OXFAM RESEARCH REPORT

GEOGRAPHIES OF CONFLICT

MAPPING OVERLAPS BETWEEN EXTRACTIVE INDUSTRIES AND AGRICULTURAL LAND USES IN GHANA AND PERU

OXFAM America

CONTENTS

ACKNOWLEDGMENTS

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March 2014

Farmer working in his field in Cusco, Peru.
Percy Ramirez / Oxfam America

FOREWORD

Mining, oil, and gas extraction have exploded across Latin America and Africa in the past decade, driven by high prices for oil, gold, and industrial metals like copper. In many countries, mining and oil activity have come into direct competition with small-scale agriculture. Tensions over control of land and, most importantly, water have led to community protests and violent conflict. Reconciling these two important development drivers has become a critical governance and development issue.

Oxfam America has been involved in these issues for more than 15 years. Throughout this time we have supported civil society engagement with governments, international financial institutions, and corporations to better protect the rights of rural communities affected by extractive industries. We have advocated for greater transparency and for greater respect for the right of communities to determine their own futures. We have seen the power of information in helping inform public debates that can lead to progressive policy change.

This report, a collaboration between Oxfam America and geographers from Clark University, seeks to contribute to productive dialogue on the tensions between extractive industries and agriculture by graphically depicting where these activities overlap in two resource-dependent developing countries: Peru and Ghana. In both countries, Oxfam America has long experience in promoting sustainable agricultural livelihoods and better development outcomes from extractive industries.

This report shows how mining and oil concessions have expanded dramatically in recent years in agriculturally productive areas. Policymakers, corporate officials, and civil society should give urgent attention to promoting policy solutions to address the actual and potential conflicts this expansion creates. Zoning land for particular uses, for example, could help reduce conflict by establishing clear rules for how land will be used. Greater transparency and increased investment of oil and mining revenues to strengthen agricultural production should also be a priority for public debate. And greater dialogue between the extractive and agricultural sectors is needed.

Reconciling extractive industries with agriculture in developing countries such as Peru and Ghana will not be easy. Governments and civil society should promote informed discussions so that countries can benefit from both their above- and below-ground resources and so that conflict and violence produced by the juxtaposition of these two sectors diminishes. We hope that this report can contribute to that dialogue.

Keith Slack
Global Program Manager
Oxfam America

March 2014

SUMMARY OF FINDINGS

When extractive industries expand, they often move into territory already used by people who depend on farming, ranching, forestry, or fishing for their livelihoods. The change adds new risk and uncertainty to the lives of these residents. Will the arrival of oil and mining operations help or interfere with their livelihood? Will it change things profoundly or marginally? Answering these questions is hard for anyone, but it is especially hard for rural residents, who may lack information about planned drilling or mining projects. Complicating matters is that players may have an incentive to present or interpret information according to their own view of a project's value.

When concessions given to extractive industries are mapped, the result can be understood as a geography of risk and uncertainty for a range of stakeholders. For industry, it maps investment uncertainty—the company hopes that a lucrative deposit lies underground, but it does not know this. Companies making short-term, speculative investments are likely to behave more assertively and hurriedly than those with longer-term, more stable investment backing. Likewise, residents in an area under concession wonder if a project will actually proceed and, if so, whether it will affect the value of their land and the quality of their water. Will their children's future be affected, for good or ill? More profoundly, will the arrival of industry forever change the feel of life in the world they know? The arrival of a concession must, by its very nature, produce uncertainty. No one can be sure if it will introduce new risks, opportunities, or both.

Mapping the way different interests overlap helps bring these risks and uncertainties into focus. Concession maps of this kind reflect geographies of possible change in people's access to the land and resources on which livelihoods depend. Change induces worry—and before one writes off such worry as irrational or overstated, it is worth noting that companies and people of means routinely buy insurance to protect themselves against highly unlikely events. Put another way, oil and mining companies worry about potential, but unlikely, change at least as much as farmers do. They, however, have the luxury of converting that worry into an insurance policy.

This document reports on a series of visualization and mapping exercises that explore the overlap between the claims of extractive industries and the geographies of natural resources vital to other players. Land suitable for farming is a key element in this overlap. This fact is significant given that both the countries under examination, Peru and Ghana, are faced with a shortage of arable land. Similarly, overlaps with water resources for farming are also significant—and growing.

Overlaps with protected areas in both countries are more limited. This situation suggests that the system governing protected areas—and their boundaries—has been moderately resilient in the face of extractive industries. Such resilience reflects, presumably, the relative strength of legislation and public support for land preservation. That overlaps more commonly involve land areas with agricultural potential, water resources, forest cover, and indigenous and campesino territories suggests the absence or weakness of any systematic way to reduce conflicts and find common ground among stakeholders. This circumstance reflects, presumably, the lack of relevant legislation or public support. Perhaps the most striking example in this regard relates to water resources. Ghana and—especially—Peru suffer water constraints that undercut both farming potential and urban quality of life. The problem is likely to grow more serious in the future. Water is a particularly scarce resource, and one would expect well-designed systems for allocating it. Yet the maps reveal extensive overlaps between concessions and water resources, overlaps that are growing steadily larger.

Increasingly in the years ahead, different land users are likely to compete for access to the same land and water resources. Maps showing where intended land uses overlap thus identify places where the expansion of extractive industries could threaten existing land- and water-dependent livelihoods. (By the same token, an effort to protect traditional livelihoods could be taken as a threat to industry.) In the absence of negotiated settlement among the interested parties, these regions are most apt to become a country's zones of conflict.

Conflict over land use and access to resources results from the operation of certain institutions. These include institutions of property (that confer rights in land, rights in the subsoil, and

Gladys Amankwaa is a cocoa farmer in Brong-Ahafo, Ghana. Recent gold finds in cocoa-producing areas are pitting industrial gold mining interests against farmers in Ghana. *Neil Brander / Oxfam America*

rights in water) and the institutions through which this property is allocated. The work presented in this report emphasizes one of these institutions: that involved in property rights in the subsoil. It would also be possible, though complicated, to map overlaps among a range of institutions—for instance, of property in concessions, property in water rights and property in land rights. Arguably the best scale at which to begin such a task would be quite local, given the amount of data that would have to be visualized.

Likewise, it would be possible to map conflicts. One might map the land or natural resources that sparked the conflict and at the same time map the home territories of the actors in conflict. (These latter maps could be local, national, or even global, given the international nature of many extractive enterprises, financing institutions, and nongovernmental organizations). Such maps have not yet been devised. In the meantime, we hope this document suggests different ways to visualize some of the new forms of competition over land use that arise as extractive industries expand.

INTRODUCTION

BACKGROUND

For more than a decade, Oxfam's Extractive Industries (EI) Program has worked to improve the lives of people living in areas affected by mining, oil, and gas operations. Most of these people depend on farming for their well-being. Recently, Oxfam launched a campaign for food justice (the GROW campaign), which focuses on how food is produced in the global food system and highlights the crucial role of smallholder farmers in providing food security. With mining and oil companies increasingly competing with farmers for land and natural resources, Oxfam must weigh which use of land has the greater potential for reducing poverty, fostering sustainable livelihoods, and contributing to rights-based development.

This report uses mapping, visualizations, and spatial analysis as tools to explore conflicts and relationships among different land users. Moreover, it suggests possible impacts in coming years on livelihoods in the areas studied. The analysis was conducted in Peru and Ghana by Clark University researchers working under contract with Oxfam America.

Both Peru and Ghana have significant and growing extractive sectors. Farming, meanwhile, is vital to both countries, despite water shortages and severe poverty in many agricultural areas. The governments in each country have at least some capacity for planning and regulating economic activity. Thus they share the challenge of managing relationships between two sectors that sometimes compete, though each sector plays a role in combating poverty. Our analysis offers insights into the interplay of industry, agriculture, and natural resources in countries known for a "mining identity"—countries whose leaders, that is, have traditionally encouraged extractive industries, with varying degrees of planning and regulation.

EXTRACTIVE INDUSTRY CONTEXT

Both Peru and Ghana have hard-rock mining and hydrocarbon sector, though activity in both countries was stagnant into the early 1990s. The International Council on Mining and Metals notes that in Ghana "during the years of economic collapse, mining suffered along with other industrial sectors.[1] Indeed, from independence in 1957 to the early 1990s not a single new gold mine was opened." In recent years, however, mining in both countries has rebounded, especially in Peru.

Growth has been most pronounced in the hydrocarbon sector. In both countries, hydrocarbon extraction is a relatively new activity, and in both it has benefited from a recent surge of investment. Oil was discovered in Ghana only in 2007, while Peru's hydrocarbon deposits have been worked for more than four decades. Between 2004 and 2008, hydrocarbon concessions in the Peruvian Amazon increased from covering less than 15 percent of the basin to nearly three-quarters of it.[2] In Ghana, meanwhile, the majority of coastal waters since 2007 have been opened to exploration or drilling for oil and gas. (The situation is similar in Peru). An analyst recently concluded that in Ghana, oil exports are projected to yield $1 billion-1.5 billion annually, or 6-9 percent of GDP, and that oil is "poised to replace cocoa as the main driver of economic growth."[3]

Understandably, many people in both countries are enthusiastic about the work of extractive industries there. Nonetheless, there is considerable public debate about the risks of relying on these industries as a path to development. Indeed, each country has experienced pollution, accidents, and serious public health incidents related to the industry.[4] Likewise, each country has experienced problems in managing the tax and royalty revenues from extraction (though each, in compliance with the Extractive Industries Transparency Initiative, seeks to foster transparency in how revenues are handled).

Because of data limitations, our study focuses primarily on large- or medium-scale operations run by corporations. Still, it is important to note that small-scale or artisanal mining is a notable activity in each country.[5] For the purpose of the visualizations produced here, we have not distinguished between corporate and noncorporate mining. Nor do our visualizations reflect illegal mining outside concession areas. Clearly, these different scales and modes of mining exert different pressures on land use and natural resources. They also trigger different forms of social conflict. It follows that these different kinds of mining call for different institutional mechanisms to manage land use competition.

Potato market in the highlands of Peru. Agriculture is an important source of employment and export revenue for the country, but large-scale mining and hydrocarbon projects can affect the land and water on which farmers rely. *Percy Ramírez / Oxfam America*

It is important to note that agriculture continues to be the largest employer of the rural population in both countries, though the work is generally low paid and often part time. Farming is also, in each country, an important source of export revenue. In Ghana, cocoa remains for now the country's most important export. In Peru, the past 20 years have seen a transformation of agriculture, especially along the coast, and the country is now a major exporter of vegetables and fruits.

EXTRACTIVE INDUSTRIES AND AGRICULTURE

Farms and mines coexist uneasily. This report takes no view on whether this relationship is fundamentally synergistic or antagonistic. The emphasis is, instead, on visualizing ways in which these two forms of land use affect each other. The report looks at the relationships between industrial activity and the spatial distribution of four attributes:

- Arable land, whether it is now being farmed or not
- Water resources (drainage basins, surface water, underground water storage, etc.)
- Protected areas
- Formally recognized indigenous communities and other rural settlements

The following definitions are used for key terms in this report:

Agricultural lands refer to croplands (including those used for shifting agriculture), grazing lands, and lands used for hunting, gathering, and fishing. A distinction is made between actual agricultural land use (as revealed and measured by remote sensing) and potential agricultural land use (as defined by the country's own authorities).

Drainage basins are defined by local authorities as hydrological subsystems nested within larger systems (typically given the name of the largest river in the system). All land is allocated to

one or another drainage basin. Although drainage basins have discernible boundaries, they can affect one another when one basin drains into another.

Settlements and ***communities*** are also defined by the local authorities. Our analysis adds a buffer of 12 km around areas identified by government records as towns or villages. We add this buffer to take into account human activity and experiences that happen beyond a settlement's borders (as when rural people graze cattle or simply enjoy a vista).

Artisanal fisheries are defined as areas with the potential for fishing, whether or not they are actively fished. The fisheries are defined as extending 12 nautical miles from the nearest settlement.

Areas for extractive industries are defined as lands and seafloors for which concessions have been given, for which lots are open for bid, or which have been identified as suitable for extractive activity.

WHY CONCESSIONS?

The decision of this report to focus on the geography of extractive industry concessions merits some discussion. A concession's size is always much larger than the footprint of its actual mining or drilling operations. For this reason, some in the mining industry have argued that an emphasis on overall concessions and their overlaps is a deliberate attempt to exaggerate the industry's adverse impact. It could also be argued that such maps overlook the positive effects that corporate taxes and royalties might[6] have in the long run on providing jobs and reducing poverty.

These caveats notwithstanding, a focus on the overall size of concessions remains appropriate for several reasons:

- A concession is a legal claim on natural resources. Although a concession gives rights to what is underground, not on the surface, it implies the right to activity on the surface. Therefore the granting of a concession marks the overlapping of claims on the same piece of land. Indeed, concession holders in some cases are entitled to enforce their legal right to alter surface land by using, if necessary, expropriation or compulsory purchase.
- When a company acquires a concession or exploration block, it signals that the market regards that piece of land as a promising site for development. Even when an acquisition is largely speculative, the company's willingness to make the investment is a conspicuous signal to the market.
- Even before extractive rights are granted, a government's demarcation of land for a possible concession signals the official view of which geographic areas may be opened to development. This signal can come even with only preliminary geological data in hand.
- The existence of a concession—marking both property claims and market projections—can in itself change the dynamics of an area, even before any extraction has begun. A concession alone can have an effect on land markets, setting off speculative buying and drawing new players (not just corporate stakeholders but also geologists, community relations teams, and activists) to the region.
- The granting of concessions that infringe on existing forms of land use can be a sign that a government's system of land use planning and allocation is incapable of "joining up" the disparate needs of farmers, miners, and others with claims on the land.
- Concessions that overlap with other forms of property, and in particular with indigenous territorial claims, indicate a lack of commitment to principles of free, prior, and informed consent. They constitute a new and significant source of uncertainty for rural residents whose lives are already uncertain.
- A decision to map only those areas that are directly affected by operations would understate the area influenced by a mine or well. These operations set in motion new population movements, the transport of heavy equipment and extracted minerals, and a variety of secondary effects. These new activities affect areas far beyond the operation itself.
- Recent research in Ghana has shown that the land-use impact of surface mining extends well beyond the area of operation. Using a chronological series of maps created from satellite data for the Wassa West District, Ghana's oldest surface-mining area, one study concluded that 45 percent of the concession area had suffered substantial loss of farmland, and 58 percent had been deforested.[7]

The following sections of this report present two sets of country-level visualizations of land use interactions. The first examines Peru; the second, Ghana. The two sections are largely empirical: they do not dwell on interpretations of the patterns that emerge, nor do they analyze them in a political context. In the final section, however, we develop a wider discussion of our findings, and we draw possible implications for rural livelihoods and policy.

PERU

The following section contains maps and tables of the Peruvian regions where oil and mining concessions, agricultural areas and watersheds overlap. They detail the following:

- The data used in our spatial-overlap analysis
- The overlap of mining concessions and river basins
- The overlap of oil concessions and river basins
- The overlap of mining concessions and agricultural areas

The maps illustrate the methods that will be applied to other locations of interest (e.g., *húmedales* [wetlands], *punas* [high altitude dry grasslands]) later in this report. The spatial data used in our analysis is also viewable in interactive form at: http://students.clarku.edu/~dcheng/peru_oxfam.php.

