
MINING AND CRITICAL ECOSYSTEMS:

Mapping the Risks



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Cover photograph:
Women and children are seen outside the Porgera gold and silver mine in Enga Province, Papua New Guinea. In addition to hosting several of the world's largest mines, Papua New Guinea is home to some of Earth's most biologically and socially diverse ecosystems and communities.
Credit: Marta Miranda.

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FOREWORD

In the last decade, concern for environmental and social issues has affected many business sectors. The emergence of corporate commitments, voluntary codes of conduct, and reporting standards signal that corporate leaders have heard societies' demands for environmentally and socially responsible corporate practices. Companies doing business in the mining, oil, and gas sectors are among the newest participants in the corporate social responsibility dialogue. These industries' recent commitment to refrain from mining development in World Heritage Sites is an acknowledgment that protection of sites of exceptional natural and/or cultural value or sensitivity is socially responsible and worth the cost.

Mineral development is a high-stakes endeavor, and nowhere more so than in areas where human communities and high-value environmental resources are perceived to be at risk. Mining companies have faced fines and clean-up costs in the tens of millions of dollars for pollution-related incidents. Investments of hundreds of millions have been written off when mining projects were blocked by social unrest and challenges to environmental destruction.

Mining can provide an important source of jobs and income, but sometimes the biggest losers of all are isolated rural communities in the vicinity of mining projects, where too-rapid social and environmental change can tear at the fabric of tradition and daily life. Such incidents have fueled an often contentious debate about how to identify areas that should be declared off-limits to mining because of their environmental and social sensitivity. These discussions have yielded general principles, but no specific framework for highlighting environmentally and socially sensitive areas.

Mining and Critical Ecosystems: Mapping the Risks represents an attempt by the World Resources Institute and partner organizations in Papua New Guinea and the Philippines to bridge this gap. It is the first study to systematically assess and map global indicators of ecosystems and communities that are vulnerable to the negative impacts of mining. It is also the first to adapt such indicators to the particular circumstances of two countries where mining plays a large role in the national economy and which face important public policy decisions regarding the future of the mining sector.

The framework developed in this study is intended to be used by financial institutions and insurance companies who, until now, have relied upon less systematic and comprehensive methods of assessing environmentally and/or socially vulnerable areas to mining. We also hope that companies, governments, and non-governmental organizations will find this work a useful contribution to ongoing efforts to define "no-go" areas for mining.

However, the pilot framework developed for this study is only one early step in a lengthy process of risk assessment and stakeholder consultation to identify probable “no go” areas for mining. Unfortunately, significant uncertainties remain regarding the fragility of ecosystems, and data gaps make it exceptionally difficult to accurately predict the impacts of mining in many areas of high conservation and social value.

“No go” decisions must ultimately be made in the context of what societies are prepared to accept in terms of risk, based on the environmental and social values attached to the areas in question. This report argues that some parts of the world hold sufficient natural and social values to justify their protection from destructive mining practices.

This pilot framework represents the first of a suite of tools that WRI intends to develop to guide socially and environmentally responsible investments in extractive industries, including forestry, mining, and oil and gas development. Over time, we hope to expand our ability to identify areas of high environmental and social value, where at the very least extreme caution is warranted in considering mining development.

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At ESSC, Executive Director Peter Walpole, S.J. provided leadership on the Philippines case study. Sylvia Mclat and Charles Mooney contributed analysis and text to the case study. Royce Eustaquio coordinated GIS and cartography for the Philippine maps. WRI and ESSC would like to thank Director Horace Ramos and his staff at the Philippine Mines and Geosciences Bureau (Department of Environment and Natural Resources) for allowing access to important geospatial data on mining contracts in the Philippines.

WRI solicited comments on an earlier draft of this report from representatives of the International Finance Corporation (IFC), mining companies, NGOs, and the Philippine government. We gratefully acknowledge comments from the following external reviewers: Hank Cauley (Ecos Corporation), Catherine Coumans (MiningWatch Canada), Jim Kuipers (Center for Science and Public Participation), John Morrison (World Wildlife Fund-US), Payal Sampat (Mineral Policy Center), and Dirk van Zyl (University of Nevada, Reno).

While recognizing the contributions of those mentioned above, the authors retain sole responsibility for the opinions expressed in this report.

Executive Summary

Like many natural resource sectors, the hardrock mining (metals and precious stones) industry has been under considerable pressure in recent years to improve its environmental and social performance. The financial and reputational costs of mining in areas that are environmentally and/or socially vulnerable have been high for both natural resource companies and the companies that insure and finance them. For example, in 1996 the gold mining company Placer Dome reported a \$65 million loss due largely to a spill at its Marcopper mine in the Philippines (Placer Dome, 1996).

International initiatives have been launched to examine where and under what circumstances mining is an appropriate land use and how (or even if) it can contribute to environmentally and socially responsible development. Nevertheless, much uncertainty remains in identifying when the potential environmental and social costs of mining are too high. Non-governmental organizations (NGOs) and companies have developed general principles and criteria for identifying areas that should be off-limits to mining, oil, and gas development. However, to date no attempts have been made to identify what might constitute “vulnerable ecosystems.”

This study addresses a critical issue that is central to achieving environmentally and socially responsible mining: the identification of areas that are too environmentally and/or socially “sensitive” for mining. It entailed development of a pilot framework that can be used as preliminary, coarse screen to identify such areas globally. We also adapted the methodology and applied the framework at the national level in two country case studies. This effort represents the first systematic attempt to develop and apply such a framework.

Companies, governments, and NGOs can use the approach piloted in this study to identify environmentally and socially vulnerable areas. The primary audience is insurance companies and financial institutions that seek to limit their potential financial losses associated with mining projects that perform poorly because of environmental and social problems. Other stakeholders, including mining companies, governments, and NGOs, should also find it useful as part of an open, transparent, consultative decision-making process for identifying probable “no go” areas for mining.

The framework developed for this study is not intended to be used as a tool for making final decisions on siting, investment, or “no-go” areas for mining projects. Data uncertainties and the qualitative nature of the methodology make it unsuit-

able for these purposes. While it does not provide a rigorous, quantitative risk assessment methodology, the framework can be used as a first step to highlight areas that may be environmentally or socially vulnerable to mining, and which may require further assessment. The framework also goes beyond most other risk assessment tools in the mining sector to incorporate indicators of governance capacity as well as other environmental and social indicators for assessing mining risk, hazards, and vulnerabilities.

THE MINING AND CRITICAL ECOSYSTEMS FRAMEWORK

This study focuses primarily on hardrock mining (that is, metals and precious gemstones), although the identification of environmentally and socially vulnerable areas is also relevant for other extractive industries, such as oil, gas, and forestry. The analysis was conducted by the World Resources Institute in partnership with organizations in two countries: Papua New Guinea (Papua New Guinea NGO Environmental Watch Group) and the Philippines (Environmental Science for Social Change).

The framework developed for this study consists of three broad categories of indicators—vulnerabilities, natural hazards, and other contributing factors—which were mapped at a global scale. Case studies in Papua New Guinea and the Philippines demonstrate application of the global framework and mapping of indicators at a national level.

The framework’s three categories and the indicators they contain are described below. Because risk assessment terminology varies widely in the literature, we first define key terms used in the analysis. For the purposes of this study, vulnerability, hazard, and risk are defined as follows:

- **Vulnerability** is the likelihood of destruction or degradation arising from a natural or environmental hazard, such as destruction of an intact ecosystem or damages to an aquatic system from water pollution.
- **Natural Hazards** are events, such as earthquakes or floods, that can cause or exacerbate mine-related problems.
- **Risk** is the probability of a hazard occurring, such as the probability that an earthquake of a given magnitude will occur in a particular time period.

- *Actuarial risk* is the probability of a hazard occurring multiplied by its consequences. Because data are limited, it is difficult to measure actuarial risks with respect to mining at the global level.
- *Other contributing factors* are conditions that either increase or decrease the risk or probability that a hazard will occur, such as particular mining practices that tend to increase environmental hazards.

The Mining and Critical Ecosystems Framework is designed to capture three key environmental challenges associated with mining: waste management, water quantity and quality, and habitat destruction (direct and indirect). The social impacts of mining are less well-documented and difficult to model; thus, the social element of the framework is limited to measuring the degree to which communities are equipped to make informed decisions regarding mining development.

