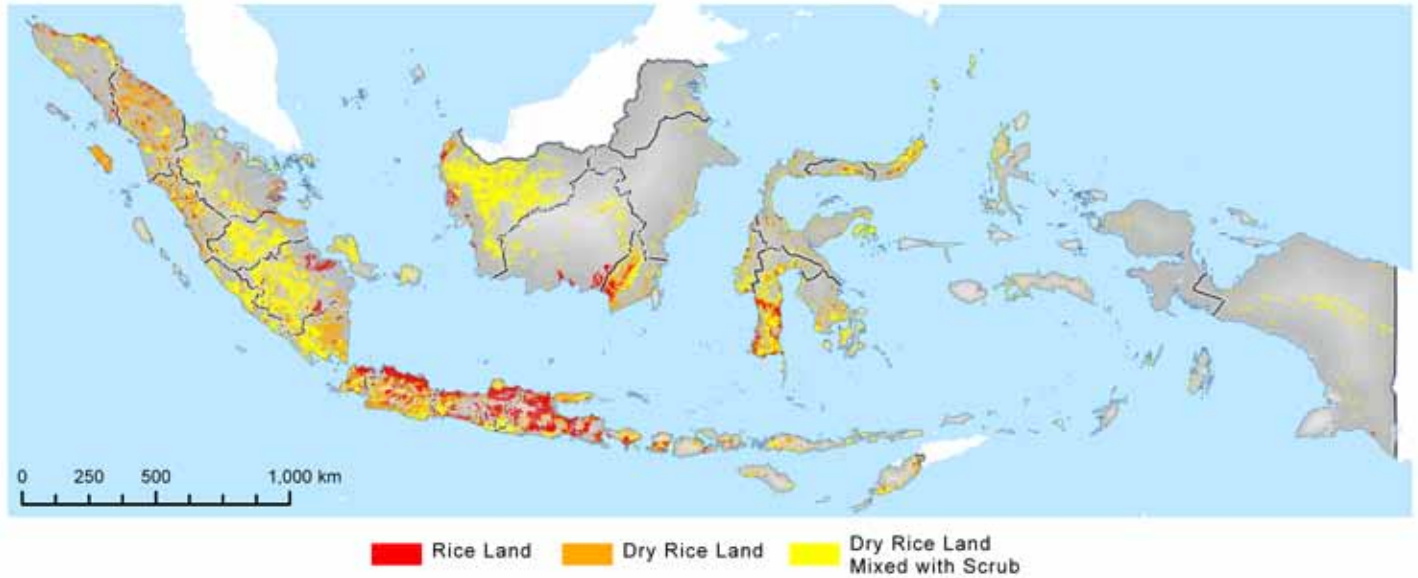
According to Indonesian Government statistics<sup>122</sup> between 2005 and 2015 Indonesia's population grew by 12.25 percent and apart from declines in 2011 and 2014, rice production steadily increased by 28 percent or 21,246,744 tons over the same period (see chart 1). The challenge for Indonesia is to maintain rice production increases to feed a growing population, while at the same time adapting to the impacts of climate change on rice production.

Chart 1: Indonesian population and rice production between 2005



*Pak Derman has been growing rice on his small plot in Kertabuena, downstream of the PT Kitadin mine north of Samarinda, East Kalimantan since 1980. PT Kitadin began developing its coal mine in 1990. In 1995, when Pak Derman began using irrigation water directly from the mine's many pits, rice production began to drop. In the 1980s, Pak Derman harvested about 8 tons a year. Now his rice paddies produce about 4 tons. Pak Derman complained that when it floods and mine pit water escapes into his rice paddy, he loses his rice crop altogether and must replant. When Pak Derman began rice farming in Kertabuena in 1980 there were 20 families growing rice in his rice group. That number is down to 17, as farm families struggle with coal mining-induced declining yields that make rice farming unsustainable.*





Map 2: Indonesian mapped rice land in 2013.

and 2015.

## RICE HARVEST AREA

According to Indonesian Government statistics,<sup>123</sup> Indonesia’s rice harvest area grew by 2.3 million hectares or 19.2 percent from 2005 to 14.1 million hectares in 2015.

In the years 2005-2015, nine provinces collectively lost 145,000 hectares from their already meager 3.3 million hectare rice harvest area (see table 4).

Province	Increase (ha)	Increase (%)
Dki Jakarta	-1,531	-57.4
Jambi	-32,727	-21.1
Riau	-26,872	-20
West Papua	-649	-8.3
North Sumatra	-40,304	-4.9
Bali	-4,971	-3.5
West Java	-37,184	-2
East And North Kalimantan	-672	-0.5
<b>Totals</b>	<b>-144,910</b>	<b>-4.4</b>

Table 4: Provinces that lost rice growing area between 2005 and 2015.