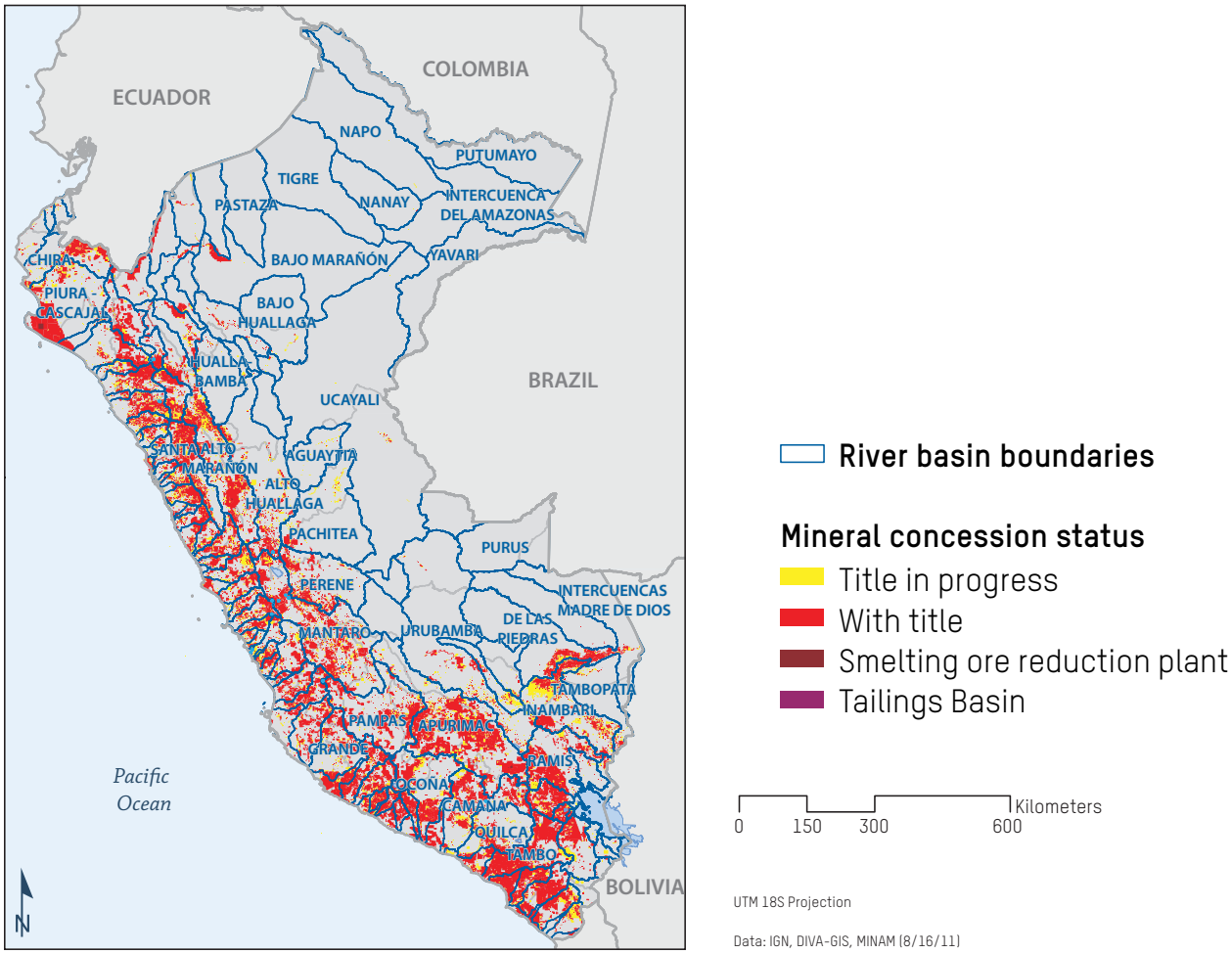
TABLE 1. DATA USED IN SPATIAL ANALYSIS OF EXTRACTIVE INDUSTRIES IN PERU

CATEGORY	NAME	SOURCE	FORMAT	TIME / RANGE	SPATIAL EXTENT
Municipal and cultural	Boundary of department, province and district	INEI	Shapefile: polygon	2008	countrywide
Elevation	DEM (Shuttle Radar Topography Mission)	NASA	Raster: 90m	2000	countrywide
Hydrology	River basins	IGN	Shapefile: polygon	2009	countrywide
	Primary river	IGN	Shapefile: polygon	2009	countrywide
	Secondary river	IGN	Shapefile: polygon	2009	countrywide
	Wetland *selva*	IGN	Shapefile: polygon	2009	countrywide
	Wetland *sierra*	IGN	Shapefile: polygon	2009	countrywide
	Lake and lagoon	IGN	Shapefile: polygon	2005	countrywide
Community	Rural agricultural communities	INEI	Shapefile: polygon	2006	countrywide
	Native communities	IBC	Shapefile: polygon	2006	countrywide
Land Cover	Land cover: observed	MDA	Raster: 30m	2000	countrywide
	Agriculture	INRENA	Shapefile: polygon	N/A	countrywide
	Land use capacity: agricultural suitability				
Mining	Concession lots	MINAM	Shapefile: polygon	2013	countrywide
	Mines and facilities locations	MINAM	Shapefile: point	2013	countrywide
Hydrocarbon	Concessions lots	PeruPetro	Shapefile: polygon	2012	countrywide
	Wells	PeruPetro	Shapefile: point	2012	countrywide
	Pipeline	IGN	Shapefile: polyline	2005	countrywide

Notes: CDC= Conservation Data Center (Peru); IBC= Instituto del Bien Común; INEI= Instituto Nacional de Estadística e Informática; IGN= Instituto Geográfico Nacional; INGEMMET= Instituto Geológico Minero Metalúrgico; INRENA= Instituto Nacional de Recursos Naturales; MDA= MDA Federal Inc.; NASA= National Aeronautics and Space Administration

FIGURE 1. SPATIAL CONFIGURATION OF MINING CONCESSIONS AND WATERSHEDS IN PERU

Concession status references the legislative decree (LD) under which the concession was granted.



WHERE MINING CONCESSIONS AND RIVER BASINS OVERLAP

Spatial data from Instituto Geologico Minero y Metalurgico (INGEMMET) depicts the rapid expansion of mining concessions in Peru over the past two decades. Using this data, the Instituto Geografico Nacional (IGN) mapped the overlap of these concessions and local river basins, or *cuencas*. The map provides one measure of the potential hydrological footprint of mineral extraction in Perú (Figure 1). The river basins' extent is based on a 2001 Peruvian government study. Within three larger watersheds (*vertientes hidrográficas*), 107 river basins are demarcated: 53 within the Pacific watershed, 45 within the Atlantic watershed, and nine within the Titicaca watershed.

As part of our analysis, we plotted the increasing share of each river basin's area given over to mining concessions in the past two decades (Figure 2). According to the data, the five drainage basins which by 2011 had the largest proportion of their area under concession were the Marañón, Mantaro, Apurimac, Camaná, and Iñambari. The overlap has increased rapidly, especially in Peru's coastal and central regions. For each of the drainage basins shown in Figure 3, we see an acceleration of these processes since 2002.

FIGURE 2. NATIONAL MAPS OF THE PERCENTAGE OF AREA OF EACH RIVER BASIN GRANTED AS A MINING CONCESSION IN PERU

Highest values are spatially clustered in highland and coastal areas, and increase most rapidly during the mid to late 2000s.

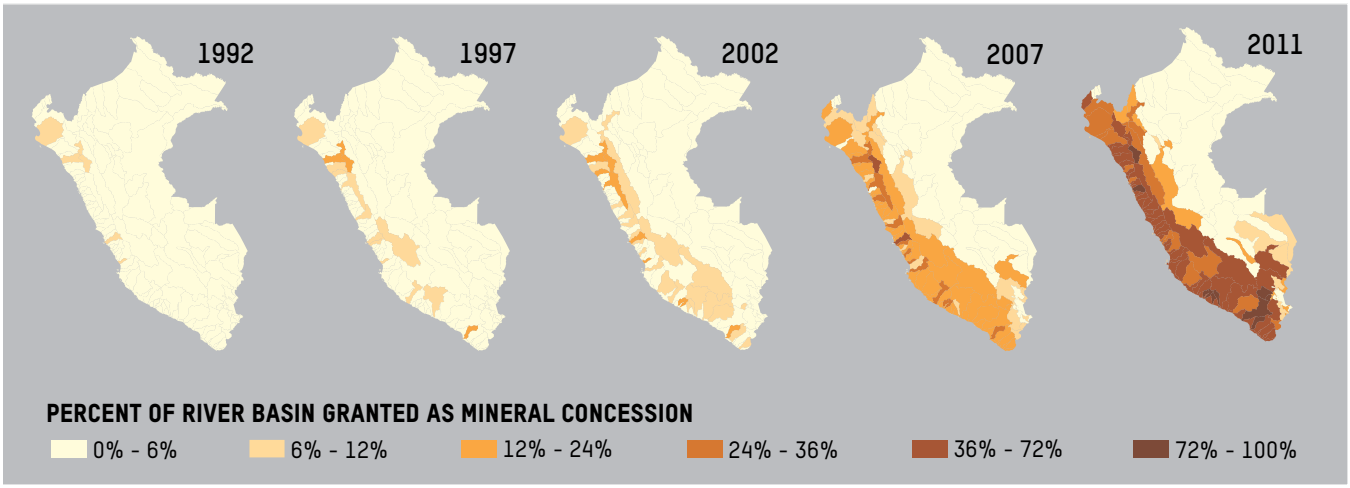
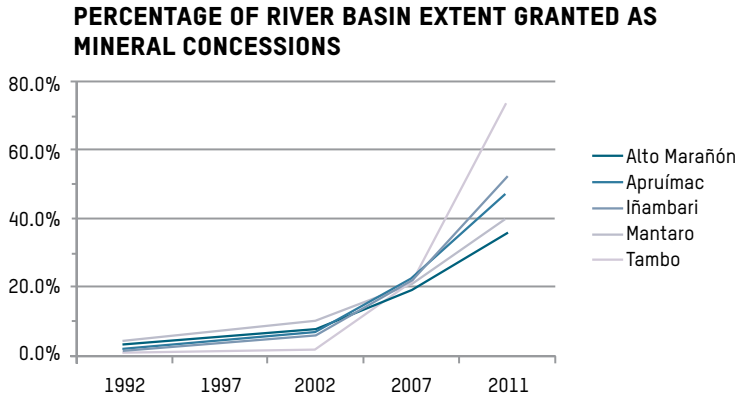


FIGURE 3. TEMPORAL PROFILES: MINING CONCESSIONS IN FIVE RIVER BASINS IN PERU

Temporal profiles showing the change in percentage of total river basin extent granted as mining concessions, and change in number of mining concessions per watershed, for the five river basins with the greatest area under mining concession (through 11/16/2011).



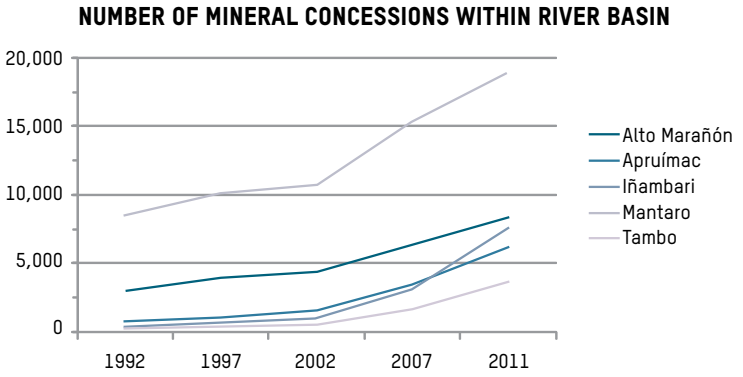
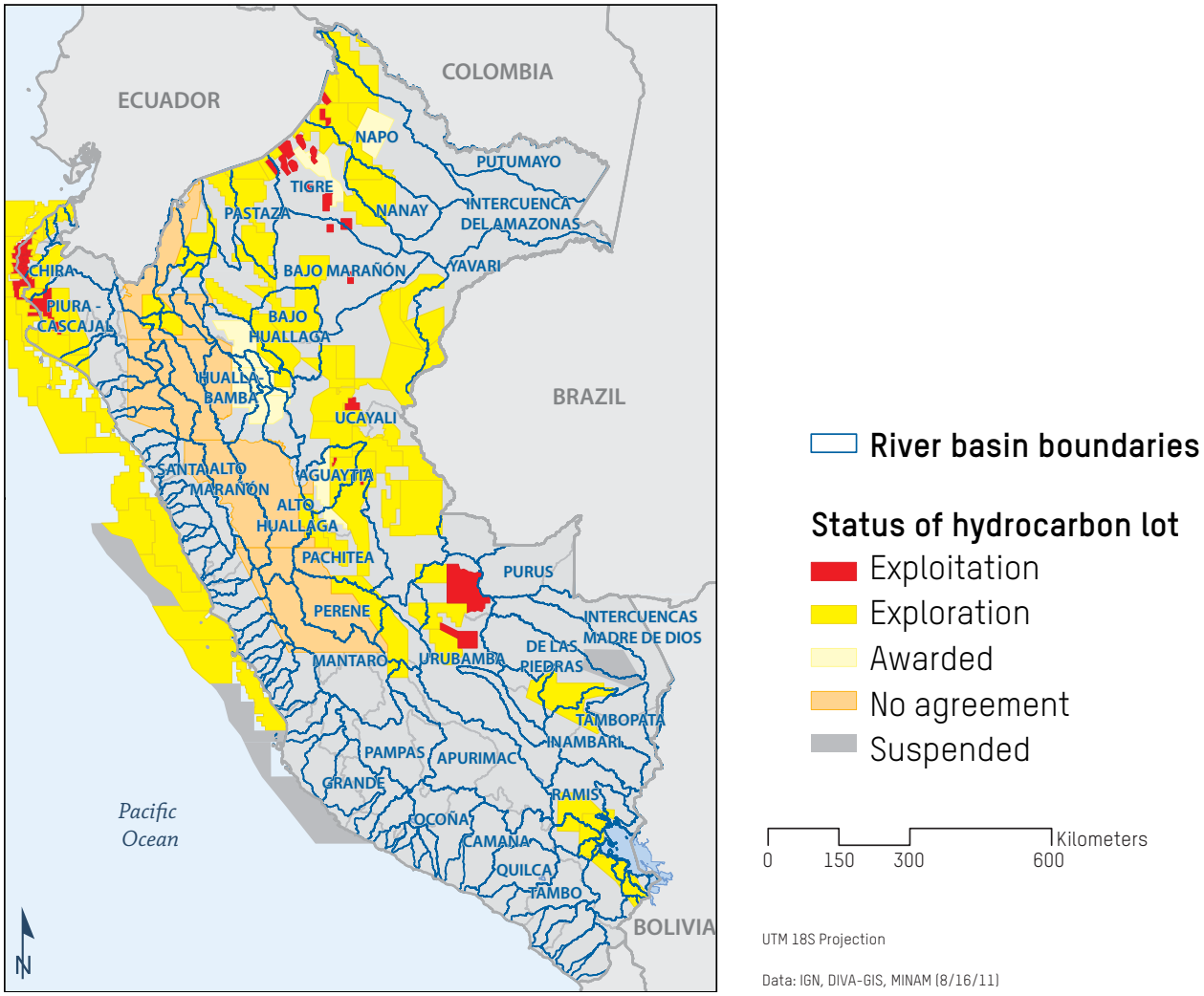


FIGURE 4. SPATIAL OVERLAP OF HYDROCARBON LOTS AND RIVER BASINS IN PERU

Spatial Overlap of Hydrocarbon Lots and River Basins in Peru.