LIMITS OF THE ANALYSIS

Until now, areas that are environmentally and socially vulnerable to mining have not been systematically mapped. Thus, the current framework is limited by data availability. Datasets identifying the location of active mines and exploration sites, the range of valuable species, and the impacts of mining on local communities are often incomplete and/or not in the public domain. Governance practices are difficult to measure and existing indicators are inaccurate and largely subjective. Because of these data limitations and the coarse scale at which the analysis was conducted, some areas not identified as “highly vulnerable” may, in fact, qualify as such if the analysis were conducted at a finer scale.

Ultimately, consideration of “no go” areas will involve value-based judgments, requiring decision-makers to weigh potential economic benefits against social and environmental costs. The values adopted in the analysis will bear importantly on whether these costs are perceived to outweigh economic benefits. The analysis conducted for this study deliberately attaches great importance to ecological integrity and healthy communities, because these values are consistent with the missions of conservation and development organizations undertaking the analysis. Using the framework to emphasize other values would yield different results.

RESULTS AND CONCLUSIONS

To date, mining has had a poor record in terms of its contribution to sustainable development. While some communities and nations have benefited significantly from mining, many who should have benefited did not. Based on the global analysis conducted for this study, we conclude that:

- Although global and national policy debates often center on “no go” areas on land that is already subject to legal protection, mining in important ecosystems that are not adequately protected may pose an even greater threat. Three quarters of active mines and exploratory sites overlap with areas of high conservation value and areas of high watershed stress.
- Many mineral-dependent countries in the developing world lack important safeguards to ensure that responsible mining occurs, such as the ability to enforce laws, control corruption, and foster a strong civil society. Nearly one quarter of active mines and exploration sites are located in countries where governance structures are weakest. In these countries, continued investment in mining will be less likely to contribute positively to economic development unless governance improves.

Our analysis indicates that:

- More than one quarter of the world’s active mines and exploration sites overlap with or are within a 10-kilometer radius of a strictly protected area.
- Nearly one third of all active mines and exploration sites are located within areas of intact ecosystems of high conservation value (see Map 2).
- Almost one third of all active mines are located in stressed watersheds (see Map 5).
- Nearly one fifth of active mines and exploration sites are in areas of high or very high seismic hazard (see Map 11), and more than one third are in areas that may be predisposed to water quality problems (see Map 13).

Based on case studies in Papua New Guinea and the Philippines, we conclude that:

- Although mining in legally protected areas and ancestral domain claims is difficult to justify in the Philippines, some mine claims overlap with these areas, producing latent claim conflicts.
- Because so many areas of active mining and/or exploration in Papua New Guinea and the Philippines are subject to multiple vulnerabilities and hazards (75 percent and 40 percent, respectively), investment in mining projects in these countries is likely to require greater due diligence to ensure that development does not result in high environmental and social costs.
- The Porgera and Ok Tedi mines in Papua New Guinea demonstrate the danger of dealing with multiple hazards by adopting environmentally risky alternatives in a country

where governance and the capacity for informed decision-making are low.

Our maps indicate that:

- More than one quarter of Papua New Guinea's fragile forests occur within oil, gas, and mining concessions (see Map 3).
- In the Philippines, more than half (56 percent) of all exploration areas and mining leases overlap with areas of high ecological vulnerability (see Map 4).
- Two thirds of exploratory concessions and more than half of active mines in the Philippines are located in areas of high seismic risk (see Map 12).

USING THE FRAMEWORK TO SUPPORT OPEN AND TRANSPARENT CONSULTATIVE PROCESSES

Identifying 'no go' areas is inherently part of a successful business strategy, especially in the extractive industries sector. Mining companies routinely assess whether investments pose greater corporate risks (e.g., loss of reputation, loss of the social license to operate, disruptions in operations) than

financial benefits. Besides mining companies, the indicators developed for this study should also be useful to insurers and providers of project finance, which are especially sensitive to potential risks posed by mining, as they stand to lose the most if the consequences of these risks result in disrupted operations and/or large claims.

Project evaluators can use the data provided in this report to answer questions in the table below. Answering positively to one or more of these questions should trigger additional investigation, including consultation with local NGOs and stakeholders to determine if the proposed project conflicts with regional conservation or social objectives. In addition, the table can be used to identify some probable "no go" issues, such as projects proposed in officially designated protected areas or those with proposed riverine tailings disposal systems.

Because the process of deciding whether a project warrants a "no go" decision is complex, it should not be reduced to a checklist approach. Such decisions will require careful information gathering, thoughtful analysis, and stakeholder engagement. Although the questions listed below can be used as an initial filter for project evaluation, they are not comprehensive and project evaluators may need to consider additional issues.

Coarse-Scale Screen of Environmental and Social Sensitivity

Question	Maps	Sample Indicators*
1. Does the proposed project fall in high conservation value areas?	2, 3, 4	<ul style="list-style-type: none"> ■ Officially designated protected areas ■ Intact, unique, or rare ecosystems ■ Areas representing the last or most important examples of habitat types ■ Fragile forests of Papua New Guinea ■ Protected/ critical watersheds in the Philippines
2. Does the proposed project fall within other environmentally vulnerable areas?	5, 6, 7	<ul style="list-style-type: none"> ■ Stressed watersheds ■ Groundwater availability in the Philippines
3. Does the project propose environmentally risky practices?	2, 3, 4, 9, 10	<ul style="list-style-type: none"> ■ Riverine tailings disposal ■ Submarine tailings disposal in areas of environmental or social vulnerability
4. Is the project located in an area of high natural hazards?	11, 12, 13	<ul style="list-style-type: none"> ■ Earthquake-prone areas ■ Predominantly wet, humid climates
5. Is the project proposed in areas with disadvantaged communities?	8, 9, 10	<ul style="list-style-type: none"> ■ Impoverished communities with low levels of education
6. Is the project proposed in a country with poor governance?	14, 15	<ul style="list-style-type: none"> ■ High corruption levels ■ Low adherence to the rule of law ■ Lack of freedom of expression in civil society

*Note: The examples listed are by no means exhaustive, but reflect the indicators that were incorporated in this study. They are meant to be illustrative of the types of information risk evaluators can use in their coarse-scale analyses.

RECOMMENDATIONS

Based on the results of this analysis and the conclusions we draw from them, we recommend that financial institutions, governments, NGOs, and the mining industry take the following actions.

1. **Banks and insurers should use indicators like those developed for this study to rate the environmental and social sensitivity of mining projects.** Although banks and insurance companies routinely apply environmental screens to identify sensitive projects, the criteria for and application of such tests appear to vary broadly and depend upon the discretion of project evaluators. A more rigorous approach would be to systematically develop and use indicators that would assess proposed mining projects and classify any with characteristics such as those listed in the table above as “environmentally or socially sensitive.”
2. **Financial institutions should subject all environmental and social impact assessments of proposed mining projects to review by an independent, external panel of experts.** A key weakness of current risk evaluation procedures used by the financial sector is reliance on company-funded environmental impact assessments to evaluate the potential risks to investors. A more rigorous risk evaluation process would entail external review of all environmental and social impact assessments by a panel of experts not employed by the mining company and preferably independent of the institution considering project finance.
3. **These expert reviews should be made publicly available, further raising the level of oversight.** For especially sensitive projects, free prior informed consent with local stakeholders should be considered a necessary condition for project financing. Client confidentiality rules may make some private banks reluctant to require transparency as a condition of project finance. However, failure to identify potential environmental and social pitfalls may prove more costly in the long term, especially if community opposition is strong enough to halt operations.
4. **Government policymakers and NGOs should use methodologies like the one developed for this study to identify areas that may be socially and environmentally sensitive to mining.** Despite the development of international standards for companies and financial institutions engaged in the mining sector, governments and civil society will continue to bear the primary responsibility for ensuring the long-term health of ecosystems and communities.
5. **Governments should support anti-corruption measures aimed at the mining sector, such as mandatory disclosure of payments made to governments by mining companies. Such information should be disaggregated to show individual company revenue flows as well as the distribution of payments at a sub-national level.** Lack of transparency is a major problem in the mining sector, especially in countries that depend heavily on mineral wealth. Although some argue that a voluntary approach would reflect a true commitment to transparency, mandatory measures will be far more likely to ensure that benefits are used effectively to promote development.
6. **The mining industry should use indicators like the ones developed for this study to identify areas that are environmentally and socially vulnerable to the impacts of mining and to identify probable “no go” areas.** While adoption of a Sustainable Development Framework put forward by the global mining industry association (the International Council on Metals and Mining, or ICMM) is an important first step, more needs to be done to make general principles operationally relevant. Principle #4 commits the industry to “implement[ing] “risk management strategies based on valid data and sound science.” Using the framework indicators developed for this study to identify environmentally and socially vulnerable areas would be a good start toward operationalizing this principle.
7. **Mining companies should make firm commitments not to develop mines in an expanded set of “no go” areas, including those identified using this and related methodologies.** The ICMM principles also call on mining companies to “respect legally protected areas.” As a first step, ICMM members should support IUCN Amman Resolution 2.82 and commit not to develop mines in strictly protected areas, that is, IUCN categories I-IV. Moreover, this study demonstrates the need for companies to go beyond the Amman Resolution to consider other areas that are environmentally and/or socially sensitive to mining and should be designated probable “no go” areas. Companies should use the framework indicators developed for this study to help them identify such areas and avoid costly investments in properties that are likely to be unfeasible for environmental or social reasons.