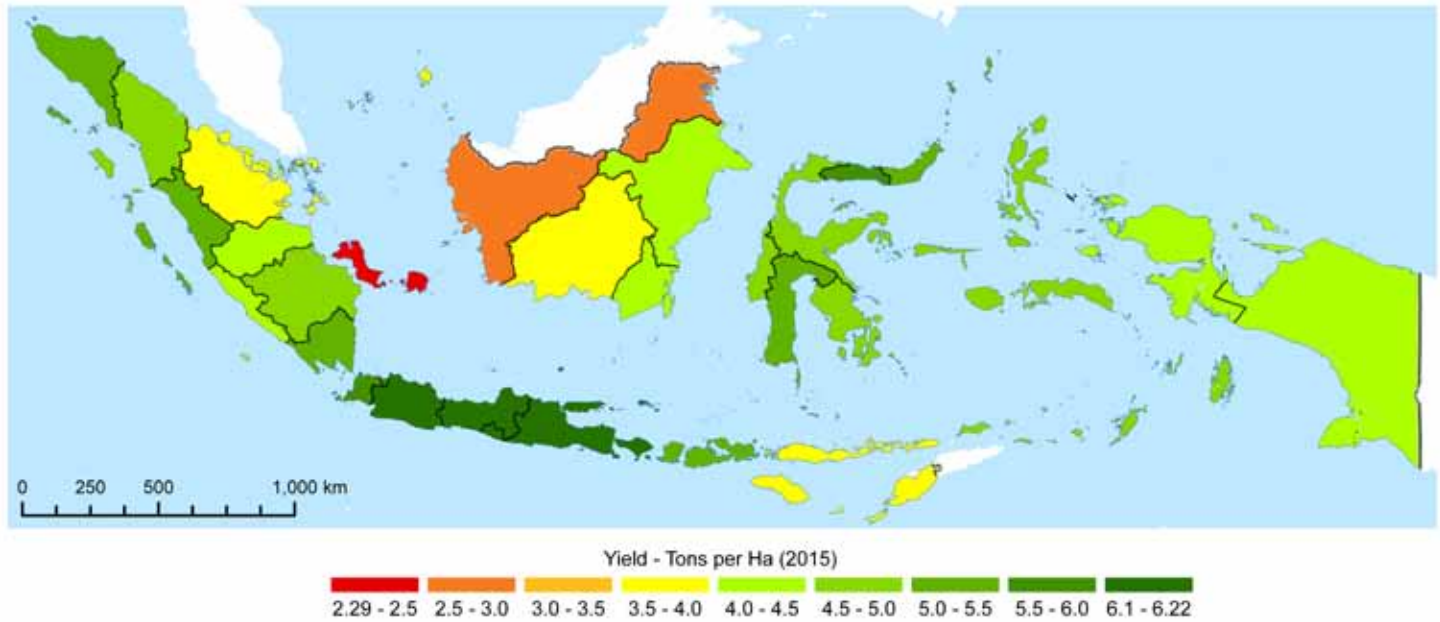
According to Indonesian Ministry of Forest 2013 spatial land cover data,<sup>124</sup> the total mapped area of Indonesian rice land is just over 44 million hectares (see map 2). This includes 26.5 million hectares of “dry rice land mixed with scrub,” where shifting agriculture/crop rotation is practiced. The mapped area of permanently cultivated land is 17.5 million hectares, of which only 7.5 million hectares is high production irrigated rice land, predominantly in Java. These figures are higher than the official data released by the Indonesian Government<sup>125</sup> which reports 14.1 million hectares of cultivated rice. The difference is probably due to the maps identifying all cropped land and wrongly assigning rice land as the sole Indonesian cultivated crop.

## RICE YIELD

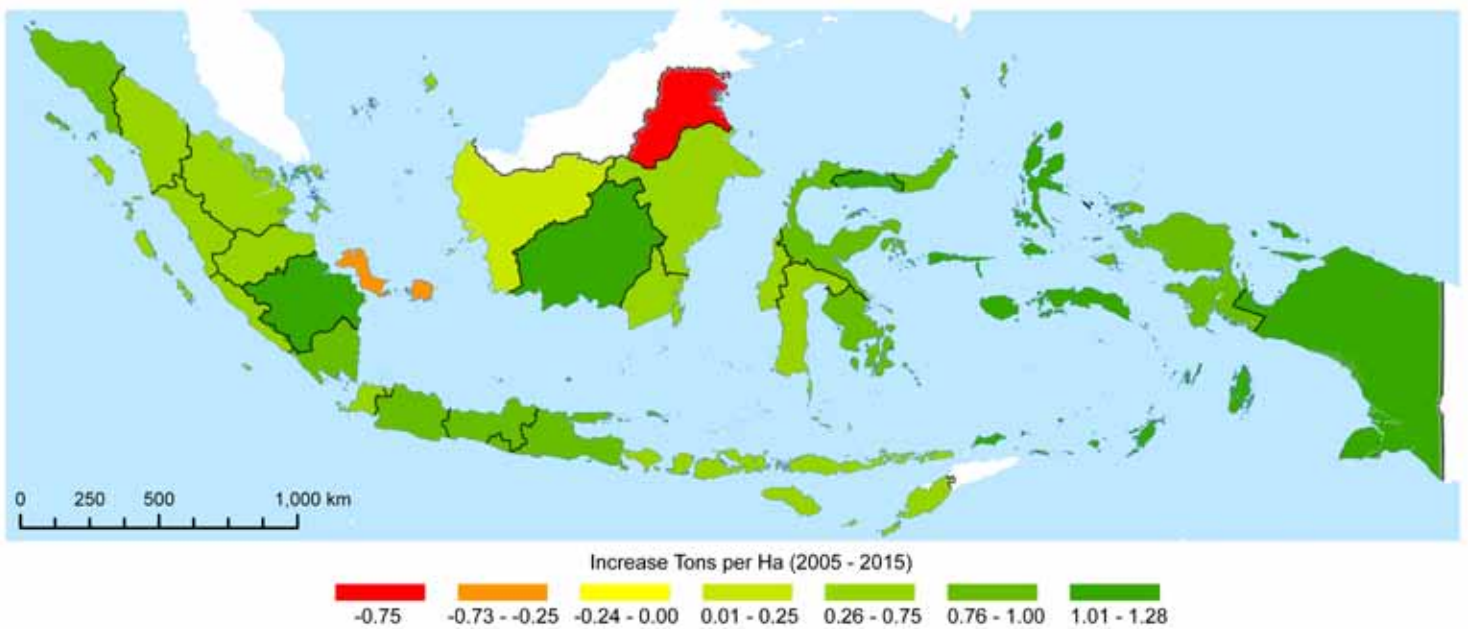
The highest yielding rice paddies are concentrated in the main irrigation rice lands of Java. In areas outside Java, yields are poor. In one transmigration settlement in Bulungan, East Kalimantan, yields on marginal peatland were as low as one ton per hectare, with many achieving even lower yields.<sup>126</sup> Many farmers suffer from food insecurity during a hunger season of up to two months each harvest season while they waited until the second harvest.<sup>127</sup>

Rice yields in Java average up to 6.2 tons a hectare. However, in some Provinces such as West and North Kalimantan yields are as low as 2.5 tons a hectare (see map 3).