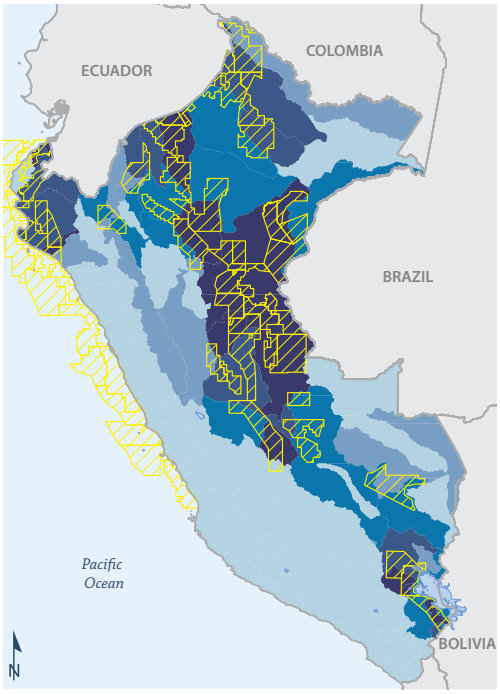
OVERLAPS BETWEEN OIL CONCESSIONS AND RIVER BASINS

To depict potential impacts of hydrocarbon extraction on water in Peru, the outlines of oil concessions obtained from Perupetro were overlaid with maps of river basins (Figure 4). Officially sanctioned operations for exploration in Figure 5 (mean size 5,000 km²) and extraction or exploitation in Figure 6 (1,000 km²) are the areas of special interest for our purposes. There is no sanctioned activity as yet for the other three categories.

Unlike the concession data for mining, the data for oil concessions do not record all changes in status over time; they are accurate only for the late 2011-2012 period and omit a number of large exploratory concessions that have lapsed. Therefore, the oil-concession maps have a high level of uncertainty. Figure 5 estimates the portion of various river basins that now overlap with oil concessions.

FIGURE 5. SPATIAL OVERLAP OF HYDROCARBON EXPLORATION AND RIVER BASINS IN PERU

Spatial configuration of exploration oil concessions and river basins in Peru.



Status of hydrocarbon lot

Exploration

River Basins

- 50 - 100%
- 30 - 50%
- 15 - 30%
- 5 - 15%
- 0 - 5%

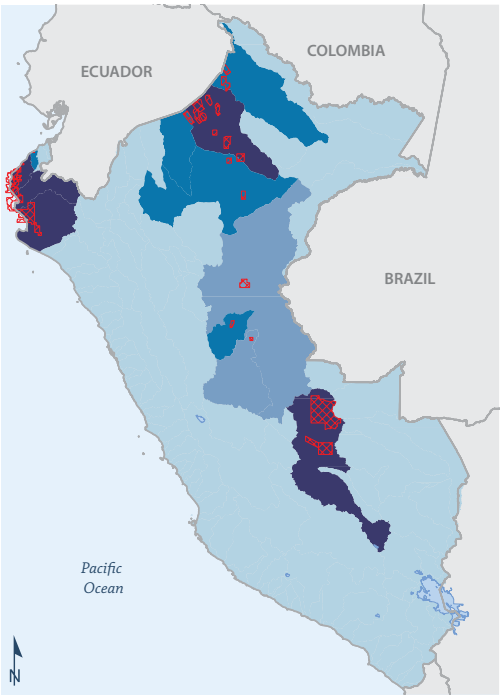
0 150 300 600 Kilometers

UTM 18S Projection

Data: IGN, DIVA-GIS, MINAM (8/16/11)

FIGURE 6. SPATIAL OVERLAP OF HYDROCARBON EXPLOITATION AND RIVER BASINS IN PERU

Spatial configuration of exploitation oil concessions and river basins in Peru.



Status of hydrocarbon lot

Exploitation

River Basins

- 5 - 15%
- 3 - 5%
- 1 - 3%
- 0 - 1%
- 0%

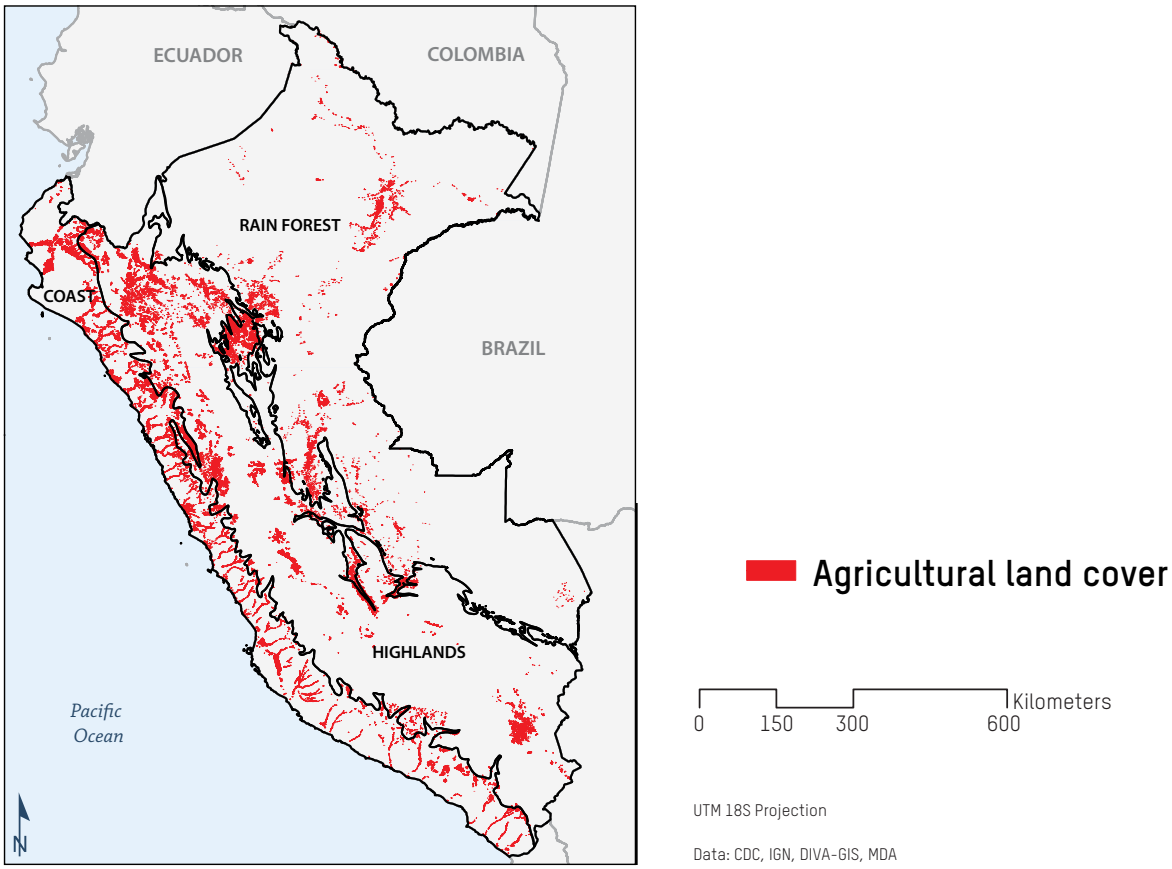
0 150 300 600 Kilometers

UTM 18S Projection

Data: IGN, DIVA-GIS, MINAM (8/16/11)

FIGURE 7. AGRICULTURAL LAND COVER IN PERU

Agricultural land cover derived from 2000 Landsat imagery (30 m spatial resolution). NOTE: Size of pixels has been exaggerated in this figure for enhanced recognition. The MacDonald Dettwiler and Associates (MDA) land cover map for the year 2000 shows 12 land-cover classes including two agriculture classes, which were aggregated for the purpose of this analysis.



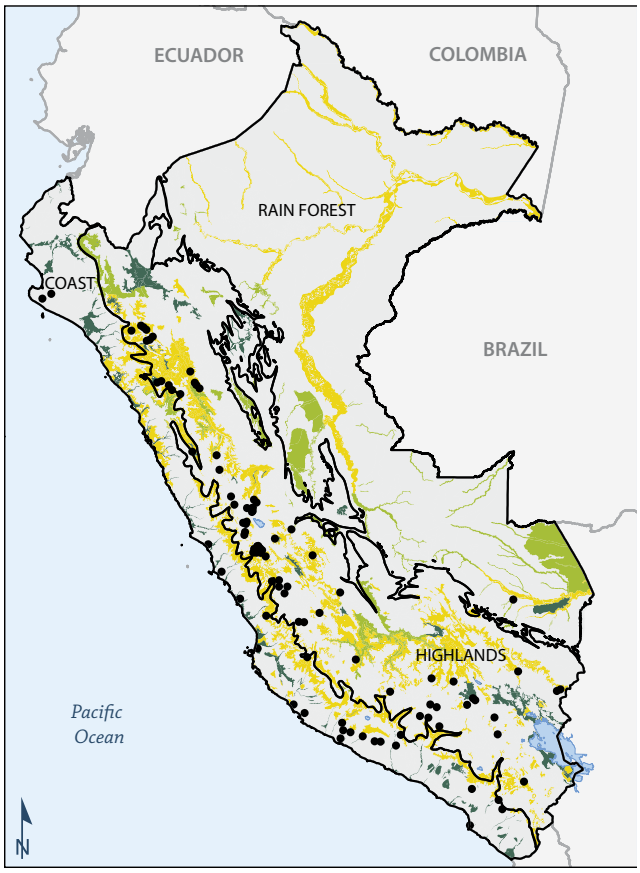
OVERLAPPING OF MINING CONCESSIONS AND AGRICULTURE

The same mining data that were overlaid with watersheds (see earlier section) were also used to measure the potential impact on croplands. To assess how this overlap of land uses varies in three different regions of Peru—coast, highlands, and rain forest—data was extracted from a detailed ecological map of Peru obtained from the Centro de Datos para la Conservacion (CDC). Additionally, the common practice of shifting crops in many forest and mountain areas from year to year required additional data. We used two sets of spatial overlay analyses: one using a land cover (LC) map derived from satellite imagery (Landsat) from 2000 showing a "snapshot" of land under cultivation (Figure 7), another derived from an INRENA dataset that assesses the likely productivity of arable land throughout Peru (Figure 4.2, additional detail is provided in the Appendix). The former figure appears to understate the territory dedicated to agriculture, while the latter probably overstates the agricultural potential of some areas.

As with watersheds, agricultural land increasingly falls within the borders of mining concessions. While the granting of concessions accelerated in 2002, interest in mining began spreading disproportionately into farming areas starting in 2007. Concessioning has been especially intensive along Peru's coast.

FIGURE 8. AGRICULTURAL LAND USE SUITABILITY IN PERU

Agricultural land use potential, derived from the Instituto Nacional de Recursos Naturales (INRENA) land use capacity map, indicates areas suitable for high-, moderate-, and low- intensity agriculture, where intensity is inversely proportional to the necessary fallow period between crops.



Marginal suitability
Low suitability
Moderate suitability
High suitability

0 150 300 600 Kilometers

UTM 18S Projection

Data: CDC, IGN, DIVA-GIS, INRENA

TABLE 2. AGRICULTURAL LAND COVER OVERLAPS WITH MINING CONCESSIONS IN PERU

REGION	TOTAL AREA	1992 AREA	1997 AREA	2002 AREA	2007 AREA	2011 AREA	1992 AREA	1997 AREA	2002 AREA	2007 AREA	2011 AREA
Coast	11,784	246	487	702	1492	2412	2%	4%	6%	12%	21%
Highlands	8,519	104	231	357	682	2798	1%	3%	4%	8%	33%
Rain forest	1,408	1	2	3	16	44	0%	0%	0%	1%	3%

Note: Spatial intersection of mining concessions with agricultural land cover according to the year 2000 MDA map, measured in absolute area (km²) and in the percentage of total areal extent of the observed agricultural land cover.

TABLE 3. AGRICULTURAL LAND USE OVERLAPS WITH MINING CONCESSIONS IN PERU

REGION	AGRICULTURE INTENSITY	TOTAL AREA	1992 AREA	1997 AREA	2002 AREA	2007 AREA	2011 AREA	1992 AREA	1997 AREA	2002 AREA	2007 AREA	2011 AREA
Coast	High	13838	168	258	398	942	2703	1%	2%	3%	7%	20%
	Moderate	0	0	0	0	0	0	0%	0%	0%	0%	0%
	Low	35367	916	1583	2501	6572	17060	3%	4%	7%	19%	48%
Highlands	High	11149	260	367	650	1234	2840	2%	3%	6%	11%	25%
	Moderate	1574	0	20	31	76	247	0%	1%	2%	5%	16%
	Low	87624	2742	4675	6400	18735	38431	3%	5%	7%	21%	44%
Rainforest	High	1582	3	3	3	5	25	0%	0%	0%	0%	2%
	Moderate	59689	102	268	765	2003	3349	0%	0%	1%	3%	6%
	Low	22046	6	9	28	209	602	0%	0%	0%	1%	3%

Note: Spatial Intersection of mining concessions with areas suitable for agricultural land use, measured in absolute area (km²) and in the percentage of total areal extent of the agricultural suitability area.

FIGURE 9. PERCENTAGE OF AGRICULTURAL LAND COVER (2000; MDA) OVERLAPPING WITH MINING CONCESSIONS, BY REGION IN PERU

Change in the percentage of agricultural land cover (2000) extent that spatially intersects mining concessions. The lowest rates of overlap are observed in the rain forest region. Overlap in the Coast region steadily increases through time, and overlap in the highlands region sharply increases in the period 2007-2011.