8. **Mining companies should also agree to disclose payments made to governments as called for in the Extractive Industries Transparency Initiative.** The Extractive Industries Transparency Initiative seeks to address corruption in the mining, oil and gas sectors by encouraging companies to disclose payments made to governments. Such a commitment would be in keeping with ICMM principles, which commit member companies to “implement policies and practices that seek to prevent bribery and corruption.”
9. **Metal product buyers, such as jewelry retailers, electronics manufacturers, and telecommunications companies, should commit to sourcing their materials only from environmentally and socially responsible mines.** Such a commitment would require metal product buyers to consider the environmental and social risks associated with sourcing materials from specific mines and thus could help persuade mining companies to change their practices. Although further detailed analysis is necessary to identify site-specific risks, mines located in areas that are environmentally or socially vulnerable, or that use risky practices, should be of concern to metal product buyers seeking to implement responsible purchasing commitments.

Chapter 1

Introduction and Background

Mine incidents are costly for companies.

Like many natural resource sectors, the mining industry has been under considerable pressure in recent years to improve its environmental and social performance. High-profile disasters have been costly for both natural resource companies and the companies that insure and finance them (see Table 1). In recent years, a plethora of international initiatives have sought to address the environmental and social performance of the mining, oil, and gas industries (see Box 1). These initiatives attempt to address the lack of international standards governing where and how these companies should operate. Each initiative has a different focus, but nearly all recognize that some parts of the world may not be suitable for mineral development. Inherent in all these processes is a vigorous debate on where mining should or should not occur and what should be taken into account when such decisions are made.

There are no global standards for responsible mining.

Unfortunately, there is as yet no consensus on international standards for the mining, oil, and gas industries, and much less on what areas may be unsuitable for development. Despite the wealth of existing information on the social and environmental impacts of these sectors, much of it is limited to case study analyses. Very little has been done to quantify the impacts of mining on specific ecosystems, much less to identify ecosystems that are vulnerable to the impacts from mining at a global level. The lack of independent data at a global level makes it difficult to understand the threat posed by mining in remote areas, which are increasingly being developed for mineral extraction. And without such data, it is difficult to develop comprehensive international standards for environmentally and socially responsible mining.

Table 1. Costs to Mining Companies from Environmental Incidents

Mine Incident	Company	Financial Cost to Company (in \$US)
Marcopper, Marinduque, Philippines (1996)	Placer Dome (40% owner); Marcopper Mining (60% owner)	<ul style="list-style-type: none">■ Total of \$43 million in after-tax charges to earnings (including \$18 million in clean-up and remediation) reported by Placer Dome■ \$2 million fine from the Philippine government■ \$2.5 million in fines between 1975 and 1988
Los Frailes, Spain (1998)	Boliden	<ul style="list-style-type: none">■ \$24.5 million in direct and indirect costs
OK Tedi, Papua New Guinea	BHP	<ul style="list-style-type: none">■ \$416 million write-off in 2001 due to withdrawal from project for environmental and social reasons■ \$49 million in compensation to landowners in 1996
Paracale, Camarines Norte, Philippines, unauthorized discharge of wastewater, 1995–1998	United Paragon Mining Corporation	<ul style="list-style-type: none">■ \$60,000 in fines

Note: Includes fines and costs to companies from mine incidents for which information is available.

Sources: Marcopper—Placer Dome, 1996; DENR-PAB, 2000. Los Frailes—UNEP/World Bank /MMSD, 2002b. OK Tedi—BHP, 2002. Paracale—DENR-PAB, 2000.

The goal of this study was to develop a qualitative framework for identifying ecosystems and communities vulnerable to the environmental and social impacts of mining. Financial institutions, mining companies, governments, and nongovernmental organizations (NGOs) could then use the methodology tested by this research in Papua New Guinea and the Philippines to guide the development of a set of standards for environmentally responsible mining, or the identification of areas that should be placed off-limits for mineral development—so-called “no go” zones. The methodology used in this report is especially relevant for financial institutions and insurance companies, which may be exposed to financial losses if investments in mining projects result in environmentally or socially costly outcomes.

Box 1. International Mining Initiatives

The last 2 years have witnessed several large international initiatives aimed at addressing mining and its environmental and social impacts:

The World Summit on Sustainable Development (WSSD): In 2002, in Johannesburg, South Africa, governments adopted an implementation plan for sustainable development, which committed states to: address the environmental, economic, health, and social impacts and benefits of mining; promote transparency and accountability for sustainable mining and minerals development; enhance the participation of stakeholders, including local and indigenous communities and women, in all stages of mining; and, foster sustainable mining practices by providing financial, technical, and capacity-building support to developing countries and countries with economies in transition (WSSD 2002).

The Mining, Minerals and Sustainable Development Project (MMSD): MMSD was a 2-year research and public consultation effort commissioned by the World Business Council for Sustainable Development (WBCSD), and sponsored principally by mining companies. The project was executed by the International Institute for Environment and Development (IIED). In its final report *Breaking New Ground*, released in 2002, MMSD identifies the challenges faced by the minerals sector and proposes an agenda for change (MMSD 2002).

The Extractive Industries Review (EIR) of the World Bank: In 2001, the World Bank launched a review with concerned stakeholders of its future role in the extractive industries. The objective of this ongoing process is to produce a set of recommendations that will guide the Banks’ involvement in the oil, gas, and mining sectors. The review is taking place within the context of the Bank’s overall mission of poverty reduction and promotion of sustainable development (EIR 2002).

IUCN, Mining, and Biodiversity: During the WSSD, the World Conservation Union (IUCN) and the International Council of Mining and Metals agreed to a dialogue to improve the performance of the mining industry with respect to biodiversity conservation and protected areas. The initial focus of the dialogue includes “best practice guidelines/principles,” “reporting criteria” for the mining industry, and a review of the application of the protected areas category system to mining (IUCN 2003).

The International Council on Mining and Metals (ICMM): An industry association, ICMM was formally launched during a high-profile meeting on mining in Toronto in 2002 and includes among its members most of the world’s major mining companies. Its mission is “to be the clear and authoritative global voice of the world’s mining and metals industries, developing and articulating their sustainable development case, discovering and promoting best practice on sustainable development issues within the industries and acting as the principal point of engagement with the industries for stakeholders at the global level” (ICMM 2003). ICMM has established various task forces to implement its work program, such as Sustainable Development Framework, Interaction with Key International Fora, Community and Social Development, and Mining and Biodiversity.

Global Mining Campaign and other NGO Networks: The Global Mining Campaign (GMC) was launched at an international meeting of community activists and NGOs in 2001. The GMC is a network of groups that exchange information and coordinate campaign efforts on mining issues. Other NGO networks have also been created in other parts of the world (e.g., U.S., Asia-Pacific), allowing increased collaboration among NGOs and community activists on mining-related issues.

At the global level, our analysis identifies indicators that should be taken into account when considering areas that may be too vulnerable to the impacts of mining. However, global level indicators are not sufficiently detailed to allow decision-makers to identify vulnerable areas and site-specific risks. For this reason, we engaged partners in two countries—Papua New Guinea (Papua New Guinea NGO Environmental Watch Group) and the Philippines (Environmental Science for Social Change)—to develop the global methodology and adapt it to the realities in their respective countries (see Map 1). Both case studies are intended to demonstrate how the global framework can be applied at a national level, using nationally available datasets for each country.