Support for irrigation was expected to improve rice production and productivity by ensuring water availability during cultivation period.<sup>128</sup> In reality little irrigation expansion has occurred outside of Java.<sup>129</sup> Damaged irrigation networks across the country limit the efficiency



Map 3: Indonesian 2015 rice yield by Province

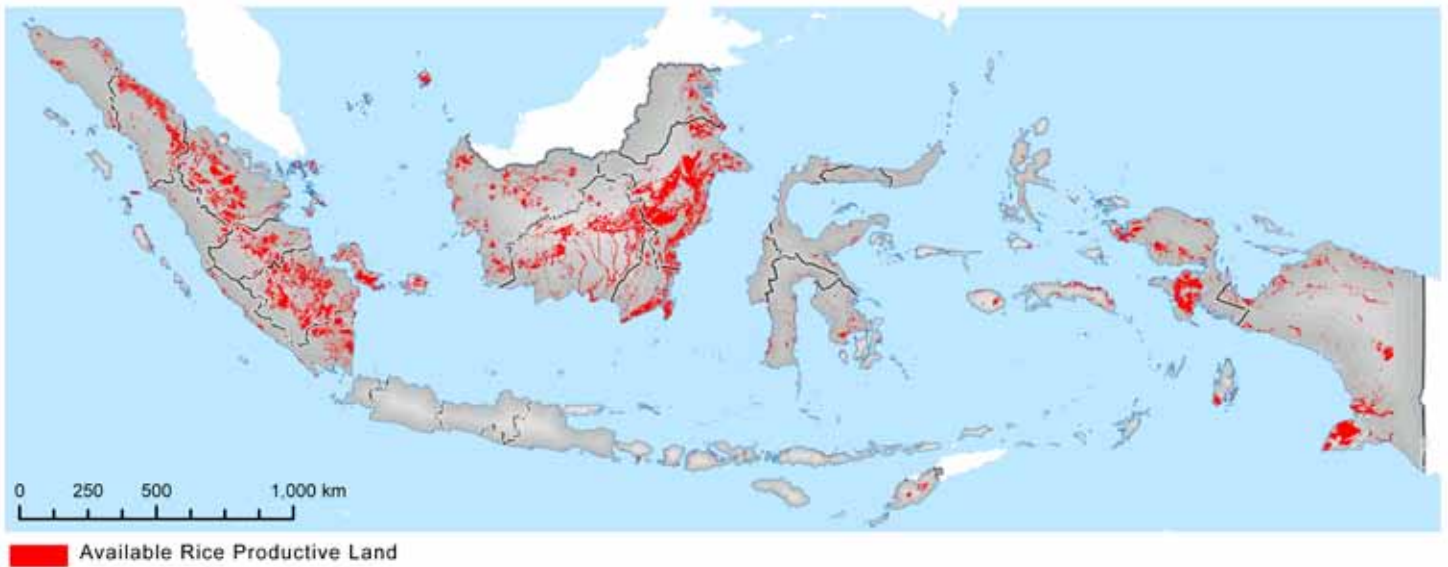


Map 4: Percent increase rice yields in Indonesian provinces from 2005 to 2015.

of water usage resulting in crop failure and reduced yields. Fourteen percent of drainage basins in Indonesia are in a critical condition.<sup>130</sup> Indonesia's ground and surface water catchment levels are low, given the country's high rainfall. Mining adds considerably to water problems by causing mass movement of soil and overburden, shortening the life-span of water catchment reservoirs and choking waterways.

The allocation and management of Indonesia's water resources are jointly overseen by the Department of Public Works and the Department of Mining and Energy.<sup>131</sup> Poor co-ordination of water management between these two departments creates a complex framework of regulations. The Agriculture Ministry estimates that the government needs at least US\$2.04 billion to fix irrigation systems.<sup>132</sup>

As of 2013, just 28 percent of that funding had been allocated.<sup>133</sup> Improvements in rice yields have therefore been patchy, with two provinces (North Kalimantan and the Islands of Bangka-Belitung) experiencing a decrease in rice yields between 2005 and 2015 (see map 4). Increasing production of rice by improving current rice farm productivity and incentivizing local farmers to diversify production is a cost effective and sustainable solution to Indonesia's food security challenges. If arable land is lost to competing land use activities such as coal mining, increasing rice yield to compensate becomes imperative, if rice production is to be maintained. However, there is a point at which improving crop yield begins to return diminishing results for the capital and labor invested. The alternative is to expand the area



Map 5: Area identified as suitable for new rice cultivation

of cultivated land.

## EXPANDING INDONESIA'S FOOD CULTIVATION AREA

According to the World Bank database,<sup>134</sup> in 2013 there was 23.5 million hectares of arable land in Indonesia, a figure that has remained unchanged since 2006, but represents an increase of

30.5 percent or 5.5 million hectares since 1960. However, the area of arable land per person fell by 50 percent over the same period, from 0.2 hectares per person in 1960 to 0.1 hectare per person in 2013 (see chart 2).

Most suitable arable land outside of the cultivated areas in Java-Bali, Sumatra and Sulawesi has already been exploited for crop production.<sup>136</sup> To maintain food production levels for a growing