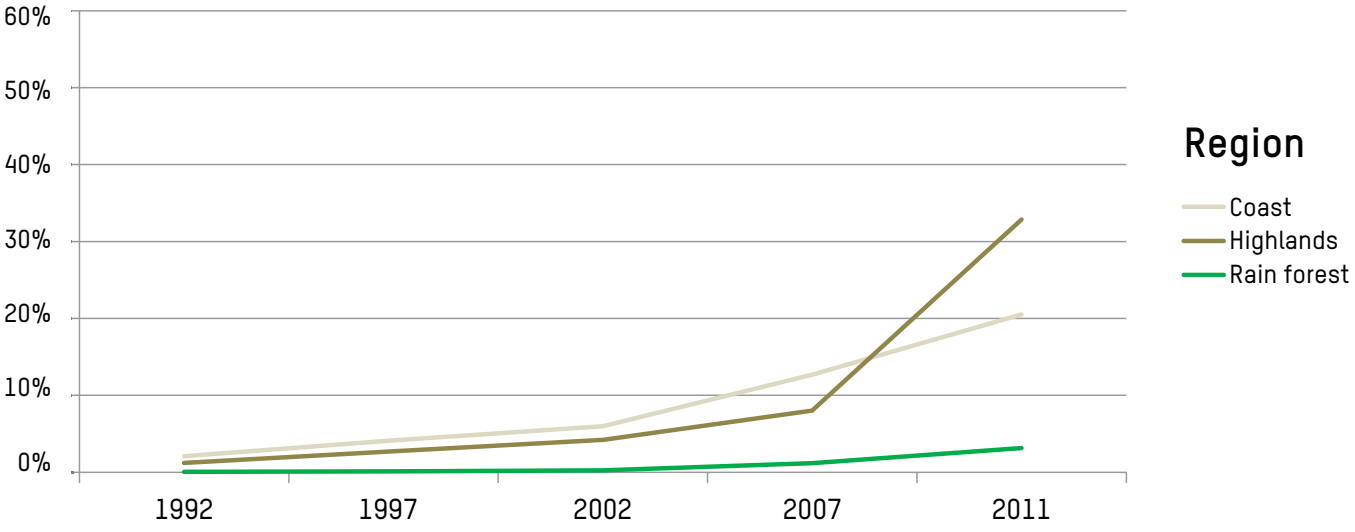
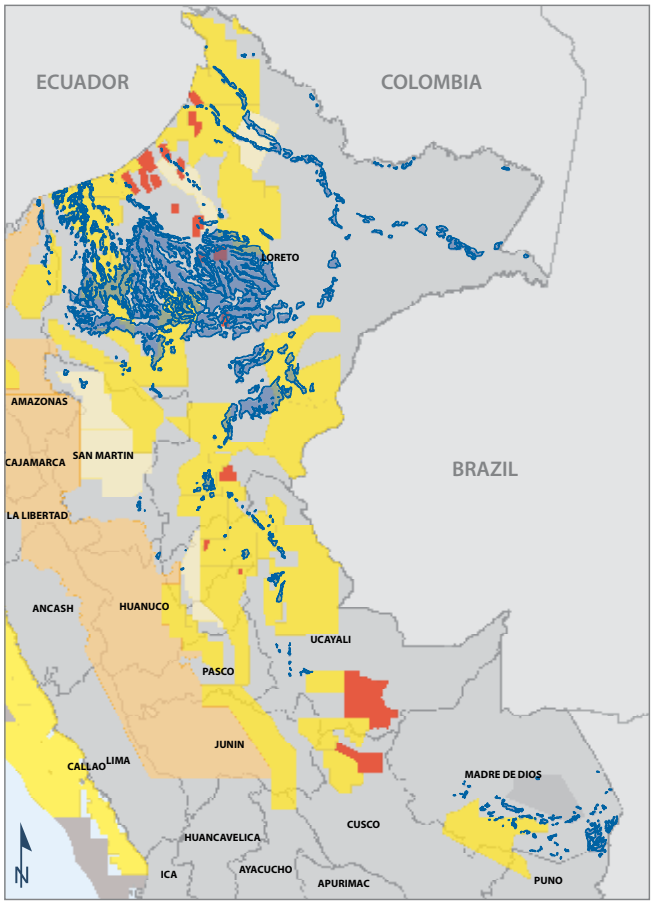


FIGURE 10. SPATIAL OVERLAP OF HYDROCARBON CONCESSIONS AND HÚMEDALES (SELVA) IN PERU

Spatial configuration of oil concessions (exploration and exploitation) and *húmedales* in the lowland wet tropical forests of Peru. (Zoomed to extent of *húmedales* located in the *selva*).



Húmedales (*selva*)

Status of hydrocarbon lot

- Exploitation
- Exploration
- Awarded
- No agreements
- Suspended

0 100 200 400 Kilometers

UTM 18S Projection

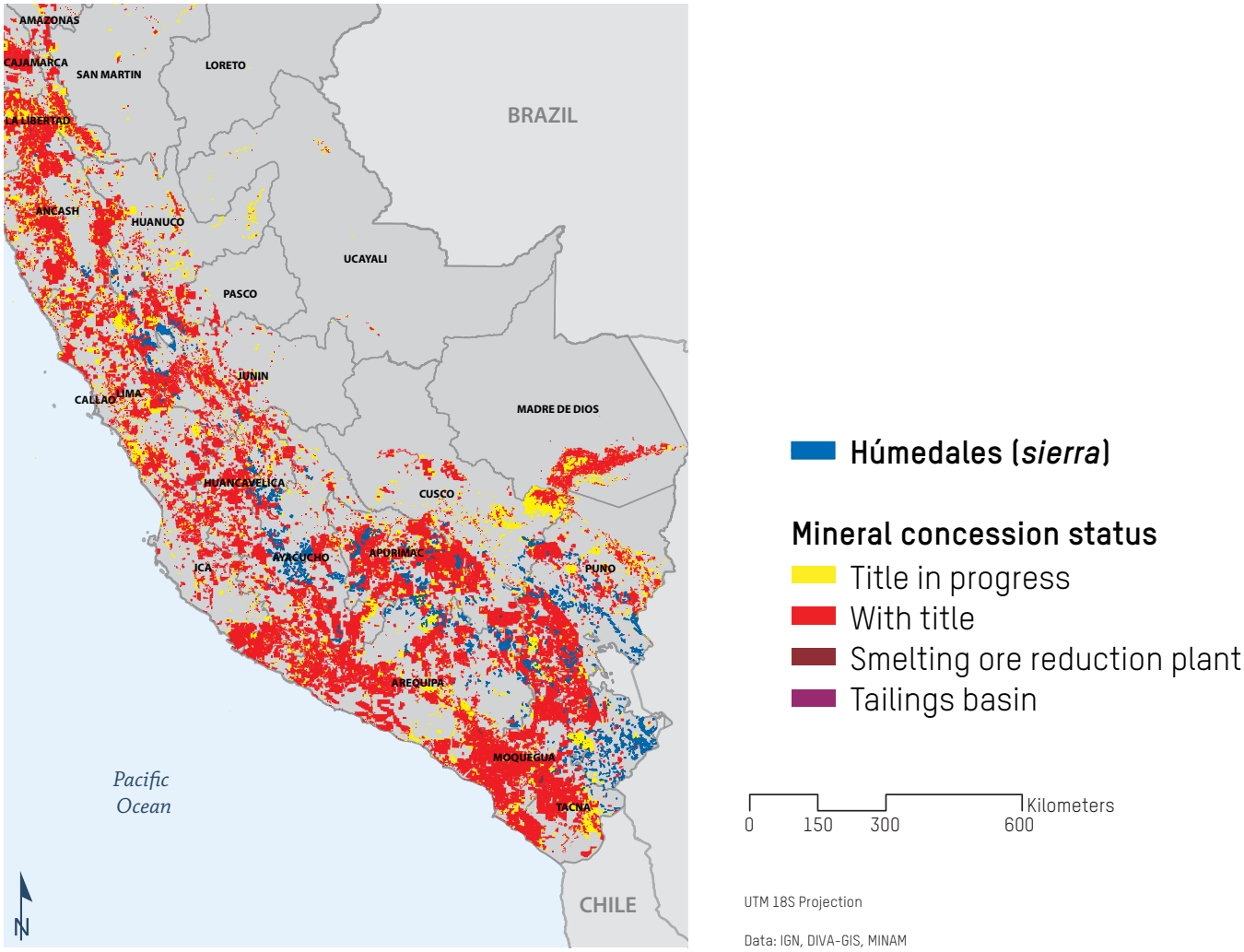
Data: INEI, DIVA-GIS, MINAM

OVERLAP OF EXTRACTIVE INDUSTRY AND WETLANDS

Another area of concern in Peru is the possible impact of extractive industry on local wetlands, or *húmedales*. These wetlands may be either seasonally or consistently wet and are found in both the highlands and lowland rain forest ecoregions. *Húmedales* provide habitat for many endemic species as well as water and forage for livestock. The significance of *húmedales* is both political and hydrological. Much of the intense conflict over plans to develop the Minas Conga project in Cajamarca has revolved around the direct and indirect effects that the planned mine could have on high-altitude lakes. These lakes have symbolic as well as ecological importance in Andean culture. Hydrologically, *húmedales* help "produce" water for downstream populations and ecosystems. Any disturbance to the *húmedales* might well have consequences for the people and habitats downstream. These consequences include downstream perceptions of such consequences. As made clear in the following maps—of hydrocarbon concessions and Peru's wet tropical forest (*húmedales selva*) and of mining concessions and high-altitude wetlands (*húmedales sierra*)—the overlaps are substantial.

FIGURE 11. SPATIAL OVERLAP OF MINERAL CONCESSIONS AND HÚMEDALES (SIERRA) IN PERU

Spatial configurations of mining concessions and *húmedales* in the highlands of Peru. (Zoomed to extent of *húmedales sierra*).

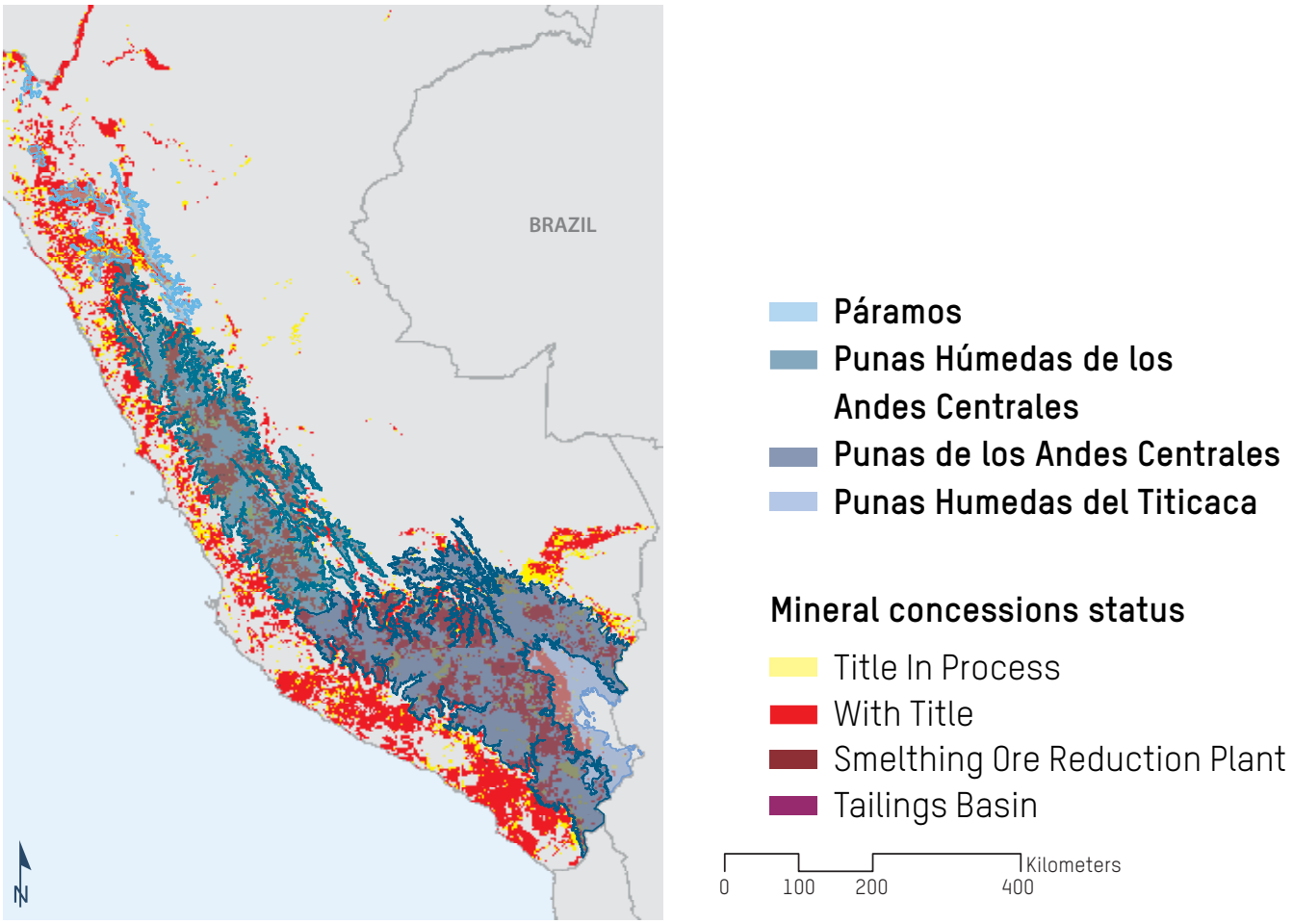


OVERLAP OF MINING CONCESSIONS AND WATER-STORAGE LANDSCAPES

The surface water and wet terrain that one can see in *húmedales* are not the only natural form of water storage in Peru. The high Andes have other vegetated landscapes that store water. In particular, regions known as *paramos* and *punas* hold water in their carbon-rich soils and peats, as well as in streams and lakes (often as ice). In the Peruvian highlands, mining concessions now overlap substantially with four regions that are important to replenishing water supplies downstream: Punas Húmedales de los Andes Centrales, Punas Húmedales del Titicaca, Punas de los Andes Centrales, and Páramos (Figure 12). Here, too, conflict has arisen over the effects of mining on *paramos*—an iconic example being the Río Blanco project in Piura. (A similar conflict has flared up in Colombia over industry's possible impact on the *paramo* of Santurbán.) The Andean *paramo* is a vital supplier of hydrological and other ecosystem services for lowland Peru, and it appears increasingly to be under stress.

FIGURE 12. SPATIAL OVERLAP OF MINING CONCESSIONS AND PÁRAMOS/PUNAS IN PERU

Spatial configuration of mining concessions and *páramos/punas* ecoregions in Peru.



MINING AND HYDROCARBON CONCESSIONS AND RURAL AGRARIAN COMMUNITIES

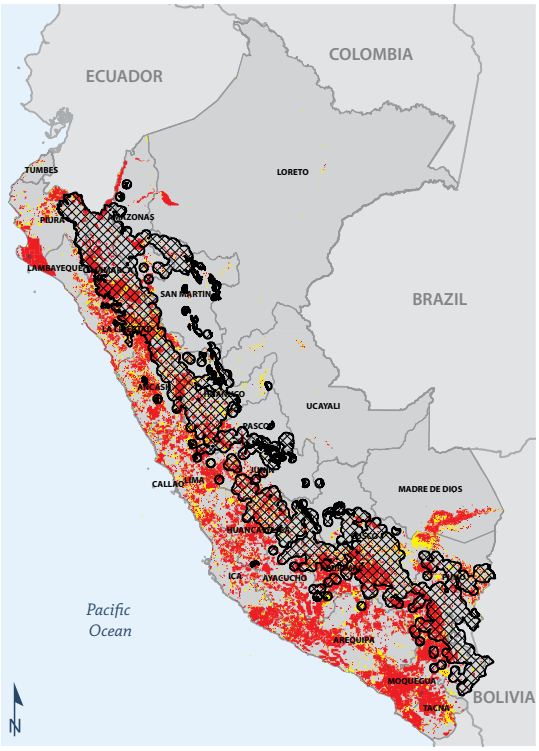
A three-step vulnerability assessment was used to approximate the overlap of extractive concessions and small-scale farming communities in the highlands of Peru. Areas defined as agricultural land were derived from 2007 data for Peru's population centers Instituto Nacional de Estadistica e Informatica (INEI). Agrarian areas were defined as all land in the highlands region within 12 km of populated centers that met the following three criteria:

- Population of 200 to 2,000 people
- Local economy based on rural agriculture (e.g., cooperative agrarian, *caserio*, *unidad agropecuaria*)
- Location within the highlands region (see Figure 15)

In the wet tropical forest of east and northeast Peru, substantial overlap exists between land leased to oil and gas companies and lands reserved for native communities. Overlap predominantly occurs between exploratory oil concessions and community lands, although actual drilling also overlaps with native lands across the region (Figure 13).