These two countries were chosen as case studies in part due to the interests of supporters of this research in the Asia/Pacific region. In addition to the importance of mining to the economies of these countries, both are characterized by exceptionally high ecological value, although the condition of remaining ecosystems is vastly different between the two. While Papua New Guinea is fortunate to retain many of its ecosystems intact, the Philippines has suffered extensive habitat destruction. Thus we believe these two countries are representative of the challenges that decision-makers are likely to face when identifying “no go” areas in countries where ecosystems remain intact or, alternatively, where ecological values are highly threatened.

The analysis focuses primarily on hardrock mining.

The analysis in this study focuses primarily on hardrock mining (i.e., metals and precious gemstones), although the identification of environmentally and socially vulnerable areas is also relevant for other extractive industries (e.g., oil and gas, forestry). Within this scope, we have chosen to emphasize issues most closely associated with large-scale mining.¹ For the purposes of this study, “small-scale mining” refers to individual operators who may be organized locally in cooperatives, but whose activities are typically not captured in formal concession agreements with the state.

This report is organized primarily according to kinds of indicators we developed to examine environmental and social vulnerabilities to mining impacts. First, the remainder of this chapter provides a brief overview of the mining industry and key environmental and social issues covered in this study, and Chapter 2 outlines the methodological framework used in this study. Then, Chapter 3 examines the results of analysis using indicators aimed at identifying areas that are environmentally vulnerable with respect to mining. Chapter 4 outlines a method for using indicators to identify socially vulnerable areas. Chapter 5 examines indicators of the types of natural hazards that must be taken into account when considering potential mine development. Chapter 6 examines indicators of other factors that contribute to mining risks, such as destructive mining practices and weak governance. Chapter 7 identifies financial institutions exposed to social and environmental risks from mining. Chapter 8 presents conclusion and recommendations to those seeking to establish “no go” zones or

¹ This is not to suggest that small-scale mining does not pose a major challenge to the health of ecosystems and communities around the world. Indeed, despite the limited scale of their operations, individual miners have had a significant impact on disproportionately large stretches of forests and riverine ecosystems. For example, since its discovery in 1983, the Mount Diwalwal small-scale mining area in the Philippines has produced considerable mercury pollution, mine accidents, crime, and social disintegration (Beinhoff and Calvez, 2000; Manila Times, 2002). However, small-scale mining is difficult to track. In most cases, small-scale miners operate illegally, making it nearly impossible to identify their location within a given country, much less represent the collective impact of their activities on global maps.

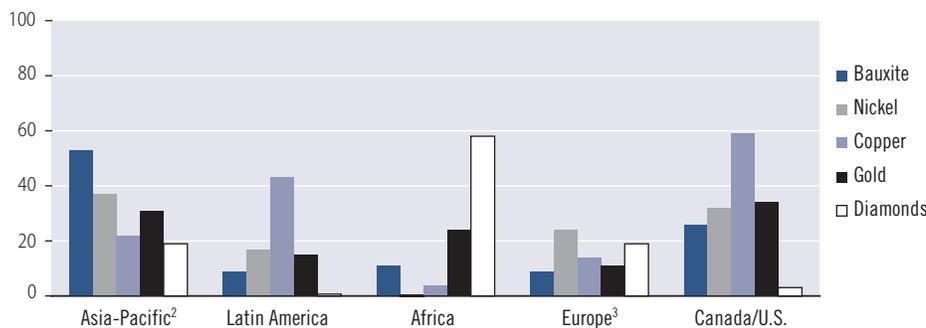
international standards for the mining sector (i.e., financial institutions, government policy-makers, and the private sector). Chapters 3–7 present the findings of our analysis, with each chapter beginning with highlights of these findings, followed by an examination of the analytical methods used and a more detailed discussion of the results.

MINING INDUSTRY TRENDS

Metal mining is a volatile and competitive industry.

Metal mining is a volatile and competitive industry. Over the past 25 years, the minerals industry has found it more difficult to meet its capital costs and turn a profit (MMSD, 2002: 58). During the 1990s, major players in the mining industry became increasingly international, with exploration peaking during the middle of the decade. Since then, exploration expenditure has dropped dramatically worldwide, due to low mineral prices and the Asian economic crisis (Kuo et al., 2000). Production of major metals occurs primarily in the Americas and the Asia-Pacific region, with Africa claiming the majority of diamond production (see Figure 1).

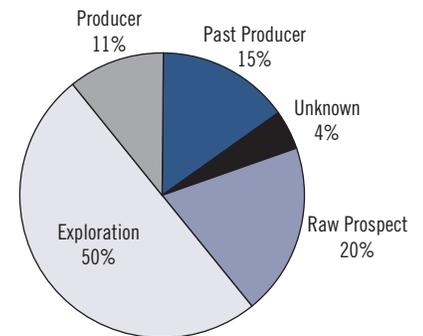
FIGURE 1. Share of Production by Global Region for Selected Minerals, 2000¹



Source: USGS, Minerals Yearbook, 2000.

Notes: 1) Primary production only; 2) Includes Australia; 3) Includes NIS and Russia.

FIGURE 2. Entries in Mines Database by Production Status



Source: InfoMine, 2003.

The mines database used in this study was purchased from InfoMine, a private, for-profit provider of mining data and information. It includes nearly 4,500 mining areas, of which half are exploration sites (see Figure 2). Most of the active mines and exploratory sites included in this database are located in North and South America, which likely reflects gaps in the quality of the global data.

PHILIPPINES

The Philippine government is seeking to attract new investments.

During the 1980s, the Philippines ranked among the top 10 producers of gold, copper, nickel, and chromites (ESSC, 1999b). In 2000, the Philippines ranked second only to Indonesia in terms of prospective minerals and resources (Kuo et al., 2000). The approval of exploration applications slowed considerably from 1999 to 2001, although it picked up again in 2002 (see Figure 3). The proposed National Minerals Policy indicates that the government seeks to attract new investments in this sector. As of the first quarter of 2003, there were two large mines and seven medium-sized mines in operation, dominated primarily by national companies (MGB, 2003). One gold mine (Rapu-Rapu) is scheduled to come on line in 2004.

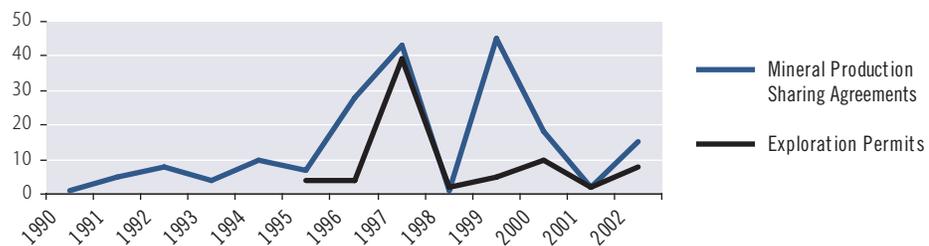
Exploration in Papua New Guinea is expected to increase.

PAPUA NEW GUINEA

Mining contributes nearly three quarters of export revenue and 17 percent of Papua New Guinea's gross domestic product (GDP). It is the second most important sector in the country's economy after agriculture. However, exploration in Papua New Guinea has stalled in recent years. The government has received only nine new applications for exploration licenses in the last 4 years, down from a peak of more than 80 in 1987 (GoPNG, 2003).

Approximately 85 exploratory concessions have been granted, most of which remain largely unexplored. Five mines ranking among the world's top 10 producers of gold and copper provide the majority of Papua New Guinea's mining production. Two of these mines are scheduled to close in the next 5 years. Notwithstanding these mine closures, the country is considered to be vastly under-explored and the importance of mining revenue to central government coffers has made discovery of new deposits a high priority (GoPNG, 2003). After stagnating in the last few years, the number of new exploration licenses is expected to climb significantly in 2003 (see Figure 4).