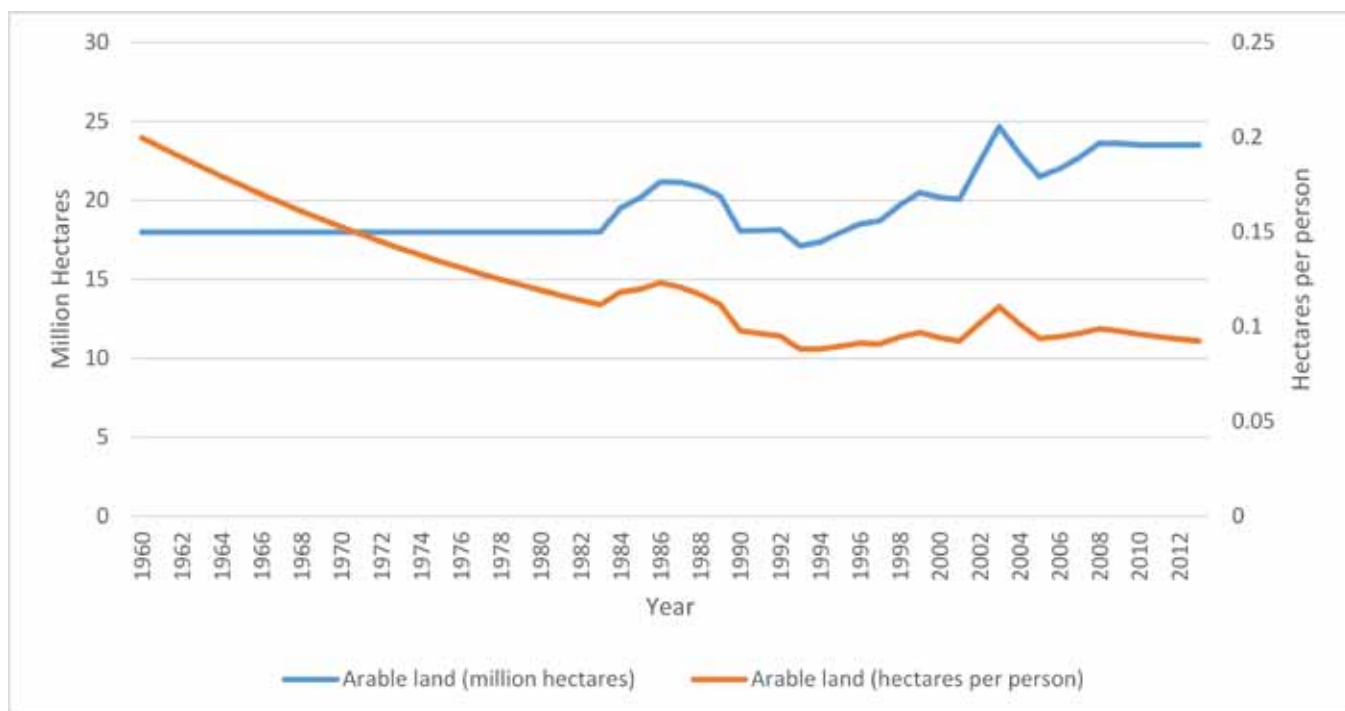


Chart 2. Indonesian arable land area and arable land per person from 1960 to 2013.

Province	Land capable of rice cultivation (ha)	(%)	Province	Land capable of rice cultivation (ha)	(%)
East Kalimantan	2,880,460	15.4	Kep. Riau	244,879	1.3
South Sumatra	2,575,341	13.7	West Sumatra	224,127	1.2
Ria	1,848,565	9.9	South Sulawesi	164,904	<1
Central Kalimantan	1,756,377	9.4	Central Sulawesi	163,464	<1
West Kalimantan	1,310,076	7.2	Southeast Sulawesi	142,608	<1
Papua	1,288,608	6.9	East Nusa Tenggara	138,252	<1
North Sumatra	1,174,976	6.3	Benkulu	122,449	<1
Jambi	844,837	4.5	Maluku	73,185	<1
South Kalimantan	794,987	4.2	West Nusa Tenggara	51,070	<1
West Papua	787,244	4.3	West Sulawesi	41,576	<1
Lampung	671,817	3.6	Gorontalo	32,088	<1
Bangka-Belitung	481,878	2.6	Bali	20,245	<1
North Kalimantan	314,334	1.7	North Sumatra	8,924	<1
Aceh	313,580	1.7			
Maluku	275,422	1.5	<b>Total</b>	<b>18,746,273</b>	

Table 5: New land capable of rice cultivation in Indonesia

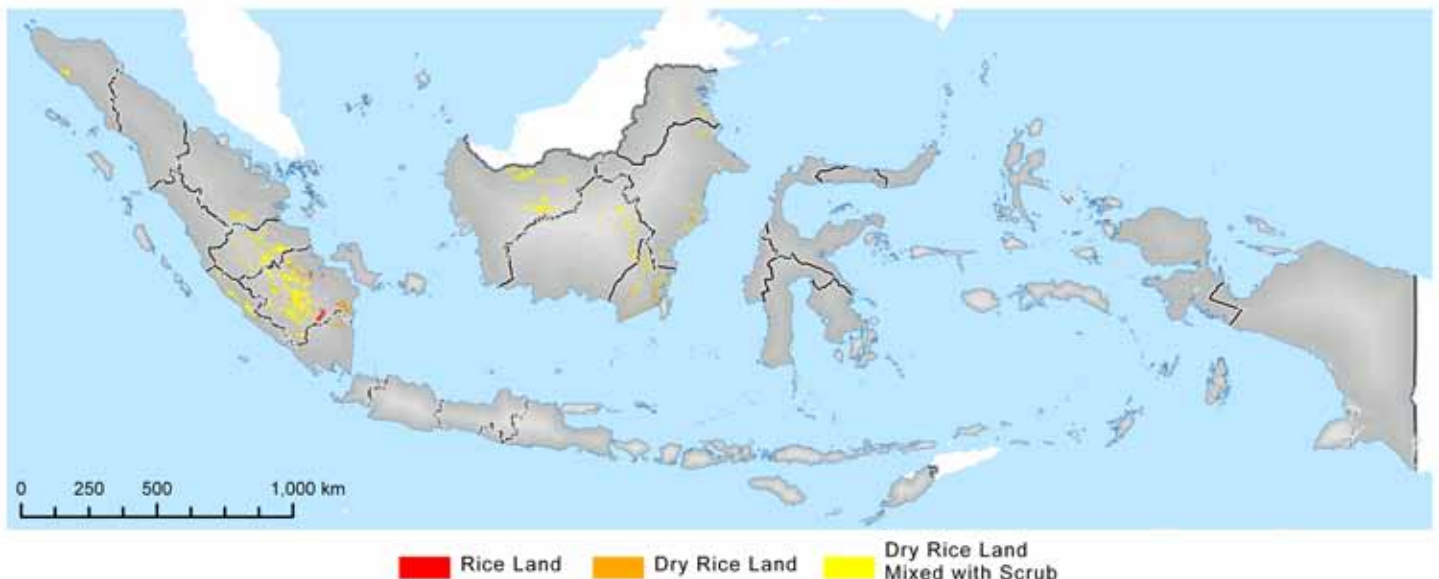
population in the face of climate change impacts, Indonesia must continue to expand its food cultivated area. The challenge is to do so without adding to the world’s greenhouse gas burden or impacting on Indonesia’s unique natural heritage.

Expanding food production supported with irrigation networks, outside the existing food production centers in Java, is hardly a new suggestion for Indonesia,<sup>137</sup> and has been achieved with variable success in some areas. However, good productive land is limited and has mostly been utilized either for existing food production or set aside for mining, forestry, oil palm and conservation.