FIGURE 13. SPATIAL OVERLAP OF MINING CONCESSIONS AND RURAL AGRARIAN COMMUNITIES IN PERU

Spatial configuration of mining concessions and rural agrarian communities in the highlands of Peru.



Rural agrarian communities

Mineral concession status

- Title in process
- With title
- Smelting ore reduction plant
- Tailings basin

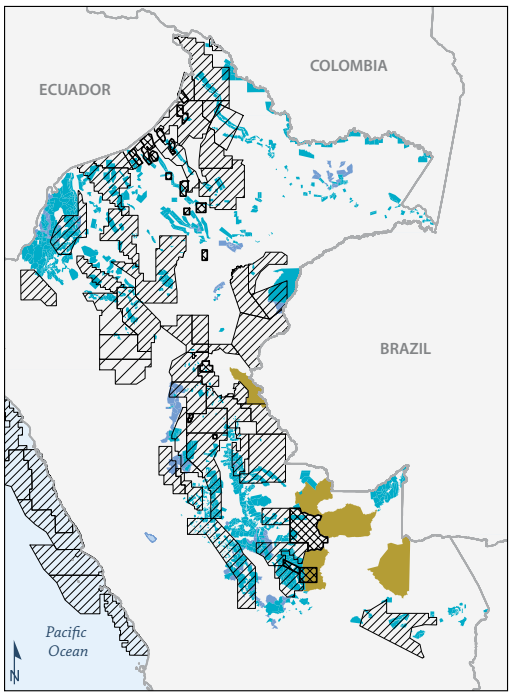
0 150 300 600 Kilometers

UTM 18S Projection

Data: IGN, DIVA-GIS, MINAM

FIGURE 14. SPATIAL OVERLAP OF HYDROCARBON LOTS AND NATIVE COMMUNITIES IN PERU

Spatial configuration of hydrocarbon lots concessions and native communities in Peru.



Native communities (with title)

Native communities (petitioned)

Territorial reserves (isolation)

Status of Hydrocarbon lot

- Exploitation
- Exploration
- Awarded

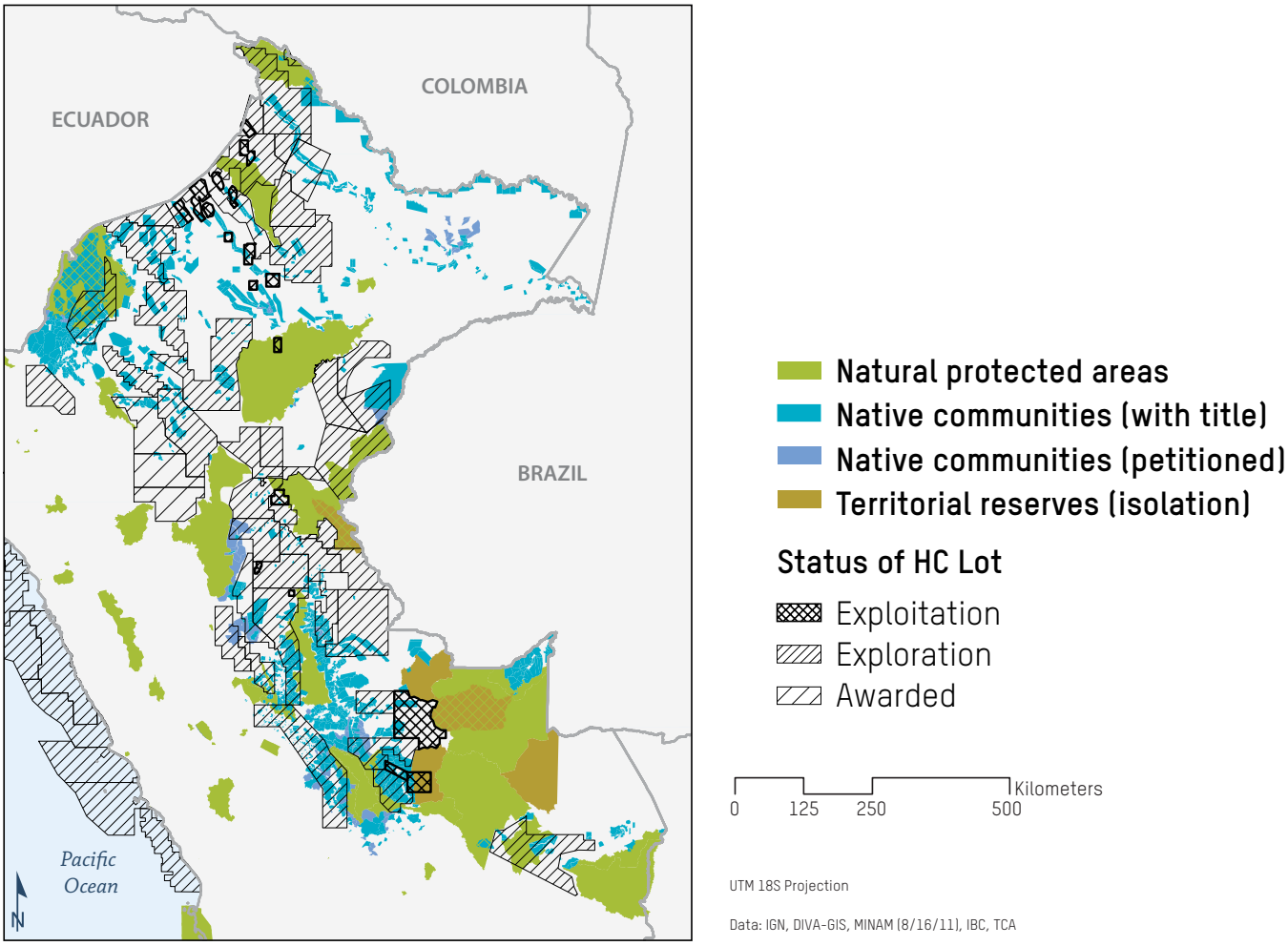
0 125 250 500 Kilometers

UTM 18S Projection

Data: IGN, DIVA-GIS, MINAM (8/16/11), IBC, TCA

FIGURE 15. SPATIAL OVERLAP OF HYDROCARBON LOTS AND PROTECTED AREAS IN PERU

Spatial configuration of hydrocarbon lots and protected areas in the lowland wet tropical forests of Peru.



OVERLAP OF EXTRACTIVE INDUSTRY AND PROTECTED AREAS

In contrast to the substantial overlaps in Peru among mineral concessions, oil and gas concessions, agricultural land, and water resources, the legal boundaries of concessions rarely intrude on legally protected conservation land or indigenous population areas. Some overlap occurs between hydrocarbon lots and reserves for indigenous people living in voluntary isolation in the Amazon basin, perhaps most notably the Camisea gas project. That said, areas of exploitation seem more likely to overlap with reserves for indigenous peoples living in voluntary isolation than do exploration lots.

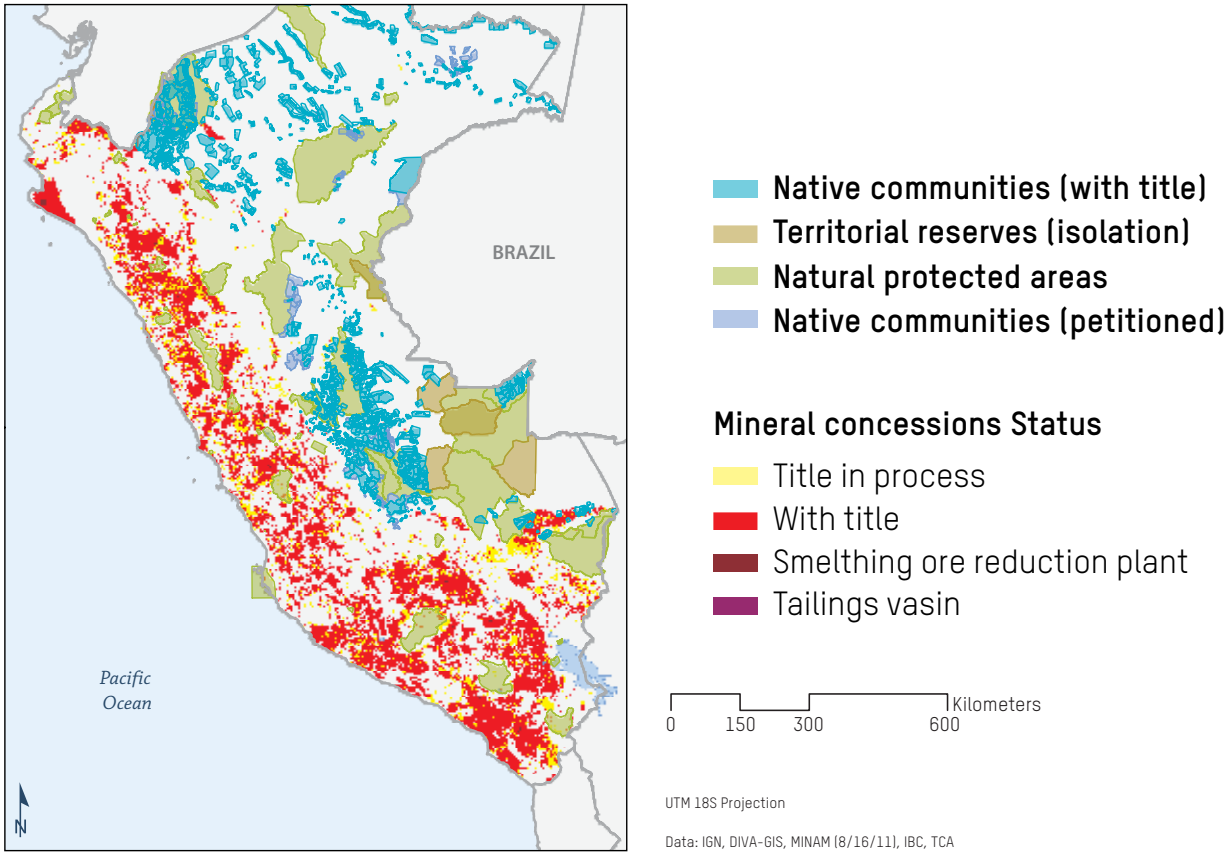
WATER CONFLICTS BETWEEN EXTRACTIVE OPERATIONS AND AGRICULTURE

In addition to situations where industry, farming, and water resources overlap geographically, there are harder-to-discern situations where industrial operations in one locale can affect farms and other water users located far away. Both farming and mining require large volumes of water. Conflict can arise when water is scarce—especially when water users worry that industry could pollute the limited water available to them.

Our study used models to examine impacts that might be felt both locally and at sites more distant from the point of extraction.

FIGURE 16. SPATIAL OVERLAP OF MINING CONCESSIONS AND PROTECTED AREAS IN PERU

Spatial configuration of mining concessions and protected areas in Peru.



First-order topographic basins were created based on the SRTM Digital Elevation Model. To mark each drainage basin that leads downstream from a mine site to the ocean, we mapped an area that included any waterway within 15 km of a mine. For each of 98 mining operations, all of the first-order topographic basins (maximum area 500 km²) that were crossed by the associated waterways were combined to form the mine's drainage basin. As with the mineral concessions, we mapped the overlap of each mine's drainage basin with actual or potential agricultural lands using INRENA data.

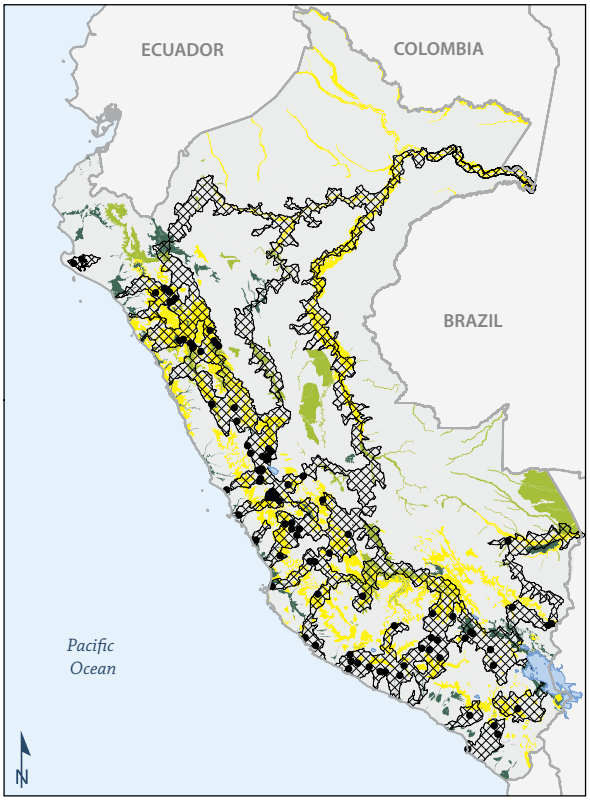
SUMMARY OF PERU ANALYSIS

Visualizing the overlapping geographies of concessions, operations, water resources, agriculture, protected areas and rural communities reveals several key patterns:

- Data mapping indicates a significant increase in activity in the extractive economy over the past 15 years.
- This increase has produced multiple geographical overlaps between the extractive economy, the agricultural economy, and natural resources. These overlaps suggest that the needs and interests of the extractive economy have been prioritized over the interests of other livelihoods.
- We see relatively few conflicts over land use between extractive industries and protected areas, suggesting that in at least this domain land use regulations are relatively robust (though this may change if the government is pressured to redraw protected area boundaries or even to redefine what activities are permissible within them).

FIGURE 17. SPATIAL OVERLAP OF MINE DRAINAGE AREA AND AGRICULTURAL LAND USE SUITABILITY IN PERU

Spatial intersections of mine drainage and agricultural land use suitability in Peru.



Mine
Aggregated drainage area (all mines)

Agricultural land use suitability
Marginal
Low
Moderate
High

0 150 300 600 Kilometers

UTM 18S Projection

Data: CDC, IGN, SRTM, DIVA-GIS, MINAM (April 2013), INRENA

- These maps give little indication of any effort by central authorities to plan mining and hydrocarbons expansion jointly with the planning of water resources or agricultural land use. Although regional and local authorities have occasionally called for such joint planning, it has been far less apart of the national government's agenda.
- The patterns conveyed in these maps are consistent with a planning system in which *comunidades campesinas*, indigenous communities and other rural and local governance bodies have little formal role in deciding the future of extractive industry in Peru.