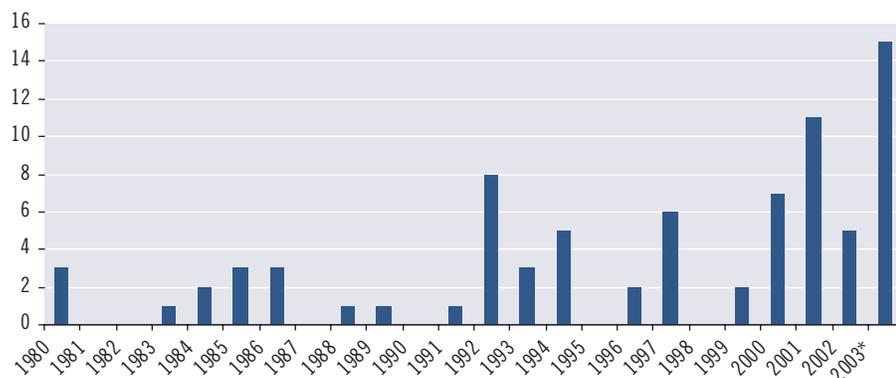
FIGURE 3. Approved Exploration and Mining Permits in the Philippines, 1990–2002



Source: MGB, 2003.

Note: Includes applications for all metal and non-metal exploratory permits.

FIGURE 4. Approved Exploration Licenses in Papua New Guinea, 1980–2003



Source: GoPNG, 2001; GoPNG, 2003.

Note: Does not include license renewal applications; *estimated.

Box 2. The Potential Scale of Mining Impacts

Ranging from 2,000 to 5,000 hectares, mining concessions or licenses typically are smaller than logging concessions. Unlike forestry, a mine site does not occupy the entire concession area and may encompass a few square kilometers. However, companies may conduct exploration activities (i.e., drilling, vegetation clearing) in the entire concession allocated to them. In addition, mines require supporting infrastructure (such as roads and electricity), processing facilities (which may be located far from the extraction site), and ports for the export of raw materials. Thus the environmental and social impacts of mining can extend well beyond the concession area, depending on the stage of mining. Some examples of the extent of known impacts include:

Road building: For every kilometer of pipeline built in the Amazon Basin, an estimated 400-2,400 hectares of forest has been cleared for colonization (Ledec, 1990:592).

Riverine tailings disposal: Mine waste dumped in the Jaba River in Papua New Guinea resulted in fish loss in 480 square kilometers (km²) of the watershed (Boge, 1998:212). About 1,300 km² of vegetation died in the Fly River watershed in Papua New Guinea and fish stocks have fallen 70–90 percent due to riverine waste disposal from the OK Tedi mine (WRI, 2003).

Acid drainage: As of 1993, the U.S. Forest Service estimated that 5,000-10,000 miles of streams within U.S. national forests were severely affected by acid drainage, in some cases from mines abandoned more than 100 years ago (USDA-FS, 1993).

Tailings spills: In 2000, approximately 100,000 cubic meters (m³) of cyanide-laced tailings spilled into the Tisza River from an impoundment at the Baia Mare mine in Romania. Cyanide was carried downstream into the Danube River in Hungary.

Processing: In the 1980s, a decline in wetland plant species attributed to smelter emissions was reported 30 kilometers from the Sudbury smelter in Ontario, Canada (Ripley, 1996:170–180).

Groundwater Depletion: As of 1996, mining was the largest industrial user of groundwater in Tucson, Arizona, accounting for 15 percent of groundwater consumption.

Human Health: In 2000, a truck spilled 300 pounds of mercury near the Yanacocha mine in Peru. Contamination from mercury poisoning resulted in the hospitalization of 200 to 300 people.

Environmental and social impacts may extend well beyond the mine site.

KEY ENVIRONMENTAL AND SOCIAL IMPACTS OF MINING

The potential environmental and social impacts of mining range from limited, site-specific contamination to large-scale, sometimes indirect ecosystem degradation. Although mines may appear to generate smaller-scale impacts than other more land-extensive activities (e.g., agriculture and forestry), the environmental and social impacts of mining may extend well beyond the mine site (see Box 2). Table 2 provides a summary of potential mining-related impacts on ecosystems and local communities.

The framework adopted in this study addresses the following key challenges:

- Waste management, which may affect water and habitat quality
- Natural resource access (land and water)
- Uneven creation and distribution of wealth, which may lead to social upheaval and, in extreme cases, violent conflict

Although some practices can play a role in minimizing the social and environmental impacts of mining, data on the implementation of such practices are not globally available. Thus the

Table 2. Potential Environmental and Social Impacts of Mining

Stage	Activities	Potential Impact
Exploration	<ul style="list-style-type: none"> ■ Geophysical/ airborne surveying ■ Drilling/trenching ■ Trench blasting ■ Exploration camp development ■ Road construction 	<ul style="list-style-type: none"> ■ Habitat loss/ fragmentation ■ Runoff of sediments/ increased suspended sediment load to surface water ■ Disturbance to wildlife and local communities ■ Increased demand for local water resources ■ Spills of fuels and other contaminants ■ Increased colonization due to road development ■ Species loss due to hunting
Site Preparation/ Mineral Extraction	<ul style="list-style-type: none"> ■ Mine construction (vegetation removal, stripping of soils) ■ Mine infrastructure development (power lines, roads, etc.) ■ Construction of plants, offices, buildings ■ Mine camp construction ■ Creation of waste rock piles ■ Creation of low- and high-grade ore stockpiles ■ Blasting to release ores ■ Transport of ore to crushers for processing 	<ul style="list-style-type: none"> ■ Habitat loss/ fragmentation ■ Chemical contamination of surface and ground waters ■ Declining species populations ■ Toxicity impacts to organisms (terrestrial and aquatic plants and animals) ■ Altered landscapes ■ Increased demand for water resources ■ Increased demand for electrical power ■ Increased erosion and siltation ■ Altered patterns of drainage and runoff ■ Dust/fumes from explosives ■ Increased colonization due to road development ■ Species loss due to hunting
Processing/Smelting	<ul style="list-style-type: none"> ■ Milling/grinding ore ■ Chemical leaching/concentration of ore ■ Smelting/refining ore 	<ul style="list-style-type: none"> ■ Discharge of chemicals and other wastes to surface waters ■ Emissions of sulfur dioxide and heavy metals ■ Increased demand for electrical power
Transport to final markets	<ul style="list-style-type: none"> ■ Packaging/loading of final product ■ Transport of product 	<ul style="list-style-type: none"> ■ Noise disturbance ■ Dust/fumes from stockpiles
Mine closure/ Post-Operation	<ul style="list-style-type: none"> ■ Reseeding/ revegetation ■ Re-contouring waste piles/ pit walls ■ Fencing dangerous areas ■ Monitoring seepage 	<ul style="list-style-type: none"> ■ Persistent contaminants in surface and groundwaters ■ Expensive, long-term water treatment ■ Persistent toxicity to organisms ■ Loss of original vegetation/biodiversity ■ Abandoned pits/shafts that pose hazards and health risks to humans ■ Windborne dust

Source: Adapted from Miranda et al., 1998; Ashton et al, 2002.

framework used in this study does not adjust for the implementation of “best” practices. A more detailed discussion of the social and environmental impacts of mining is provided in Appendix 2 to this report, which is available on WRI’s website (<http://www.wri.org/>).

WASTE MANAGEMENT

Open-pit mining usually involves the movement of mass quantities of material, as well as processing to extract valuable metals. In general, there are three types of mining waste:

- **Overburden and waste rock:** This includes soil, vegetation, and earth located above a deposit (known as overburden), as well as rock that has been mined and is deemed uneconomical for further processing (known as waste rock). Overburden is often saved for future use in revegetation and some mineralized waste rock may be stockpiled for processing when the mine closes.
- **Tailings:** The residual slurry that remains once ore has been processed. Tailings are often liquid (usually at least 50 percent water) and are disposed of in impoundments on land or in the aquatic environment. A key risk with tailings impoundments is the potential for containment failure, releasing many tons of toxic effluent into local waterways.
- **Leach heap spent ore:** This is the residual material that remains from processing ore in a heap leach facility. Heap leaching is most frequently used in North America and consists of crushing ore, placing it on a liner, and spraying it with a cyanide solution. Heap leaching allows companies to process low-grade ores more economically.

Waste management is a key challenge for environmentally and socially responsible mining.

Many of the environmental problems associated with mining stem from the management of these types of waste. Environmental challenges having the greatest impact on ecosystems include:

- **Sedimentation:** Sediments from waste dumps and tailings may be disposed of or erode into waterways, harming fish and other aquatic wildlife.
- **Acid Drainage (AD):** AD occurs when sulfide-bearing rock reacts with air and water, producing acidic waters containing dissolved metals that may drain as runoff into water bodies, killing aquatic flora and fauna. AD is arguably the most severe environmental impact associated with mining because once it occurs, costly and perpetual water treatment is often the only solution.
- **Metals Deposition:** Tailings often contain heavy metals as well as reagents used in processing, such as cyanide. Poor tailings management may result in the release of metal-laden waste into the environment. In addition, heavy metals may be leached as a result of acid drainage.