Recent estimates put the dryland agricultural area in Indonesia at 50 million hectares, but of this only 35 to 37 million hectares are suitable for cultivation of food crops.<sup>138</sup> These estimates

do not, however, account for conservation areas and primary forest and peatland protected under moratorium or existing land use allocation. In order to expand Indonesia’s food cultivation it is necessary to cultivate suitable land within oil palm, forestry plantation and coal concessions. These land use allocations must therefore be changed to allow for food cultivation or risk increasing future food production deficits.

Using the land system spatial dataset RePPPOT (Regional Physical Planning Project for Transmigration)<sup>139</sup> and the Indonesian Government Land Use spatial dataset,<sup>140</sup> existing cultivated rice land was matched with land system categories for all of Indonesia except Java. The result was a map of land suitability for rice production. After removing existing cultivated land, primary forest,



Map 6: Indonesian rice cultivation within coal concessions



Land Cover	Mining/Cnst. (ha)	Exploration / Feas. (ha)	Rice affected by coal (ha)	All rice land (ha)	Rice affected by coal (%)
Rice Land	48,212	274,609	322,821	7,484,271	4.3
Dry Rice Land	297,006	907,586	1,204,592	10,146,583	11.9
Dry Rice Land/ Scrub	1,458,527	5,398,923	6,857,450	26,448,055	25.9
<b>Total</b>	<b>1,803,745</b>	<b>6,581,118</b>	<b>8,384,863</b>	<b>44,078,909</b>	<b>19</b>

Table 6: Total area of mapped cultivated land and the area of these lands affected by coal concessions.

Land Cover	Mining/construction	Exploration/feasibility
<b>Rice Land (4 tons/ha)</b>	192,848	1,098,436
<b>Dry Rice Land (2.5 tons/ha)</b>	742,515	2,268,965
<b>Dry Rice Land Mixed w/Scrub (0.5 ton/ha)</b>	729,264	2,699,462
<b>Total (tons)</b>	<b>1,664,627</b>	<b>6,066,863</b>

Table 7: Indonesian rice production estimated lost and at risk to coal mining.



Map 7: Land identified as capable of rice cultivation within coal concessions.

peatlands and protected areas, we estimate that there are about 18.75 million hectares of additional land capable of cultivation outside of Java (see map 5).

The largest areas of land capable of new cultivation is in the Provinces of East Kalimantan with (2.9 million hectares), South Sumatra (2.6 million hectares), Riau (1.8 million hectares) and Central Kalimantan (1.3 million hectares) (see table 5). East Kalimantan Central Kalimantan and South Sumatra, also have the largest areas of coal mining concessions and coal production (see table 1).

## COAL'S IMPACT ON FOOD PRODUCTION LAND

The impact that coal mining has on food production is extensive with multiple issues that have yet to be resolved. However, the greatest impact that mining has on food production in Indonesia is the loss of productive cultivated land.

### COAL'S CONFLICT WITH EXISTING RICE PRODUCTION LAND

According to Indonesian Government Coal Concession spatial data,<sup>141</sup> and Ministry of Forest spatial land cover data,<sup>142</sup> coal concessions cover 19 percent of Indonesia's total 44 million hectares of existing mapped rice land (see table 6). Of this area of rice land affected by coal concessions, 1.6 million hectares (7 percent) are within operating mine concessions (Production, Exploitation and Mining categories) and 6.5 million hectares (15 percent) within coal exploration concessions (see map 6 and table 6). Coal concessions cover 4.3 percent (322,821 hectares) of high yield irrigated rice land, 12 percent (1.2 million hectares) of dry rice land, and 26 percent (7 million hectares) of shifting agriculture dry rice land mixed with scrub (see table 6).

Coal concessions affect 8.7 percent of Indonesia's mapped permanently productive irrigated and dry rice land: 345,000 hectares by operating mine and construction concessions and 1.18 million hectares by exploration and feasibility concessions. Using the conservative yield figures of four tons per hectare for irrigated rice, 2.5 tons per hectare for dryland rice, and 0.5 ton per hectare for shifting/rotated rice, we estimate that about 1.7 million tons of rice per year has been lost due to coal mining and 6 million tons per year of rice production is at risk, if the exploration and

feasibility concessions are mined for coal (see table 7).

### COAL'S THREAT TO INDONESIA'S POTENTIAL RICE PRODUCTION

According to Indonesian Government Coal Concession spatial data,<sup>143</sup> the land system spatial dataset RePPPProT<sup>144</sup> and the Indonesian Government Land Use spatial dataset,<sup>145</sup> mapped coal concessions cover 23 percent (4.3 million hectares) of land identified as capable of growing rice outside of Java and existing rice cultivation (see map 7 and table 8).

East Kalimantan and South Sumatra, the Provinces with the largest areas of identified land capable of new rice cultivation (2.9 and 2.6 million hectares respectively), also have the highest area of coal concessions affecting this land (54.1 percent and 39 percent respectively). South Kalimantan, Jambi and Central Kalimantan have 48, 35 and 22 percent of identified land capable of new rice cultivation affected by coal concessions (see map 7 and table 8).

Operating coal mine concessions occupy 1.1 million hectares of the area identified as capable of new rice cultivation. Half of these operating mine concessions are in East Kalimantan.

With costly rehabilitation expenses and a high risk of environmental damage, the land occupied by operating mine concessions is unlikely to ever be useful for cultivation. If this area was available for cultivation, even dry land rice production using a conservative yield of 2.5 tons a hectare would produce an additional 3 million tons of rice annually, enough to feed well over 10 million people.

The area of land capable of cultivation that currently lies within exploration concessions remains available if Indonesia can chart a new course and prioritize long-term food security over short-term economic interest. If it were re-allocated from coal exploration to rice cultivation, this area of land could conceivably produce an additional 7.9 million tonnes of rice annually, enough rice to feed over 30 million Indonesians.

Much of the land set out in table 8 is already occupied by forestry and oil palm plantations. However, these land uses do not necessarily exclude its use for future food production. Coal mining, however, leaves the land useless for such activities.

We estimate the total impact on Indonesia's future rice production if all this potentially productive agricultural land was mined for coal would be the loss of 4.3 million hectares and annual yield of over 10 million tonnes of dryland rice production.