These visualizations give a sense of what is and is not valued in de facto national land planning systems. They also suggest why the expansion of the extractive economy in Peru has been such a difficult and contentious process.

TABLE 4. AGRICULTURAL LAND USE SUITABILITY (INRENA) OVERLAPS WITH MINE DRAINAGE IN PERU

REGION	AGRICULTURE INTENSITY	AREA OF OVERLAP (KM²)	PERCENT OF TOTAL AREA IN CATEGORY
Coast	High	2,263	16%
	Moderate	0	0%
	Low	8,951	40%
Highlands	High	4,947	45%
	Moderate	207	19%
	Low	19,522	53%
Rain forest	High	514	32%
	Moderate	3,722	26%
	Low	21,617	32%

Note: Areal extents of overlaps between mine drainage and potential agricultural suitability in Peru, and percentage of total agricultural land use suitability area located within mine drainage. SOURCE: IRENA.

GHANA

Unlike Peru, where data about extractive industries was voluminous and accessible, comparable data in Ghana was relatively difficult to come by. Nonetheless, we gathered enough to make a comparable, if modest, analysis of Ghana's extractive industries (Table 5).

OVERLAP OF MINERAL CONCESSIONS AND AGRICULTURE

A July 2012 map of mineral concessions from Ghana's Ministry of Lands and Natural Resources was digitized to create a spatial dataset accurate to within a kilometer. The analyzed concessions belonged to one of three types, each with specific mineral rights (Table 6).

Geographic data about these mineral concessions was overlaid with detailed maps of land under cultivation to assess the likelihood of conflict or interference with farming at a particular location. As in Peru, the concession data was also overlaid with detailed maps of land suitable for farming, even if not presently farmed, in order to gauge the extent to which mining operations could limit future agricultural output.

Land cover. We based our maps of existing agricultural land cover from satellite imagery, especially the European Space Agency's GlobCover product, captured in 2005 and 2006 and distributed at 300 m² resolution. GlobCover is currently the best free source of global information about land cover and land use. Although our land-cover data for Peru came from Landsat imagery with a resolution of 30 meters (provided at-cost by a vendor), data at that level of detail was unfortunately not available for Ghana.

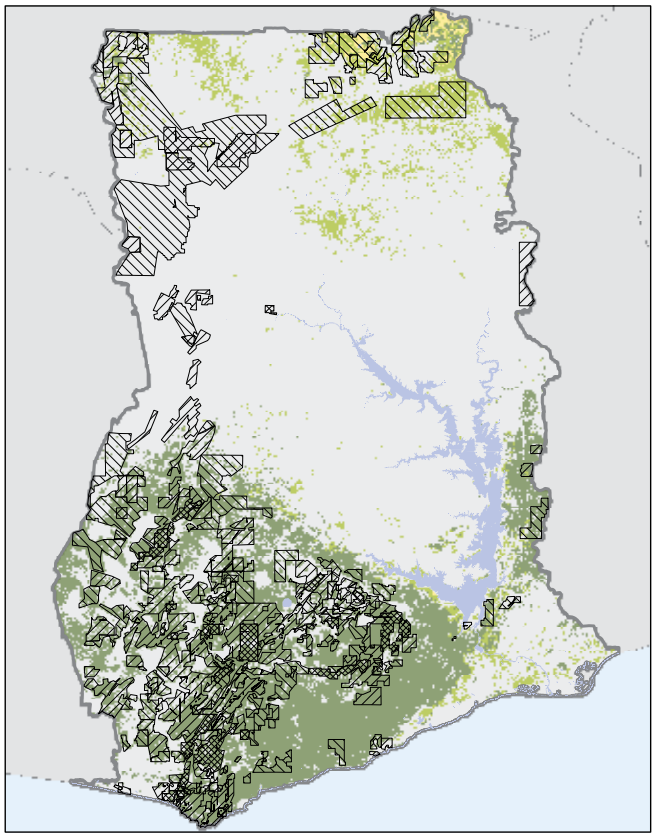
TABLE 5. DATA USED IN SPATIAL ANALYSIS OF EXTRACTIVE INDUSTRIES IN GHANA

CATEGORY	NAME	SOURCE	FORMAT	TIME / RANGE	SPATIAL EXTENT
Political	Administrative boundaries	GADM	Shapefile: polygon	2012	countrywide
Elevation	DEM (Shuttle Radar Topography Mission)	NASA	Raster: (90m)	2000	countrywide
Hydrology	Rivers	FAO	Shapefile: polygon	2000	countrywide
	Lakes	FAO	Shapefile: polyline	2000	countrywide
	Drainage basins	-from DEM	Shapefile: polyline	2000	countrywide
Community	Populated places	Geonames	Shapefile: point	2000-	countrywide
	Fishing Villages (coastal)	Aerial photos	Shapefile: point	2012	countrywide
Land Cover / Land Use	Land cover: observed agriculture	ESA (GLOBCOVER/ MERIS)	Raster: 300m	2005-2006	countrywide
	Land use capacity: GAEZ Agricultural Suitability	FOA/IIASA	Raster: 9km	2012	countrywide
	Forest reserves	MLNR	Shapefile: polygon	2012	
Mining	Concession lots	MLNR	Shapefile: polygon	2012	countrywide
	Mines and facilities locations	WBI, InfoMine	Shapefile: point	2012	countrywide
Hydrocarbon	Concessions lots	WBI	Shapefile: polygon	2008	countrywide
	Wells	WBI	Shapefile: point	2008	countrywide

Notes: GADM: database of Global Administrative Areas; NASA: National Aeronautics and Space Administration; FAO: Food and Agriculture Organization; ESA: European Space Agency; IIASA: International Institute for Applied Systems Analysis; MLNR: Ghana Ministry of Lands and Natural Resources; WBI: World Bank Institute.

FIGURE 18. SPATIAL OVERLAP OF MINERAL CONCESSIONS AND AGRICULTURAL LAND COVER IN GHANA (2005–2006)

Location of mineral concessions relative to agricultural land cover in Ghana.



Reconnaissance licenses
Prospecting licenses
Mining leases

Land Cover
Rain-fed crops
Mosaic—crop/veg
Mosaic—veg/crop

0 60 120 240 Kilometers

UTM 30-N Projection

Data: MLNR, ESA, GDAM

Our analysis took into account three kinds of agricultural land cover:

> **Rain-fed croplands:** This category is characterized by shrubby growth, herbaceous plants, and tree crops, and is found only in Ghana's north.
>
> **Mosaic—cropland/vegetation:** This category, found throughout Ghana, is typically 50-70 percent farmland (both rain-fed and irrigated). The rest of the land cover is wild vegetation: grasses, shrubs, or forest.

Mosaic—vegetation/cropland: This mixed land cover is 50 to 70 percent natural vegetation, and the balance is agricultural land. This is the dominant pattern in southwestern Ghana, where all active mines are operating and where the granting of concessions has been most extensive.

TABLE 6. TYPES OF CONCESSIONS IN GHANA

TYPE OF PERMIT	ACTIVITIES ALLOWED	MAX. EXTENT	DURATION
Reconnaissance	*Survey or remote sensing exploration*	1,050,0 km^2	1 year
Prospecting	*Drilling, excavation for exploration*	157.5 km^2	3 year
Mining	*Extraction*	63.0 km^2	< 30 years

Note: Comparison of mineral licenses and leases used in the analysis. Source: Ghana's Mining Portal.

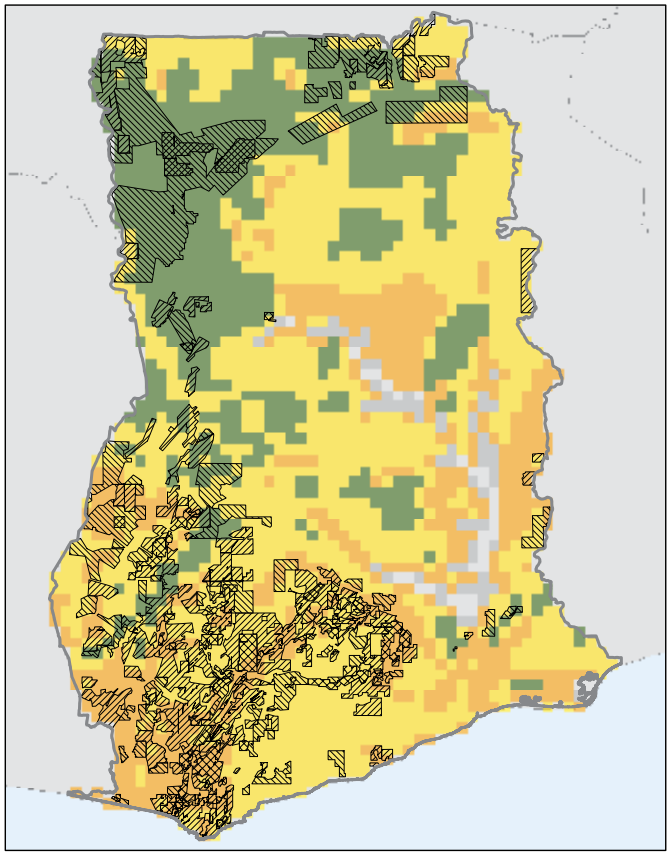
TABLE 7. AGRICULTURAL LAND COVER CATEGORY UNDER MINERAL CONCESSION, BY CONCESSION TYPE IN GHANA

CONCESSION TYPE	RAIN-FED CROPS	MOSAIC: CROPLAND / VEG	MOSAIC: VEG / CROPLANDS	LOW ESTIMATED CROPLAND AREA AFFECTED (HA)	AVG ESTIMATED CROPLAND AREA AFFECTED (HA)	HIGH ESTIMATED CROPLAND AREA AFFECTED (HA)
Reconnaissance license	40,970	276,397	726,020	324,000	461,000	597,000
Prospecting license	5,714	45,750	1,363,996	301,000	511,000	720,000
Mining leases	0	201	300,328	60,000	105,000	150,000

Extent of each agricultural land cover category under mineral concession, by concession type. High, low, and average estimates of total agricultural land overlap with concession rely on the ranges of sub-pixel cropland extent seen in the Mosaic category definitions.

FIGURE 19. SPATIAL OVERLAP OF MINERAL CONCESSIONS AND AGRICULTURAL LAND USE SUITABILITY IN GHANA

Illustration of the overlap between mineral concessions and classes derived from GAEZ crop suitability values (see Table 7), for Maize with low input levels in Ghana. High spatial variability can exist in the suitability of concession land: concession land in the southwest is generally only moderately suited for maize cultivation, though some concession land in the north is highly suitable.



Reconnaissance license
Prospecting license
Mining lease

Crop suitability
High (probable risk)
Intermediate (potential risk)
Low (possible risk)
Very marginal
Not suitable

0 40 80 160 Kilometers

UTM 30-N Projection

Data: FAO/IIASA, MLNR,GDAM

Land Use. To assess an area's possible crop output, we relied on the Agro-Ecological Crop Suitability and Potential Yield products from the FAO's Global Agro-Ecological Zones (GAEZ) methodology. The specific product used, the Crop Suitability Index, considers climatic, soil, and terrain conditions to estimate the potential productivity of an area. A climate baseline from the period 1961 to 1990 was used, with crops primarily rain-fed. Three levels of farming intensity were considered (using GAEZ metadata):

> **High:** The farming system is mainly market-oriented. Farming uses improved or high yielding crop varieties, fertilizer, and weed, pest, and disease control. Operations are fully mechanized.
>
> **Intermediate:** The farming system is partly market-oriented, partly for subsistence. Improved varieties of crops are used. Farms rely largely on manual labor with hand tools and/or animal traction and some mechanization. There is some fertilizer application and chemical pest, disease, and weed control; adequate fallows; and some conservation measures.
>
> **Low:** The system is mostly subsistence farming. Farmers use traditional cultivars (if improved cultivars are used, they are treated in the same way as local cultivars) using labor-intensive techniques. There is no application of nutrients, no use of chemicals for pest and disease control, and little or no conservation measures.

GAEZ suitability values are compiled globally for 48 crops, 31 of which are or could be grown in Ghana. Figure 19 shows the overlap of existing mineral concessions in Ghana and areas suitable for 13 of these crops: alfalfa, banana/plantain, cassava, cocoa, coffee, cotton, maize, oil palm, wetland rice, sorghum, soybean, sweet potato, and sugarcane. The suitability of each crop and farming style was evaluated according to the kind of land in each locale. The results fell into five categories, from high suitability to no suitability (Fig. 19). In each location, the higher the suitability of a crop and farming style, the more likely that mining activity there will or could interfere with it (Table 8).

The information in Table 8 suggests that the consequences of industrial operations for local farmers vary greatly, according to the type of extractive activity and the type of farming. For instance, the risks that a mining lease poses to farmers are more tangible and imminent than those posed by an exploratory license because mining alters a landscape more drastically than exploration does. Also, a mining license leaves no doubt as to which piece of land is subject to excavation or drilling.

TABLE 8. CROP CULTIVATION AT RISK OF EXTRACTIVE INDUSTRY DEVELOPMENT IN GHANA

CONCESSION TYPE	INPUT LEVEL	RECONNAISSANCE	PROSPECTING	MINING
ALFALFA	High	POTENTIAL	PROBABLE	PROBABLE
	Interm.	unlikely	POTENTIAL	POTENTIAL
	Low	unlikely	unlikely	unlikely
BANANA/ PLANTAIN	High	unlikely	POTENTIAL	POTENTIAL
	Interm.	unlikely	POTENTIAL	POTENTIAL
	Low	unlikely	POTENTIAL	POTENTIAL
COCOA	High	unlikely	PROBABLE	PROBABLE
	Interm.	unlikely	POTENTIAL	POTENTIAL
	Low	unlikely	POTENTIAL	POTENTIAL
COFFEE	High	unlikely	PROBABLE	PROBABLE
	Interm.	unlikely	POTENTIAL	PROBABLE
	Low	unlikely	POTENTIAL	PROBABLE
COTTON	High	PROBABLE	POTENTIAL	unlikely
	Interm.	POTENTIAL	unlikely	unlikely
	Low	POTENTIAL	POTENTIAL	unlikely
CASSAVA	High	POTENTIAL	PROBABLE	PROBABLE
	Interm.	POTENTIAL	POTENTIAL	POTENTIAL
	Low	POTENTIAL	POTENTIAL	POTENTIAL
MAIZE	High	PROBABLE	POTENTIAL	POTENTIAL
	Interm.	POTENTIAL	POTENTIAL	unlikely
	Low	POTENTIAL	POTENTIAL	unlikely
OIL PALM	High	unlikely	POTENTIAL	PROBABLE
	Interm.	unlikely	POTENTIAL	POTENTIAL
	Low	unlikely	POTENTIAL	POTENTIAL
WETLAND RICE	High	unlikely	unlikely	unlikely
	Interm.	unlikely	unlikely	unlikely
	Low	POTENTIAL	unlikely	unlikely
SOYBEAN	High	PROBABLE	PROBABLE	PROBABLE
	Interm.	POTENTIAL	POTENTIAL	POTENTIAL
	Low	POTENTIAL	POTENTIAL	unlikely
SWEET POTATO	High	POTENTIAL	PROBABLE	POTENTIAL
	Interm.	POTENTIAL	POTENTIAL	POTENTIAL
	Low	POTENTIAL	POTENTIAL	POTENTIAL
SORGHUM	High	PROBABLE	POTENTIAL	unlikely
	Interm.	POTENTIAL	unlikely	unlikely
	Low	POTENTIAL	unlikely	unlikely
SUGARCANE	High	unlikely	POTENTIAL	POTENTIAL
	Interm.	unlikely	POTENTIAL	POTENTIAL
	Low	unlikely	POTENTIAL	POTENTIAL

Likelihood that a crop-cultivation practice is exposed to risk of extractive industry development, derived from average GAEZ agricultural suitability value of mineral concession land, with respect to 13 crops suitable in areas within Ghana and three input levels.