NATURAL RESOURCE ACCESS

Mining may have far-reaching indirect impacts.

Mines require access to land and water, and may compete with other uses (Ashton et al., 2002). Such access can result in indirect effects such as colonization from road-building (and associated wildlife hunting and deforestation), displacement of communities and indigenous peoples, increased prostitution, and alcoholism. These indirect impacts may constitute the worst long-term legacy of mining. Because mineral processing requires substantial energy and water, mining may conflict with other land uses if water resources are already scarce.

Mining does not always result in the equitable distribution of wealth.

POVERTY ALLEVIATION AND WEALTH DISTRIBUTION

Mining companies often point to the wealth generated from mining as evidence of the positive contributions mining can generate, especially in developing countries. However, some researchers contend that a higher proportion of the population in mineral-dependent states live below the poverty line. In addition, mineral-dependent countries are characterized by greater gaps between the rich and the poor (Ross, 2001a; Gelb et al., 1988). Rural communities dependent upon mineral development are especially vulnerable to the boom and bust cycles typical of the industry (Kuyek and Coumans, 2003). New evidence suggests that mining has contributed to civil wars by providing revenue for warring factions (Ross, 2001b; Sherman, 2000). For example, in Africa control over diamond mines has become a primary objective for rebels seeking income to finance civil wars (Sherman, 2002).

Chapter 2.

The Methodological Framework

The need to assess a broad range of environmental and social factors when considering the impacts of potential mining projects has been a recurring theme in recent international dialogues on mining. The final report of the Mining, Minerals and Sustainable Development project stressed the need for a “rigorous risk assessment process” that would allow companies and other stakeholders to identify which areas should be off-limits to mineral extraction (MMSD, 2002: 169). Unfortunately, there are few models for such a process. Prior efforts produced preliminary criteria and indicators for a range of goals, but these initiatives do not provide consistent definitions of what may constitute environmentally and socially vulnerable areas with regard to mining (see Box 3). To date, none of these efforts has developed maps to identify areas vulnerable to the impacts of mining.

The framework assesses environmental and social vulnerability to mining.

The framework developed for this study sought to complement these ongoing efforts by providing a set of indicators that will allow decision-makers to define areas that may be environmentally or socially vulnerable to mining. These indicators are represented in mapped data layers and are based largely on publicly available information. Thus, others seeking to identify environmental and social vulnerabilities at finer scales can replicate the methodology adopted in this study.

The framework is meant to fit within a broader risk assessment process.

The framework is not intended to provide performance standards for mining projects, although it can inform the development of such standards. It is also not a tool for conducting cost-benefit analysis of mining projects, nor does it provide the business case for defining “no go” areas. Instead, the framework is designed to address the needs of companies that are

Box 3. Developing Criteria and Indicators for “No Go” Zones

Several initiatives have addressed the concept of “no go” zones or the development of indicators to measure sustainability in the extractive industries sectors:

“No Go” Zones in the Extractive Industry Sector: A World Wildlife Fund discussion paper released in 2002 identified criteria and indicators for designating “no go” areas for mining. The paper proposed a decision tree consisting of three filters: 1) protection status, 2) potential threats to biodiversity, and 3) potential threats to human communities (Dudley and Stolton, 2002). Conservation International recently released a similar “site selection” decision-tree framework for the oil and gas industry, which considers biodiversity impacts only (EBI, 2003).

Identifying “High Conservation Value Forests”: Principle 9 of the Forest Stewardship Council’s Principles and Criteria of

Forest Stewardship introduced the concept of “high conservation value forests.” Such forests do not necessarily constitute “no go” areas; however, Principle 9 stipulates that any industrial use of these forests must maintain or enhance their conservation values. Efforts are underway to define specific criteria to identify such forests.

Measuring Mining Indicators: The U.S. Geological Survey recently completed its Minerals Roundtable indicator development process, which culminated in a final report listing key indicators that measure sustainability issues in the mining sector. The goal of the project was to develop a set of indicators that measure the contributions of mining to sustainable development in the U.S. (Shields et al., 2003). The indicators were developed for use in the United States and are of limited value for most developing countries, where data are lacking.

already convinced of the need to identify areas that are sensitive to the impacts of mining and are seeking methodologies and tools to help them define “no go” areas. Although the results of this study lead to the definition of some “probable no go” areas or issues, the framework is meant to fit within a broader risk assessment process that includes transparent stakeholder dialogue and consultation with independent experts.

The remainder of this chapter outlines the basic framework used in this study. Appendix 1 provides a summary of the indicators and data used. Details on the sources and methodologies used are available on WRI’s website (<http://www.wri.org/>).

GLOBAL FRAMEWORK

The indicator framework used in this study is organized according to categories describing vulnerabilities, natural hazards, and other factors contributing to the probability of hazards occurring (see Figure 5). Each category is divided into sub-categories as follows:

VULNERABILITY CATEGORY

- Biological, cultural, and natural values
- Watersheds
- Human communities

NATURAL HAZARD CATEGORY

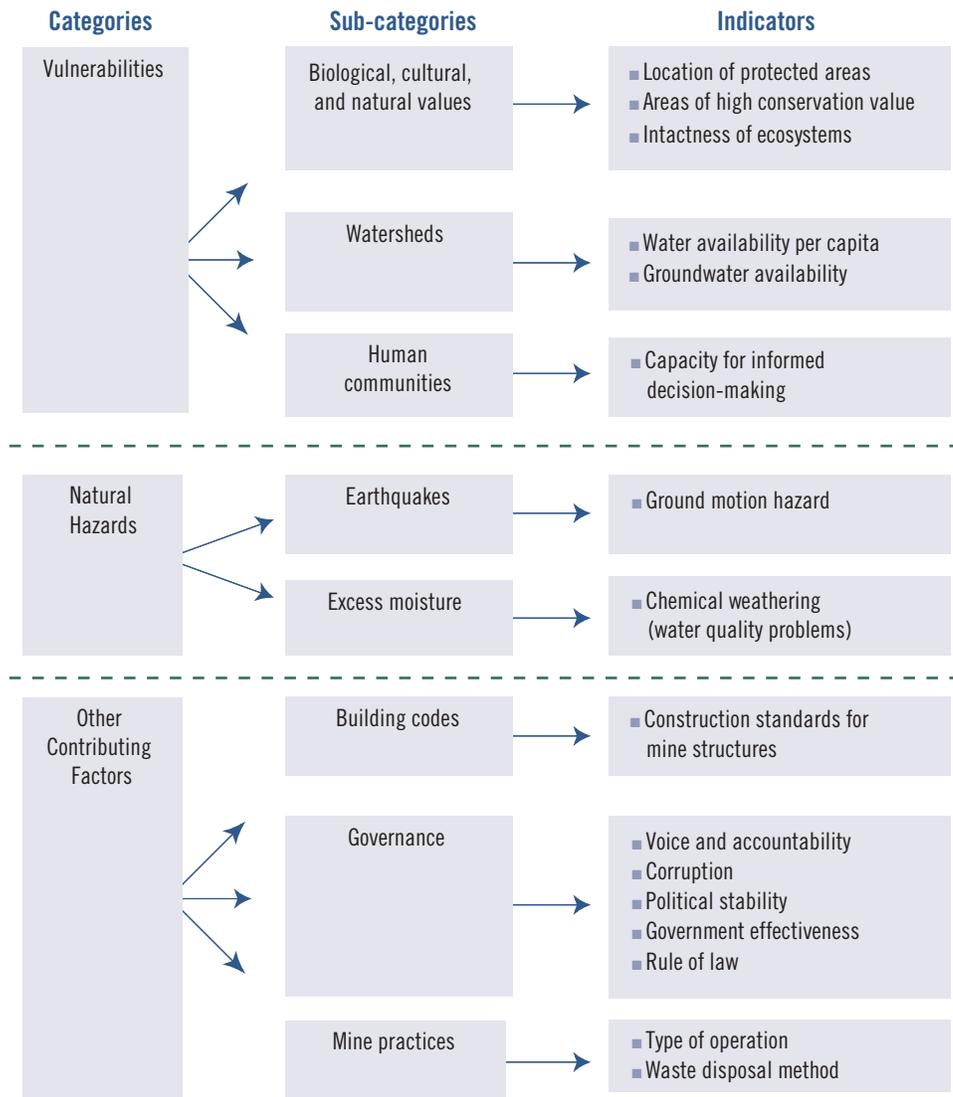
- Earthquakes
- Excess Moisture

OTHER CONTRIBUTING FACTORS CATEGORY

- Governance
- Mine practices
- Building codes

The framework is designed to capture three key environmental challenges associated with mining: waste management, water quantity and quality, and habitat destruction (direct and indirect). The social impacts related to mining are less well documented and are difficult to model. For this reason, the social element of the framework is limited to measuring the degree to which communities are equipped to make informed decisions regarding mining. Governance (e.g., transparency, public participation, and control of corruption) and mine practices are considered “other contributing factors” that may influence whether mining projects produce positive or negative environmental and social impacts.