Province	Mining (ha)	Exploration (ha)	Construction (ha)	Feasibility (ha)	Total (ha)
East Kalimantan	557,832	981,463	17,461	2,736	1,559,492
South Sumatra	163,570	807,609	24,399	7,660	1,003,238
Central Kalimantan	134,161	237,208	3,289	5,634	380,292
South Kalimantan	153,916	205,963	10,001	9,427	379,307
Jambi	29,107	256,786	6,744	209	292,846
West Papua		172,836			172,836
West Kalimantan	13,423	125,978		79	139,480
North Kalimantan	19,526	88,579	3,670		111,775
Lampung	59	86,144			86,203
Riau	30,438	51,860		3,619	85,917
Papua		70,201			70,201
Aceh	2,491	18,470			20,961
Bengkulu	1,210	7,204			8,414
West Sumatra	339	6,968			7,307
North Sumatra		6,002			6,002
Maluku		3,064			3,064
North Maluku		1,226			1,226
Central Sulawesi		326			326
South Sulawesi		207			207
Southeast Sulawesi	13	4			17
<b>Total</b>	<b>1,106,085</b>	<b>3,128,098</b>	<b>65,564</b>	<b>29,364</b>	<b>4,329,111</b>

Table 8: Provinces outside of Java capable of new cultivation and affected by coal concessions.

#### COAL'S CUMULATIVE IMPACT ON INDONESIA'S FUTURE RICE PRODUCTION

We estimate that coal production concessions cover almost 3 million hectares of existing and potential rice land and exploration concessions cover an additional 9.7 million hectares.

The potential impact on future rice production based on existing rice systems, and applying dryland rice yields to new rice production

areas, is about 18.5 million tonnes per annum (see table 9).

The cumulative total impact on Indonesia's potential rice production due to coal mining reaches over 50 million tonnes a year when rice systems are improved (see table 10). This would require significant resources to enable irrigated rice in all the land capable of growing rice we have identified, as well as improving existing rice production land – dryland rice to irrigated rice and rotating/ shifting rice production to permanent dryland rice production. We make the assumption that

Rice system and yield	Mining concessions (ha)	Lost production from mining concessions (tonnes)	Exploration concessions (ha)	Lost production from exploration concessions (tonnes)	Total rice land affected by all coal concessions (ha)	Total rice production lost under existing rice systems (tonnes)
Rice Land - 4 t/ha	48,212	192,848	274,609	1,098,436	322,821	1,291,284
Dry Rice Land 2.5t/ha	297,006	742,515	907,586	2,268,965	1,204,592	3,011,480
Dry Rice Land/ Scrub 0.5/t/ha	1,458,527	729,264	5,398,923	2,699,462	6,857,450	3,428,725
Rice capable land - using dry rice cultivation system 2.5t/ha	1,171,649	2,929,123	3,157,462	7,893,655	4,329,111	10,822,778
<b>Total</b>	<b>2,975,394</b>	<b>4,593,749</b>	<b>9,738,580</b>	<b>13,960,518</b>	<b>12,713,974</b>	<b>18,554,267</b>

Table 9: Coal concessions and Indonesia's rice land and lost rice production under existing agricultural systems

Rice system and yield	Lost production from mining concessions (tonnes)	Lost production from exploration concessions (tonnes)	Total rice production lost under existing rice systems (tonnes)
Irrigated Rice Land (4 t/ha)	192,848	1,098,436	1,291,284
Dry Rice Land (2.5t/ha) to irrigated rice (4t/ha)	1,188,024	3,630,344	4,818,368
Dry Rice Land/ Scrub (0.5/t/ha) to dryland rice (2.5t/ha)	3,646,318	13,497,308	27,429,800
Rice capable land - irrigated rice (4t/ha)	4,686,596	12,629,848	17,316,444
<b>Total</b>	<b>9,713,786</b>	<b>30,855,936</b>	<b>50,855,896</b>

Table 10: Potential lost rice production within coal concessions under improved agricultural systems





*KPC Mine, East Kalimantan (JATAM). [ DROPBOX FILE - Melubangi bumi (Bengalon, Kutim) .JPG]  
Tambang KPC, Kalimantan Timur (JATAM).*

## CONCLUSION

Despite rapid economic growth and a corresponding increase in middle class wealth, many Indonesians are going hungry.<sup>146</sup> This is borne out by the alarming levels of nutritional deficits that persist across the country, and felt to a disproportionate degree by Indonesian children. More than a third of Indonesian children under five suffer from stunting, a statistic that will continue to haunt the country for generations due to the debilitating impact stunting has on the future success and productivity of those it afflicts. The present massive land use allocation for export commodities, such as coal and oil palm, adds to the burden of finding enough food to ensure that all Indonesian children can look forward to a full and productive life and a chance to share in the country's growing wealth.

While oil palm is also responsible for limiting available land for growing enough affordable food, it is the land allocated to coal mining that occupies the greatest net area. Indeed along with 19 percent of existing rice cultivation and 25 percent of suitable land for new rice cultivation, 15 percent of land allocated for oil palm is also at risk of being stripped and mined for coal.

Land allocated to coal mining covers almost 10 percent of Indonesia, 80 percent of which is under exploration and poses the greatest risk to Indonesia's future food security. Allowing the mining of such an area would defeat the National Government goal of being able to grow enough food for its people. From the evidence gathered in this report, it appears that coal mining has a greater potential impact on Indonesia's future food production than any other land use. Indonesia's national government has reined in the expansion of oil palm planting and has promised a similar check of coal's expansion, but as yet these promised reforms remain outstanding. Operating coal mines occupy almost 4 million hectares and are having a devastating immediate impact. Coal companies are currently allowed to avoid compliance with Indonesia's meager land rehabilitation and water protection regulations. Coal mining therefore leaves the land scarred and barren, water catchments choked and polluted, and groundwater depleted. Coal mining can therefore confidently be assumed to destroy any potential cultivation on the land that it occupies.