An open pit mine in Prestea, Ghana, encroaches on a natural water source. Large-scale industrial mining operations that affect water sources increase the likelihood of conflict between miners and small-scale farmers in Ghana. *Jeff Deutsch / Oxfam America*

As Table 8 shows, extractive activity in general poses relatively less risk to the cultivation of crops like bananas, rice, and sugarcane; the farming of cocoa, coffee, and soybean is more likely to be adversely affected. As a rule, farmers using modern, high-input techniques suffer less disturbance from extractive operations than do traditional, low-input farmers. This suggests that a pathway exists for conflict resolution between extractive industries and commercial large-scale, high-yield agricultural producers, at least.

OVERLAP OF MINE DRAINAGE AREAS AND AGRICULTURE

We determined the locations of mines and mineral deposits and mines from a World Bank Institute database and from InfoMine's online mapping application. Information about rivers came from Food and Agriculture Organization (FAO). First-order topographic basins were mapped using the SRTM Digital Elevation Model. As with Peru, we delineated drainage basins downstream from mines by mapping an area that included waterways within 15 km of the mine. For each of the 17 mines, all of the first-order topographic basins (maximum area 500 km²) that were crossed by associated river channels were aggregated to form the mine's drainage basin (see Figure 20). As with the mineral concessions, we determined the overlap of each mine's drainage area with actual or potential croplands, using GlobCover data as well as the GAEZ Agro-Ecological Crop Suitability and Potential Yield Index data.

Land cover. The overlap analysis for agricultural land cover and mine drainage basins was similar to the operations described for Peru. In the GlobCover product, no pixels in the southwest of Ghana were classified as "rain-fed croplands." Nearly all of the arable land within mine drainage basins belongs to the vegetation-cropland mosaic, where small-scale, low-intensity farming prevails.

Land use. Our analysis of overlap between mine drainage basins and potential farmland was the same as for mineral concessions. The 17 mine drainage basins were aggregated to form a total drainage area (Figure 21) in order to simplify presentation of results (Table 110).

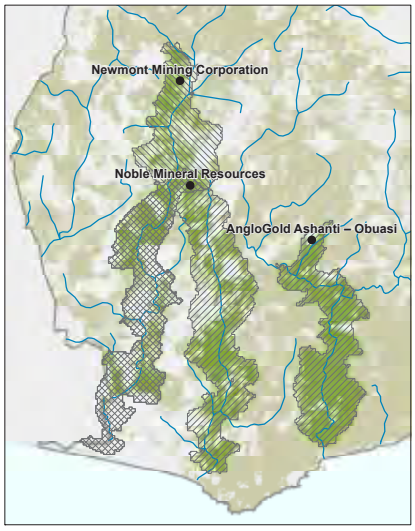
The cultivation of coffee, cassava, and oil palm is seen to be at risk across all input levels, while the probability of risk varies in the cultivation of alfalfa, banana, and cocoa. Cultivation of the seven other crops considered here does not face substantial risk of extraction-related water conflict.

TABLE 9. EXTENT OF AGRICULTURAL LAND COVER CATEGORY WITHIN EACH MINE'S DRAINAGE BASIN IN GHANA

COMPANY	NAME	MOSAIC: CROPLAND / VEG	MOSAIC: VEG / CROPLANDS	LOW ESTIMATED CROPLAND AREA AFFECTED (HA)	AVG ESTIMATED CROPLAND AREA AFFECTED (HA)	HIGH ESTIMATED CROPLAND AREA AFFECTED (HA)
Anglo Ashanti Gold	Ashanti Iduapriem	0	116,244	23,000	41,000	58,000
Anglo Ashanti Gold	Ashanti Obuasi	0	277,830	56,000	97,000	139,000
Endeavour	Nzema	0	14,202	3,000	5,000	7,000
Ghana Bauxite Company	Awaso	0	371,205	74,000	130,000	186,000
Ghana National Petroleum Corporation	Prestea Sankofa Gold	0	77,544	16,000	27,000	39,000
Ghana Manganese Corp.		0	93,708	19,000	33,000	47,000
Gold Star	Prestea Bogosu	0	109,701	22,000	38,000	55,000
Gold Star	Wassa	0	135,441	27,000	47,000	68,000
Gold Star	Benso	0	161,415	32,000	56,000	81,000
Gold Fields	Damang	0	161,415	32,000	56.000	81,000
Gold Fields	Tarkwa	0	76,374	15,000	27,000	38,000
Kinross	Chirano	0	182,682	37,000	64,000	91,000
Newmont Mining Corp.	Ahafo	324	276,507	55,000	97,000	138,000
Noble Mineral Resources	Bibiani	0	424,701	85,000	149,000	212,000
Perseus Mining Ltd.	Edikan	0	358,317	72,000	125,000	179,000
Signature Metals	Konogo	0	500,616	100.000	175,000	250,000
	Kade	0	600,246	120,000	210,000	300,000
TOTAL		324	1,670,589	334,000	585,000	836,000

FIGURE 20. SPATIAL OVERLAP OF MINE DRAINAGE BASINS AND AGRICULTURAL LAND COVER IN GHANA (2005-2006)

Areas of mine drainage for three of the 17 mines in Ghana. Agricultural land cover outside of the drainage basins is shown with transparency to highlight agricultural land cover within these drainage basins.



Mosaic—veg/crop (within drainage)
Mosaic—crop/veg (outside drainage)
Mosaic—veg/crop (outside drainage)

0 20 40 80 Kilometers

UTM 30-N Projection

Data: WBI, ESA, NASA, GDAM

FIGURE 21. SPATIAL OVERLAP OF MINE DRAINAGE BASINS AND AGRICULTURAL LAND USE SUITABILITY FOR OIL PALM, HIGH INPUT LEVEL IN GHANA

Overlaps between total mine drainage area and crop suitability, for oil palm with high input levels in Ghana.

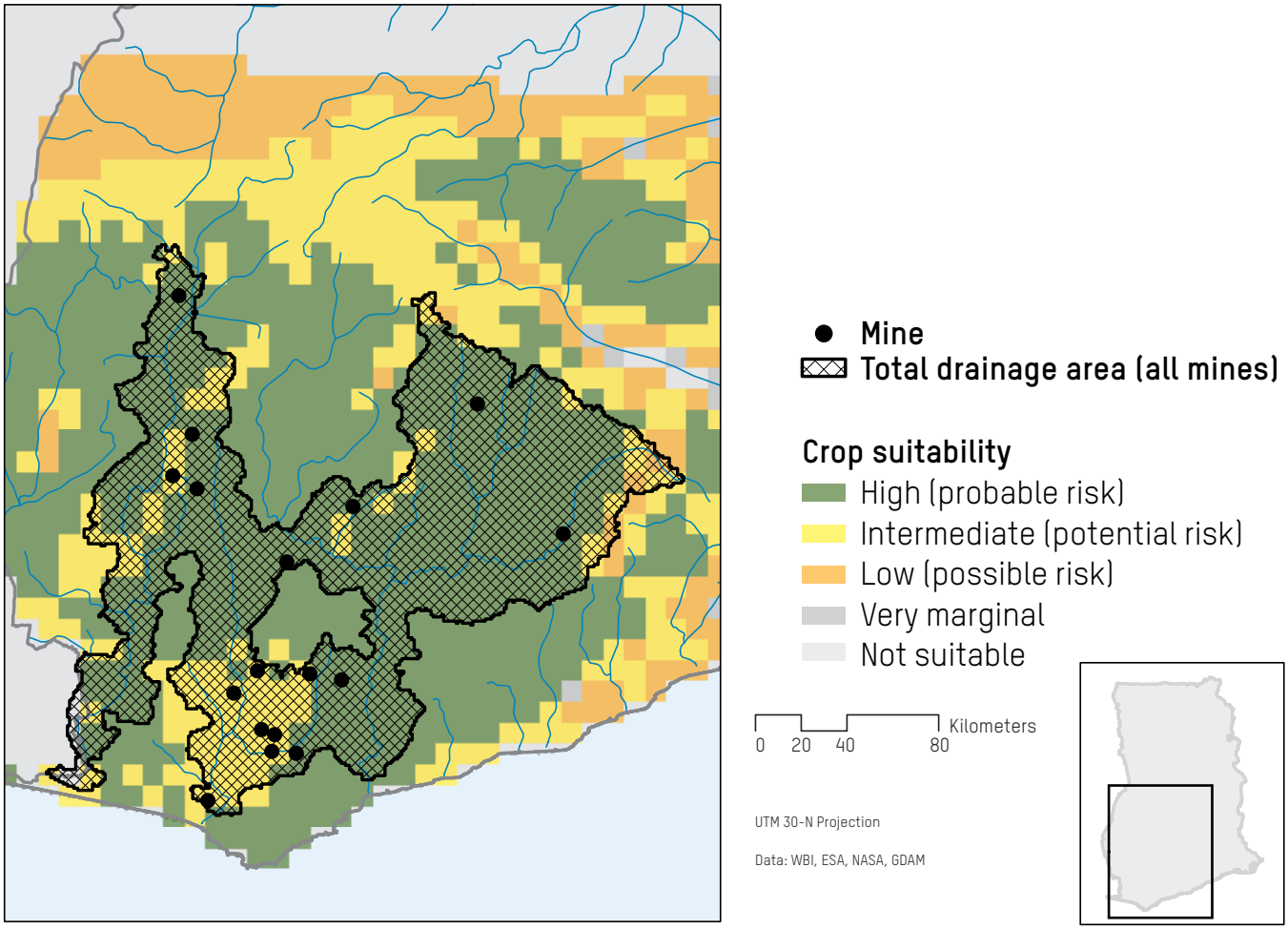


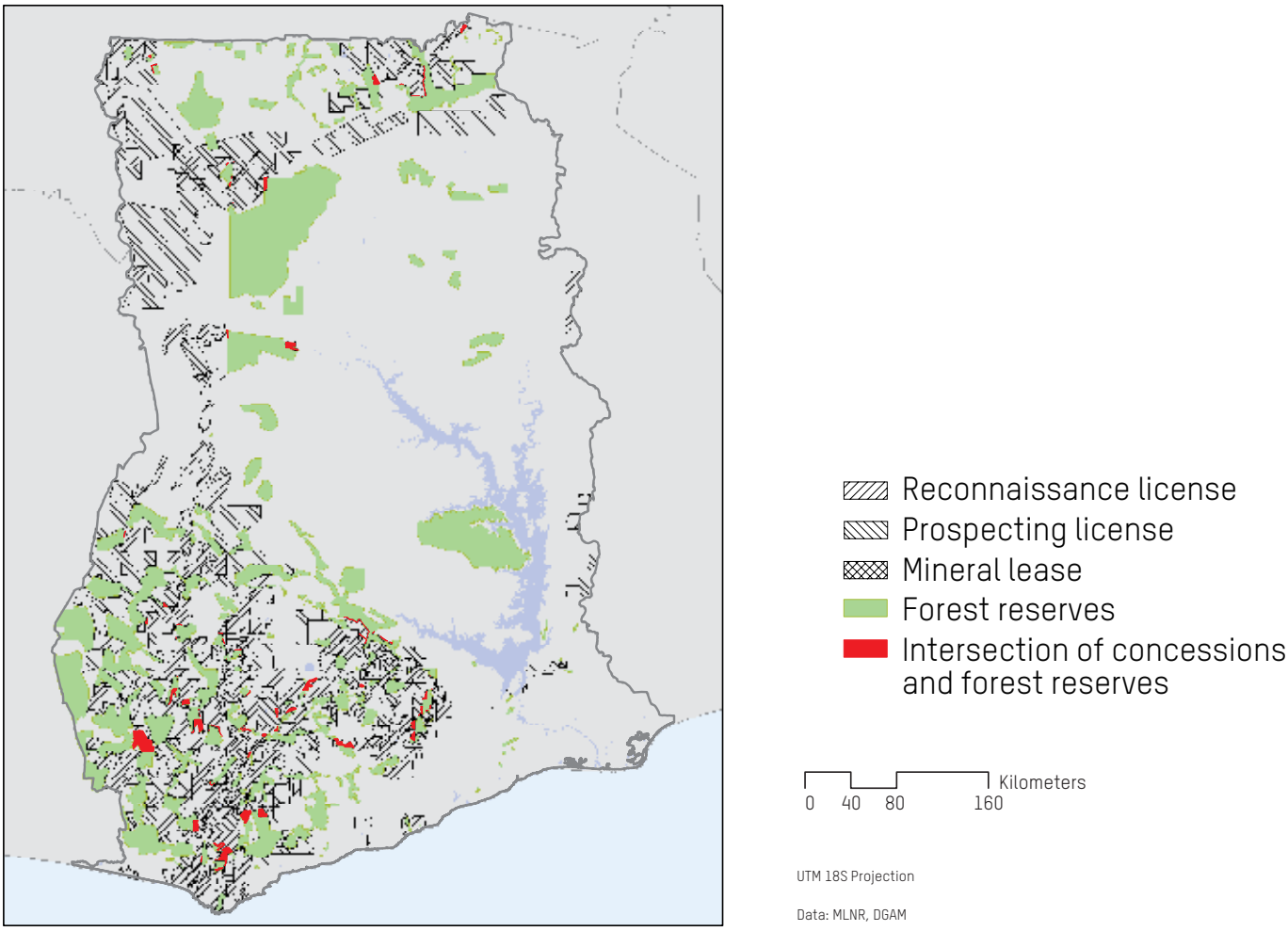
TABLE 10. LIKELIHOOD OF RISK TO AGRICULTURE FROM MINERAL EXTRACTION IN GHANA

INPUT LEVEL	ALFALFA	BANANA/ PLANTAIN	COCOA	COFFEE	COTTON	CASSAVA	MAIZE	OIL PALM	WETLAND RICE	SOYBEAN	SWEET POTATO	SORGHUM	SUGARCANE
High	PROBABLE	PROBABLE	PROBABLE	PROBABLE	unlikely	PROBABLE	POTENTIAL	PROBABLE	unlikely	POTENTIAL	POTENTIAL	unlikely	POTENTIAL
Interm.	POTENTIAL	POTENTIAL	PROBABLE	PROBABLE	POTENTIAL	PROBABLE	POTENTIAL	PROBABLE	unlikely	unlikely	POTENTIAL	unlikely	POTENTIAL
Low	PROBABLE	POTENTIAL	POTENTIAL	PROBABLE	unlikely	PROBABLE	POTENTIAL	PROBABLE	unlikely	POTENTIAL	POTENTIAL	unlikely	POTENTIAL

Note: Likelihood that a crop-cultivation practice is exposed to extraction-related water conflict, derived from average GAEZ agricultural suitability value in drainage areas, with respect to 13 crops suitable in areas within Ghana and three input levels

FIGURE 22. SPATIAL OVERLAP OF MINERAL CONCESSIONS AND FOREST RESERVES IN GHANA

Illustration mineral concessions, forest reserves, and areas of overlap in Ghana.