FIGURE 5. Mining and Critical Ecosystems Indicators Framework



Risk assessment terminology varies widely in the literature.² This study defines vulnerability, hazard, and risk as follows:

- **Vulnerability** is the likelihood of destruction or degradation arising from a natural or environmental hazard. For example, a coral reef may be vulnerable to mining because potential release of mine waste would destroy corals and the fish that depend upon them. A community may be considered vulnerable if its residents lack the capacity to make informed decisions regarding a potential mine. In this report, the terms vulnerability and sensitivity are used interchangeably and sensitivity does not refer to the degree to which a vulnerable community or ecosystem is affected by exposure to a particular stress.

² Weyman and Anderson-Berry (2002) define risk as a function of hazard (comprised of spatial and temporal characteristics) and vulnerability (exposure of the elements at risk). Clark et al. (2000) identify human vulnerability to environmental change as a function of exposure, sensitivity, and resilience. UNEP (2000) defines vulnerability according to exposure to hazard, coping capacity, population density, and time.

- *Natural hazards* are events, such as earthquakes or floods, that can cause or exacerbate mine-related problems. The release of mine waste into the environment can be considered an environmental hazard.
- *Risk* is the probability of a hazard occurring, such as the probability that an earthquake with a certain magnitude will occur in a given timeframe.
- *Actuarial risk* is the probability of a hazard occurring multiplied by its consequences. Because data are limited, it is difficult to measure actuarial risks with respect to mining at the global level.
- *Other contributing factors* are conditions that either increase or decrease the probability of a hazard occurring, for example, particular mine practices that may contribute to environmental hazards or the status of local and/or national governance structures, which may affect a given community's capacity for informed decision-making about proposed mining projects. Although an analysis of governance is not often included in risk assessment frameworks, these factors were considered critical for evaluating the degree to which ecosystems and communities are exposed to risk.

APPLICATION OF THE FRAMEWORK

The indicators were mapped at a global scale as well as in country case studies in Papua New Guinea and the Philippines. The resulting analysis identifies areas that may be environmentally or socially vulnerable to the impacts of mining, based on ecological values, the existence of hazards, and the presence of other contributing factors. For example, as a hypothetical scenario, a mine with a proposed submarine tailings disposal facility may be under consideration in a small island nation in the tropics. The unique, diverse aquatic ecosystems and fishing communities depending upon these areas for their livelihoods are considered potentially vulnerable to the impacts of the mine. The release of mine tailings into the marine environment constitutes a hazard. The design of the tailings disposal system and whether government officials overlooked flaws in its design in exchange for bribes are defined as other contributing factors that could increase the exposure of the marine environment and local fishing communities to risk.

Defining the extent to which the marine environment and nearby fishing communities are vulnerable to mining-related risks requires understanding the probable impact mine-related hazards will have on these areas. In many cases, the relationship between species and their habitats are poorly understood. For example, the relationship between aquatic species that may be destroyed by deep-sea disposal of mine tailings and the importance of these organisms as food sources for other species in the marine ecosystem may not have been researched by scientists. In addition, data may be lacking on the likely extent of the area in which tailings dumped in the deep sea will smother bottom-dwelling organisms. In this context, the mining and critical ecosystems framework cannot provide a final determination of the effect of tailings released in the marine environment. However, this study argues that some areas may be too vulnerable to be exposed to the high degrees of uncertainty posed by certain mine practices.

Data limitations constrained the indicators used in this study.

The framework does not define “no go” areas for mining.

LIMITATIONS OF THE APPROACH

Ideally, definitions and data would be available to address each of the categories and its associated indicators. However, this was not the case, at either the global or national levels. Data on the social impacts of mining are lacking, especially at the global scale. Thus the framework is weighted more heavily toward consideration of environmental issues, for which more information was available. It was also not possible to calculate the probabilities of events occurring (e.g., earthquakes) or to accurately measure the consequences of these events, due to lack of mine-specific data at either the global or national scales. The application of the framework to Papua New Guinea and the Philippines required adjusting the indicators. Thus, the analysis presented in this report uses one or both case studies to illustrate the various indicators selected, depending on the quality of the data and the relevance of the indicator for each country. For example, a watershed stress analysis was conducted for the Philippines, where water availability is problematic, but not for Papua New Guinea, where it is not.

At a global level, the framework is necessarily coarse. As such, it cannot be used to make definitive “no go” decisions with respect to specific mining projects. Instead, it is meant to be used as a preliminary filter, beyond which further investigation is required to make a final determination regarding whether mining is appropriate at a particular site. For decision-makers, the global maps provide a coarse assessment of areas where mining may be more problematic, but not necessarily where it should be allowed. The case studies are designed to enhance and expand upon the global framework by applying the concepts outlined globally to nationally available data. Even at the national scale, however, the definition of “no go” zones must take place in the context of a transparent stakeholder process.

Data availability and quality pose problems. Additional details on data limitations are included in Appendix 1 and on WRI’s website. However, general limitations include:

- **Ecological value:** Not enough is known regarding the number, habitat requirements, and distribution of many critical species at a global level. In addition, some ecosystems (in particular marine and freshwater) have been poorly studied and are thus underrepresented in this study.
- **Governance and social data:** Global governance indicators are largely subjective and some, such as degree of corruption, are characterized by a lack of data. Data on the social impacts of mining are limited. Sub-national data on income and education are not consistently available globally, which limited the scale of analysis.
- **Mining data:** Global data on location, status, and type of mine operations are limited and incomplete. The dataset used for this project is a summary of information on known mine and exploration sites provided by mining companies to a private data organization. In many cases, data points are estimates based on the distance to the nearest landmark, and the data are limited by the accuracy and completeness of information provided by mining companies. Thus, the mining dataset is likely an underestimate of existing and potential mines. Although mine location is determined by the existence of economically viable deposits, there is currently no publicly available dataset that describes the location of such deposits at a global level.

Despite these limitations, the methodology for the global-level analysis provides a first glimpse into vulnerable areas that should be treated with caution when considering future mine projects. Some global datasets, such as seismic hazard and water scarcity, are relatively complete and detailed. As can be expected, the national datasets contain much more detailed data, such that our degree of confidence in these analyses is relatively high.

Chapter 3.

Mining in Environmentally Vulnerable Areas

Protected areas, areas of ecological value, and stressed watersheds are considered vulnerable.

Habitat destruction is the most important cause of biodiversity loss, especially in the humid tropics (McNeely et al., 1995:751). The most obvious impact on biodiversity from mining is the removal of vegetation, which in turn alters the availability of food and shelter for wildlife. At a broader scale, mining may affect biodiversity by changing species composition and structure. To identify areas that might be especially vulnerable from an ecological perspective, we developed three global indicators: protected areas, ecological value, and watershed stress. A comparative analysis of these indicators with the InfoMine database revealed the following:

- More than one quarter of active mines and exploration sites overlap with or are within a 10-kilometer radius of a strictly protected area (IUCN I-IV).
- Nearly one third of all active mines and exploration sites are located within intact areas of high conservation value.
- Nearly one third of all active mines are located in stressed watersheds.
- Nearly three quarters of active mines and exploration sites are located in areas deemed by conservation organizations to be of high ecological value.

Unprotected, high value ecosystems are most vulnerable to the impacts from mining.

Mining in strictly protected areas has received considerable attention to date and the issue will likely remain contentious in countries where legislators are considering opening protected areas to mining, such as Ghana and Indonesia. However, the results of this analysis suggest that at the global level the overlap between mines and areas of high ecological value will likely present even greater challenges in the future, especially in areas that are not yet formally protected or where protected area boundaries are poorly defined.