Investigations for this report reveals rice and fish farmers adjacent to coal mines suffer 50 percent reductions in rice yields and 80 percent reductions in fish yields. We believe that the main cause is aluminum, iron and manganese pollution from coal mining, which is not adequately regulated by Indonesian governments. Aluminum, a major coal mine pollutant and one of the major non-biological factors limiting plant growth, is particularly lethal to young rice plants at concentrations as low as 0.5 part per million. Sixty percent of the water samples taken in and around

Indonesian coal mines for this report were found to contain aluminum concentrations above this level, and one, from a rice irrigation channel, was found to be 32 times this level. Indonesia is the world's largest exporter of steaming coal for coal-fired power station. The contribution this makes to the world's greenhouse gas burden alone should be a factor incorporated in future food supply calculations. A rapidly growing population and a stubborn preference for rice, a limited commodity on global markets, means that Indonesia must continue to increase rice production on an ever shrinking area of land. Climate impacts such as El Niño droughts often affect Indonesia's rice crop, forcing the country to import rice, thereby pushing up the price of the country's food staple. Climate change is expected to increase the frequency and intensity of these events, as well as increase crop pest and disease. Experts predict climate change may reduce Indonesia's rice crop by as much as 27 percent in 2050 when the country's is also expected to feed 25 percent more people.

Indonesia therefore must continue to expand its food cultivation. In order to meet this challenge it will be necessary to cultivate suitable land within oil palm, forestry plantation and coal concessions. These land use allocations must therefore be changed to allow for food cultivation or risk increasing future food production deficits. While oil palm and forestry plantations restrict immediate food production expansion, it is coal mining that leaves land unusable for food production.

We estimate that coal mining has already reduced Indonesia's annual rice production by 1.7 million tonnes through the mining of cultivated land. We further estimate that under currently used cultivated systems 6 million tonnes of annual rice production is at risk, if coal companies are allowed to mine exploration concessions that cover existing cultivated land.

Coal's impact on Indonesia's rice growing potential is of most concern with respect to future food security objectives. Given the severely abject and destructive conditions of mines, almost 18.5 million tons of annual rice production potential could be lost. Indeed, if these areas were provided with irrigation and improved seed varieties and fertilizer, the land occupied by coal concessions could produce over 50 million tons of rice a year, enough to feed all of Indonesia's expected population increase to 2050 and beyond, even after climate impacts are taken into account. Indonesia cannot afford to lose valuable food producing land. Nor can it continue to allow its water resources, essential for crops, to be polluted and choked with sediment. If the country is to continue to feed itself, the National Government must overturn all coal concessions on cultivated land and land capable of cultivation and force coal companies to rehabilitate the land that it currently mines.

## FOOTNOTES

- <sup>1</sup> Gilles Pison, 2015.
- <sup>2</sup> Food and Agriculture Organization, electronic files and web site, 2016.
- <sup>3</sup> Food Security Council, the Ministry of Agriculture and World Food Programme (WFP), 2015.
- <sup>4</sup> Food Security Council, the Ministry of Agriculture and World Food Programme (WFP), 2015.
- <sup>5</sup> Food Security Council, the Ministry of Agriculture and World Food Programme (WFP), 2015.
- <sup>6</sup> World Bank, 2017.
- <sup>7</sup> BPS. 2014.
- <sup>8</sup> World Bank, 2017.
- <sup>9</sup> World Bank, 2017.
- <sup>10</sup> UNICEF, 2013.
- <sup>11</sup> World Bank, 2017.
- <sup>12</sup> International Food Policy Research Institute. 2014.
- <sup>13</sup> Black et al. 2013.
- <sup>14</sup> Mervyn Piesse, 2016.
- <sup>15</sup> World Bank, 2015.
- <sup>16</sup> Horton and Steckel, 2013.
- <sup>17</sup> OECD, 2015b.
- <sup>18</sup> Tempco, 2016.
- <sup>19</sup> FAO, 2016.
- <sup>20</sup> Food Security Council, the Ministry of Agriculture and World Food Programme (WFP), 2015.
- <sup>21</sup> GRiSP, 2013.
- <sup>22</sup> GRiSP, 2013.
- <sup>23</sup> Widyanti et al, 2014.
- <sup>24</sup> Indonesia Investments, 2015.
- <sup>25</sup> Jakarta Globe, 2012.
- <sup>26</sup> Widyanti et al, 2014.
- <sup>27</sup> Oryza, 2015.
- <sup>28</sup> Wailes, 2005; Indonesia Investments, 2016.
- <sup>29</sup> Wall Street Journal, 2015.
- <sup>30</sup> Wall Street Journal, 2015.
- <sup>31</sup> Reuters, 2014.
- <sup>32</sup> Reuters, 2014.
- <sup>33</sup> Reuters, 2014.
- <sup>34</sup> OECD, 2015.
- <sup>35</sup> Naylor et al, 2007.
- <sup>36</sup> FAO, 2016.
- <sup>37</sup> FAO, 2016.
- <sup>38</sup> John McCarthy, 2014.
- <sup>39</sup> The Economist, 1998.
- <sup>40</sup> The Economist, 1998.
- <sup>41</sup> Food Security Council, the Ministry of Agriculture and World Food Programme (WFP), 2015
- <sup>42</sup> Yuliawan and Handoko, 2016.
- <sup>43</sup> Handoko, Sugiarto and Syaukat, 2008.
- <sup>44</sup> Food Security Council, the Ministry of Agriculture and World Food Programme (WFP), 2015
- <sup>45</sup> GRiSP. 2013.; McCarthy and Obidzinski, 2015.
- <sup>46</sup> Disaster Management Center Dompot Dhuafa, 2015.
- <sup>47</sup> Food Security Council, the Ministry of Agriculture and World Food Programme (WFP), 2015
- <sup>48</sup> McCarthy, J.F and Obidzinski, K,
- <sup>49</sup> Nurni Sulaiman, 2014.
- <sup>50</sup> Nurni Sulaiman, 2014.
- <sup>51</sup> See for example Rautner et al, 2002; Faisal Maliki Baskoro, Jakarta Globe, 2011; McCarthy and Obidzinski, 2015; John McCarthy, The Jakarta Post, 2014.
- <sup>52</sup> McCarthy, JF, 2013.
- <sup>53</sup> FAO, 2014.
- <sup>54</sup> IEA, 2016.
- <sup>55</sup> Enerdata, 2015.
- <sup>56</sup> Enerdata, 2015.
- <sup>57</sup> Fedina S. Sundaryani, The Jakarta Post, 2016.
- <sup>58</sup> Fedina S. Sundaryani, The Jakarta Post, 2017.
- <sup>59</sup> Fedina S. Sundaryani, The Jakarta Post, 2016.
- <sup>60</sup> Petromindo, 2009-2013
- <sup>61</sup> Petromindo, 2009-2013
- <sup>62</sup> Reuters, 2016.
- <sup>63</sup> Indonesia Investments, 2016.
- <sup>64</sup> Indonesia Investments, 2016.
- <sup>65</sup> Takashi Sasaoka et al, 2015.
- <sup>66</sup> ELTI, 2013.
- <sup>67</sup> Clara Ferreira Marques, 2016.
- <sup>68</sup> Clara Ferreira Marques, 2016.
- <sup>69</sup> Sasaoka et al, 2015.
- <sup>70</sup> See for example Hydrocology Environmental Consulting, 2013.