OVERLAPS OF MINERAL CONCESSIONS AND FOREST RESERVES

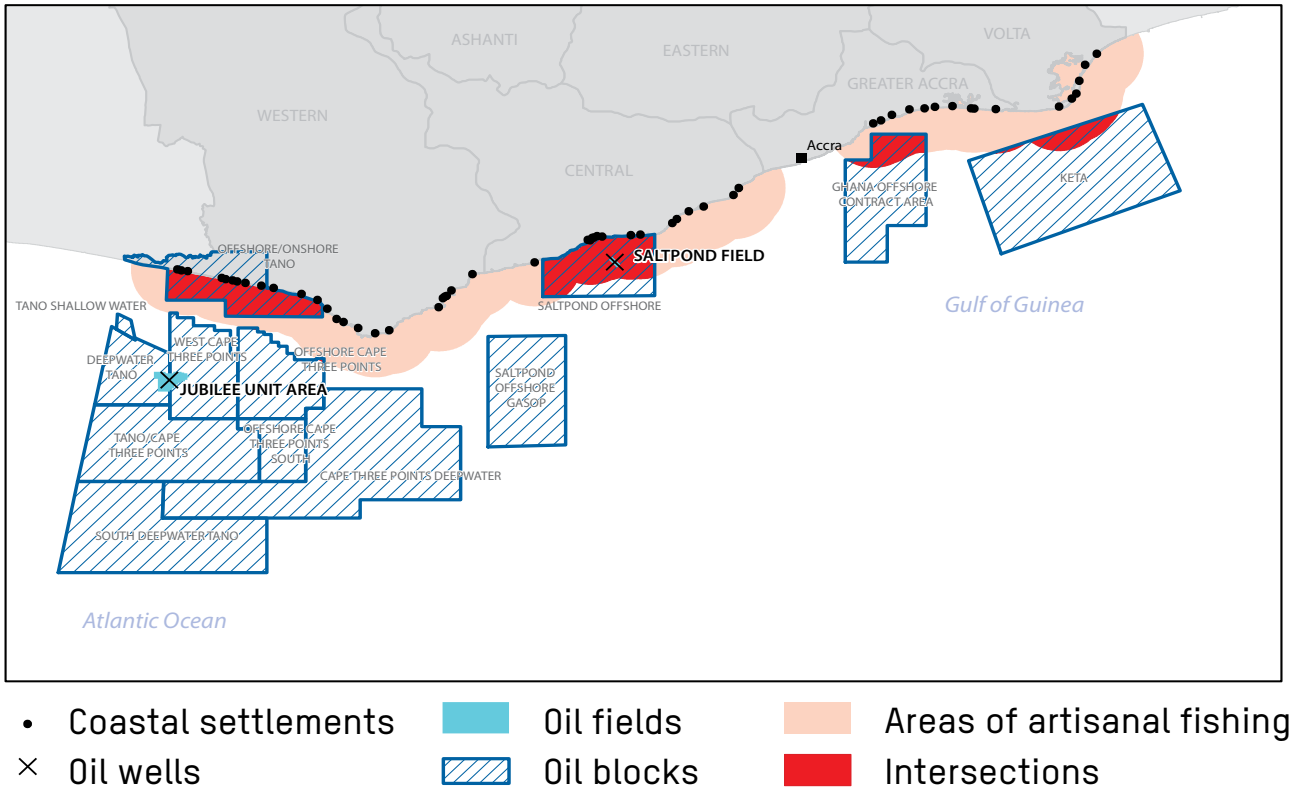
The forest reserves administered by Ghana's Ministry of Lands and natural Resources are not necessarily healthy, intact woodlands. Still, the designation encourages initiatives related to biodiversity protection, sustainable forest management, and carbon sequestration.

The extent of overlap between concessions and forest reserves varies both in land area and in proportion of the concessions involved:

- 78 km² for exploratory licenses (0.3 percent of total area licensed)
- 238 km² for prospecting licenses (0.9 percent of total area licensed)
- 245 km² for mining leases (6.3 percent of total area leased)

These results suggest that forest reserves limit exploration but do not impede the actual extraction of minerals. Compared with forest reserves in Peru, Ghana's forest reserves evidently enjoy less legal and administrative protection from development. Forest governance in Ghana is thus an area that would likely benefit from focused attention.

FIGURE 23. DISTRIBUTION OF COASTAL SETTLEMENTS IN RELATION TO OIL BLOCKS, OIL FIELDS, AND OIL WELLS



- Coastal settlements
- Oil wells
- Oil fields
- Oil blocks
- Areas of artisanal fishing
- Intersections

IMPACT OF OFFSHORE DRILLING ON SMALL-SCALE FISHING IN GHANA

The possible impact of extractive industry on small-scale or artisanal fishing in Ghana is particularly relevant now. In December 2010, the Jubilee Oil Field opened off the western coast, making Ghana a major oil-producing country. The growth of off-shore oil drilling has added new risks to Ghana's marine ecosystem. Oil development could disturb delicate marine ecology and fish catches, which are an important source of livelihood along the coast.

For our analysis, coastal settlements were geotagged using Google Earth imagery from 2012. Areas of small-scale or artisanal fishing are delineated in figure 23. The areas include a buffer of 12 nautical miles from coastal settlements, except Accra. The distance reflects the limitations imposed by surf, equipment weight and bulk, and boat range.[8]

Drilling in the Saltpond Field, being especially close to shore, poses a risk of pollution for coastal settlements in the Central region of Ghana. Spills from the Saltpond Field could also endanger Accra and coastal areas to the east. Drilling in the Jubilee Field is farther offshore and thus poses less direct risk to coastal communities. However, with west-to-east currents along the coast, the Jubilee Field's location near the western boundary of Ghana's offshore fields exposes coastal areas to the east to risk from a potential spill.

Cocoa beans drying in Akatakyieso village Ghana. Farmers in this area were relocated and lost access to their fields when a mine run by AngloGold Ashanti was established. Cocoa farming is more likely to be adversely affected by large-scale mining in Ghana. *Jeff Deutsch / Oxfam America*

SUMMARY OF GHANA ANALYSIS

Visualizing the overlapping geographies of extractive activity, water resources, farmland, protected areas, and coastal communities in Ghana reveals similar patterns to those in Peru. Because our data for Ghana was not as rich as that for Peru, our analysis of current conditions is rudimentary in comparison. Nor were we able to map overlaps between concessions and rural settlements as we did for agrarian and indigenous communities in Peru. Nevertheless, we can identify several key patterns:

First, the expansion of extractive industries is causing, or soon will cause, land use conflicts. Such a trend is clearly the case with forest reserves, and it is likely to occur in agricultural areas.

Second, conflicts between off-shore drilling and small-scale fishing are also foreseeable.

Third, as in Peru, either the government planning system fails to anticipate these conflicts or else it is biased in favor of industry. Especially worrisome in Ghana is the permitting of mines within forest reserves.

Fourth, our analysis suggests a need to address potential land conflicts in a crop-specific way. The effect of extractive activity on farming varies greatly depending on the crop involved. Paying attention to these differences could help lead to smarter land use decisions.

CONCLUSION

Despite its benefits, development always brings risk and uncertainties to communities. People and groups respond to new risks with a wide range of coping strategies. Rural protest can be seen as one such response, when other strategies have failed.

Policy-oriented development research is itself a response to the uncertainties that decision-makers face. Ideally, better data and analysis will reduce the guesswork that is normally part of choosing of a particular course of action.

Practitioners of so-called sustainability science recognize that stakeholders always operate under conditions of uncertainty. They seek information to reduce that uncertainty, and demand that information be credible before it is acted upon.[9]

The arrival of new industry in an area exposes local people to new uncertainties, for better or worse. Whether the industry's operations will help or undermine their health and livelihoods is hard for them to know in advance. Rural residents, in particular are least likely to have access to clear, unbiased, and thorough information about how a new mining project, for example, could affect their lives.

Our analysis clearly indicates that agricultural production and extractive industries are increasingly occurring in the same geographic areas in Peru and Ghana. Unless managed effectively by governments with appropriate policy coordination, the overlap of agriculture and extractive industries is a recipe for continued social conflict.

APPENDIX
PERU—MAP OF LAND SUITABLE FOR AGRICULTURE

The map used in this study to identify land suitable for agriculture in Peru was based on an INRENA dataset that assesses the most productive land use for all parts of the country. The 7,299 geographical units assessed range in size from 1,700 m^2 to nearly 66,000 km^2. The average land unit is approximately 400 km^2 and has from one to three uses attributed to it.

The four kinds of land use considered are, in descending order of economic value: agriculture, pasture, forest (not including protected areas), and areas that are protected or otherwise unclassified. If agriculture is not an area's optimal use, we list the reasons, such as soil quality, erosion risk, and rainfall patterns.

If at least part of a geographical unit was best-suited to agriculture, our map marked it as being potentially agricultural. Each location was categorized as high-, moderate-, or low-intensity according to the proportion of its area that is suitable for farming, judging from the INRENA data.

Typically, we designated a place as suited primarily for agriculture if agriculture described at least 80 percent of its area (though in some cases this value was as low as 40 percent. A place was listed as having agriculture as a secondary land use if 10-30 percent of its area was suitable for farming. Agriculture was designated as the tertiary land use if 5-20 percent its area was suitable for crops.

Our map of potential agricultural areas does not label all areas where agriculture could ever occur, but rather the places where conditions are most suitable for the cultivation of crops. For our purposes, some forms of agrarian production, such as raising livestock, were not considered forms of agriculture. It should also be noted that the scale of INRENA's data was not fine enough to let us identify cultivated tracts of land that are very small.

NOTES

1 International Council on Mining and Metals (ICMM), *Ghana Country Case Study: The Challenges of Mineral Wealth: Using Resource Endowments to Foster Sustainable Development* (London: ICMM, 2011).

2 On this topic, see the sustained work of Matt Finer and colleagues on the geographies of hydrocarbon concessions in the western Amazon: Matt Finer, Clinton Jenkins, Brian Keane, and Stuart Pimm, *Future of the Western Amazon: Threats from Hydrocarbon Projects and Policy Solutions* (Washington, DC: Save America's Forests, 2008); Matt Finer, Clinton Jenkins, Stuart Pimm, Brian Keane, and Carl Ross, "Oil and Gas Projects in the Western Amazon: Threats to Wilderness, Biodiversity, and Indigenous Peoples," *PLoS One* 3, no. 8 (2008): e2932; and Matt Finer and Marti Orta-Martínez, "A Second Hydrocarbon Boom Threatens the Peruvian Amazon: Trends, Projections, and Policy Implications," *Environmental Research Letters* 5, no. 1 (2010): 014012.

3 David W. Throup, *Ghana: Assessing Risks to Stability* (Washington, DC: Center for Strategic and International Studies, 2011). See also ICMM, 2011; and Keith Slack, "Mission Impossible? Adopting a CSR-Based Business Model for Extractive Industries in Developing Countries," *Resources Policy* 37, no. 2 (2012): 179–184.

4 Slack, "Mission Impossible?"; and Ray Bush, " 'Soon There Will Be No-One Left to Take the Corpses to the Morgue': Accumulation and Abjection in Ghana's Mining Communities," *Resources Policy* 34, nos. 1–2 (2009): 57–63.

5 Gavin Hilson and Chris Garforth, '' 'Agricultural Poverty' and the Expansion of Artisanal Mining in Sub-Saharan Africa: Experiences from Southwest Mali and Southeast Ghana," *Population Research and Policy Review* 31, no. 3 (2012): 435–464; and Gavin Hilson, '' 'Once a Miner, Always a Miner': Poverty and Livelihood Diversification in Akwatia, Ghana," *Journal of Rural Studies* 26, no. 3 (2010): 296–307.

6 The "might" here is an important caveat. There are many possible routes from tax and royalty payments to poverty reduction, but whether these routes actually function is an empirical question. While cases such as Botswana, or more recently, Bolivia, suggest that poverty effects can be significant, the Peruvian case is subject to much more debate—and the sustainability of poverty impacts that depend on cash transfers rather than economic diversification is also subject to debate.

For more on these topics, see for instance: William Ascher, "Mineral Wealth, Development and Social Policy in Indonesia," in *Mineral Rents and the Financing of Social Policy: Opportunities and Challenges*, ed. Katja Hujo (New York: Palgrave Macmillan, 2012), 223–256; Javier Arellano-Yanguas, "Aggravating the Resource Curse: Decentralisation, Mining and Conflict in Peru," *Journal of Development Studies* 47, no. 4 (2011): 617–638; and Leonith Hinojosa, Anthony Bebbington, and Armando Barrientos, "Social Policy and State Revenues in Mineral-Rich Contexts," in Hujo, *Mineral Rents*, 91–121.

7 Vivian Schueler, Tobias Kuemmerle, and Hilmar Schroeder, "Impacts of Surface Gold Mining on Land Use Systems in Western Ghana," *Ambio* 40, no. 5 (2011): 528–539.

8 Emmanuel Akyeampong, "Indigenous Knowledge and Maritime Fishing in West Africa: The Case of Ghana," in *Indigenous Knowledge Systems and Sustainable Development: Relevance for Africa*, eds. Emmanuel Boon and Luc Hens (Delhi: Kamla-Raj Enterprises, 2007), 173–182.

9 The literature on risk and uncertainty is extensive, even within development studies. For classic texts, see James Scott, *The Moral Economy of the Peasant: Rebellion and Subsistence in Southeast Asia* (New Haven, CT: Yale University Press, 1976). For agriculture, see B.L. Turner and Stephen Brush, eds., *Comparative Farming Systems* (New York: Guilford, 1987).

On saliency, credibility, and legitimacy, see David Cash, William Clark, Frank Alcock, Nancy Dickson, Noelle Eckley, David Guston, Jill Jäger, and Ronald Mitchell, "Knowledge Systems for Sustainable Development," *Proceedings of the National Academy of Sciences (PNAS)* 100, no. 14 (2003): 8086–8091; The Social Learning Group / William Clark, Jill Jäger, Josee van Eijndhoven, and Nancy Dickson), eds., *Learning to Manage Global Environmental Risks*, 2 vols. (Cambridge, MA: MIT Press, 2001); Sheila Jasanoff, "Contested Boundaries in Policy-Relevant Science," Social Studies of Science 17, no. 2 (1987): 195–230; and William Clark and Nancy Dickson, "Sustainability Science: The Emerging Research Program," *PNAS* 100, no. 14 (2003): 8059–8061.

On similar issues with respect to mining, see Anthony Bebbington and Jeffrey T. Bury, "Institutional Challenges for Mining and Sustainability in Peru," *PNAS* 106, no. 41 (2009): 17296–17301.

COVER: Left: Open pit mine in the town of Prestea, in Ghana's Western Region. *Jeff Deutsch / Oxfam* America
Right: Indigenous Kichwa women in San Martin, Peru, cultivate traditional crops. *Percy Ramirez / Oxfam America*

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