- <sup>71</sup> Geller, et al, 2012.
- <sup>72</sup> Martini et al, 2007.
- <sup>73</sup> Greenpeace Southeast Asia, 2016.
- <sup>74</sup> Tessa Toumbourou, 2014.
- <sup>75</sup> Tessa Toumbourou, 2014.
- <sup>76</sup> Fergus Jensen, 2016.
- <sup>77</sup> Indonesia Investment, 2015a.
- <sup>78</sup> Komnas HAM, 2015. (Republic of Indonesia’s National Commission For Human Rights (Komnas HAM). Komnas HAM’s recommendation on cases of children drowning in Samarinda’s abandoned mine pits.
- <sup>79</sup> <http://af.reuters.com/article/idAFL8N18Q0H1?sp=true>
- <sup>80</sup> Puhlovich & Coghill, 2011; Richardson, 2012.
- <sup>81</sup> U.S. Code, 1977.
- <sup>82</sup> See for example Jambor and Blowes, 1998; Parker, 1999.
- <sup>83</sup> See for example Banks, Burke and Gray, 1997; Brady, Smith and Schueck, 1998.
- <sup>84</sup> Saria, Shimaoka and Miyawaki, 2006.
- <sup>85</sup> Jennings et al, 2000; Montero et al, 2005; Lottermoser, 2007.
- <sup>86</sup> Kargbo et al, 1993; Bell et al, 2001; Nordstrom and Alpers 1999.
- <sup>87</sup> Tornos, F., López Pamo, E. Sánchez España,
- <sup>88</sup> Greenpeace Southeast Asia, 2014.
- <sup>89</sup> Mike Ives, 2015.
- <sup>90</sup> Nagajyoti et al, 2010.
- <sup>91</sup> Babel & Kurniawan, 2004; Hossain et al, 2012
- <sup>92</sup> Hossain et al, 2012.
- <sup>93</sup> Takashi Ozawa et al, 1999.
- <sup>94</sup> Takashi Ozawa et al, 1999.
- <sup>95</sup> Tan, 1968.
- <sup>96</sup> US EPA, 1996.
- <sup>97</sup> Milind et al, 2012; ATSDR. 2007.
- <sup>98</sup> Exley, 1996.
- <sup>99</sup> Rosseland et al, 1990; Berntssen et al, 1997; Exley, 1998
- <sup>100</sup> Mossor-Pietraszewska, 2001.
- <sup>101</sup> Mossor-Pietraszewska, 2001.
- <sup>102</sup> Mossor-Pietraszewska, 2001.
- <sup>103</sup> Delhaize and Ryan. 1995.
- <sup>104</sup> Balsberg Pahlsson, 1990; Carvalho et al, 1980; Foy, 1988; Foy, 1992; Kamprath & Foy, 1985; Roy et al, 1988.
- <sup>105</sup> Thawornwong & Van Diest, 1974.
- <sup>106</sup> Stein et al, 2014.
- <sup>107</sup> Becker and Asch, 2005.
- <sup>108</sup> Lantin and Neue, 1989.
- <sup>109</sup> Abifarin, 1988; Lantin and Neue, 1989.
- <sup>110</sup> Brandt, 1948; Doudoroff, and Katz, 1953.
- <sup>111</sup> O’Sullivan et al, 1997.
- <sup>112</sup> El Jaoual & Cox, 1998.
- <sup>113</sup> Berger & Gerloff, 1947.
- <sup>114</sup> Berger & Gerloff, 1947.
- <sup>115</sup> Srivastava & Dubey, 2011.
- <sup>116</sup> Banktrack, 2016.
- <sup>117</sup> PT Bumi Resources Tbk, 2017.
- <sup>118</sup> Karmini, K. 2017.
- <sup>119</sup> Indonesia Investments, 2016.
- <sup>120</sup> GRiSP, 2013.
- <sup>121</sup> FAO, 2005.
- <sup>122</sup> BPS, 2015.
- <sup>123</sup> BPS, 2015.
- <sup>124</sup> MoEF, 2015.
- <sup>125</sup> BPS, 2015.
- <sup>126</sup> McCarthy and Obidzinski, 2015.
- <sup>127</sup> McCarthy and Obidzinski, 2015.
- <sup>128</sup> Panuju et al, 2013.
- <sup>129</sup> Di Nunzio, 2013.
- <sup>130</sup> Di Nunzio, 2013.
- <sup>131</sup> Di Nunzio, 2013.
- <sup>132</sup> Di Nunzio, 2013.
- <sup>133</sup> Di Nunzio, 2013.
- <sup>134</sup> World Bank, 2016.
- <sup>135</sup> Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded.
- <sup>136</sup> Panuju et al, 2013.
- <sup>137</sup> Panuju et al, 2013.
- <sup>138</sup> Panuju et al, 2013; Agus et al, 2015.
- <sup>139</sup> RePPPProT. 1990.
- <sup>140</sup> MoEF, 2015.
- <sup>141</sup> Petromindo, 2009-2013.
- <sup>142</sup> MoEF, 2015.
- <sup>143</sup> Petromindo, 2009-2013.
- <sup>144</sup> RePPPProT. 1990.
- <sup>145</sup> MoEF, 2015.
- <sup>146</sup> Sandra Siagian, 2017.

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