Overlap between mining areas and important ecosystems is apparent in Papua New Guinea and the Philippines.

Such challenges are particularly apparent when considering the results of the two country case studies examined in this study. In Papua New Guinea, more than one third of the country's forests and nearly half of the country's mangroves have already been allocated in oil, gas, or mining concessions. More than one quarter of forests classified as "fragile" in Papua New Guinea government data overlap oil, gas, and mining concessions. In the Philippines, more than half of all exploratory and mining concessions overlap with areas of high ecological vulnerability. Although mining is prohibited in intact forests and protected areas, approximately one third of concessions overlap with these areas. Lack of clarity regarding protected area boundaries and uncertainty regarding the definition of intact forests provides an opportunity for land use conflicts between mining and conservation objectives. The remainder of this chapter examines in detail each of the ecological value indicators.

Protected areas reflect natural and cultural values held by societies.

MINING AND PROTECTED AREAS

Societies routinely seek to formally protect areas of high cultural and natural value by establishing protected areas, such as wildlife refuges, national parks, natural monuments, and biosphere reserves. Some areas are considered protected for conservation purposes while others may be considered valuable for their scenic or landscape values. The World Conservation Union (IUCN), an international, quasi-governmental body consisting of governments and conservation NGOs has developed a system for categorizing protected areas according to the degree of protection. Categories I-IV are protected for conservation purposes, while categories V and VI are considered “mixed use” areas. Although all categories are considered equally important, a gradation of human intervention is implied, such that Categories Ia and Ib are the least influenced by human activity and Categories V and VI are often modified landscapes. Strictly protected areas (IUCN I-IV) represent approximately 10 percent of the world’s land surface while World Heritage sites represent only 1 percent.

In addition, the United Nations Educational, Scientific and Cultural Organization (UNESCO) maintains a list of designated “World Heritage Sites” and “Ramsar Sites.” Both designations are subject to international conventions that establish listed sites as worthy of special attention due to their global natural or cultural significance. Of the 138 natural World Heritage sites, more than one quarter are threatened by mining or oil and gas development (UNESCO, 2003). Two of the natural areas listed as World Heritage in Danger sites are currently threatened by mining.

A key goal for biodiversity conservation is ensuring representation of ecosystems and the species that live within them. Although the total area under protection has increased nine-fold in the last 40 years, many regions and ecosystems remain poorly represented. The Pacific region has the fewest number of protected areas globally. In addition, grasslands, coastal, and marine ecosystems are poorly represented in protected areas (Chape et al., 2003).

Although governments have not explicitly prohibited mining in all IUCN I-IV protected areas, some countries, including the Philippines, have passed laws making it illegal to mine in these protected areas. In 2000, IUCN members passed Resolution 2.82, calling on all governments to prohibit mining, oil, and gas development in IUCN I-IV protected areas and recommending that any extractive activity in categories V and VI should take place only if it is compatible with the objectives for which the protected area was established (IUCN, 2000).

OTHER ECOLOGICALLY VULNERABLE AREAS

Many areas of high ecological value are not yet formally protected.

Officially designated protected areas are only one component of ecologically vulnerable ecosystems. Many conservationists argue that protected areas are insufficient to protect the world’s biodiversity (Soule, 1986). On one hand, much of the world’s biodiversity is found outside of designated protected areas (McNeely et al., 1990). On the other hand, many existing protected areas suffer from poor management, lack of funding, and isolation from other areas of high biodiversity (Miller et al., 1995).

In light of the challenges inherent in conserving the world’s biodiversity through protected areas, conservation organizations such as Conservation International, World Wildlife Fund,

Birdlife International, and The Nature Conservancy have identified important ecosystems for conservation purposes. Some approaches (e.g., Conservation International’s “hotspots”) focus on “the last of the best” places—that is, those critical remnants of habitat that could disappear within a few years absent aggressive, near-term intervention. The World Wildlife Fund has identified globally important ecoregions, some of which have been subsequently evaluated at a regional scale to identify conservation priority areas based on biological value, conservation status, and degree of threat.

Other approaches, such as WRI’s intact forests assessments, focus on identifying large areas of relatively undisturbed habitat, which if managed carefully could sustain human livelihoods and provide basic natural resources for many years to come (Bryant et al., 1997; Aksenov et al., 2002). Although approaches to identifying areas of conservation value differ, they typically take into account several common themes (see Table 3). We aggregated these approaches and compared them with active mines and exploration sites. Nearly three quarters of active mines and exploration sites overlap with areas of high conservation value.

Conservation mapping approaches may be useful for establishing institutional priorities, but they provide little insight into which areas may be vulnerable to the potential impacts of mining. Depending on the methodologies used, high values are placed either on biologically important remnants that may disappear without immediate conservation interventions (“hotspots” approach) or large blocks of intact landscapes that should be conserved for future generations (wilderness and ecosystems approaches). However, none of these approaches adequately addresses whether and under what conditions development should occur. In fact, high-value, highly threatened remnants and intact, remote ecosystems could be equally vulnerable if development activities were to proceed in an unsustainable manner.

Our analysis identifies intact areas of high conservation value and classifies these areas by size.

Ideally, an assessment of areas ecologically vulnerable to mining would take into account many of the criteria listed in Table 3. However, data for most of these criteria are lacking at a global level. For this reason, we chose to use ecosystem intactness as a measure of ecological value because it is a necessary condition for maintaining key species and ecosystem function. Scientists at Columbia University and the Wildlife Conservation Society recently undertook a global mapping effort to assess the relative condition of the world’s natural habitats and identify the degree of human influence on the Earth’s surface. They estimated that less than 15 percent of the Earth’s terrestrial habitats remain uninfluenced by human activities (Sanderson et al., 2002).

We combined this analysis of human influence with the aggregated conservation value layer to identify areas of high conservation value that are relatively undisturbed. These intact areas were further stratified by size (see Map 2). The smaller areas (< 1,000 km²) may be especially vulnerable to mining if they are home to the last representative samples of a given community type or ecosystem that will not survive in smaller habitat patches. For example, many mammals may not survive in patches smaller than 100 km². The largest game mammals are more likely to require patches larger than 10,000 km² (Armbruster, 1993; Beier, 1993; Terborgh, 1992).

Table 3. Criteria Used to Define Biodiversity Conservation Priorities

Category	Criteria	Definition
Biological	Species richness	Number of species in a given area
	Rarity	Least common species or ecosystems
	Endemism	Degree of separation of a population, species, or ecosystem from its closest comparable analogue
	Representativeness	Degree to which a given area contains examples of all species or ecosystems
	Threat	Degree of imminent danger or harm from human activities
	Function	Role of species, communities, or ecosystems in determining survival of other species, communities, or ecosystems
	Condition	Relative condition of ecosystems or populations based on degree of intactness
Social/ Institutional	Utility	Importance of biodiversity elements known to have utilitarian value to humans
	Feasibility	Potential success of conservation efforts based on political, economic, and logistical factors
	Other	Ethnic, religious, and/or cultural values assigned by local cultures

Source: Adapted from Johnston, 1995.

Mining in areas of high conservation value should only proceed if these areas will retain their ecological values after development.

The existence of high conservation values does not automatically preclude mineral development. However, such industrial activities should proceed only if it can be demonstrated that these areas' ability to retain their wilderness values and ecosystem services will remain intact after development. Ultimately, decisions regarding which ecosystems may be too fragile to withstand the impact of mining development will largely depend on local species requirements, as well as the potential for conflict with restoration goals in ecosystems that have already been degraded.

Other parameters, such as uniqueness, should also be considered.

In addition to intactness, other parameters, such as uniqueness and representativeness, should also be considered. For example, the Asia-Pacific region is characterized by small islands, which are rich in endemic species. Uninhabited small islands in this region often serve as important refugia for critical species, warranting protection from human intervention. The coral reef and coastal ecosystems in the Asia-Pacific region harbor the highest degree of aquatic biodiversity in the world (Burke et al., 2002). Mining poses significant challenges on small islands due to the lack of safe and acceptable waste disposal sites, as well as the inherent ecological fragility of these unique terrestrial and aquatic ecosystems. Competing land uses and the high levels of biodiversity may justify a "no go" decision with regards to mining on the smaller islands in this region.

The intactness analysis also offers little guidance with respect to mining in areas that demonstrate high biological value but have suffered significant disturbance. Indeed, such areas often coincide with highly threatened ecosystems, especially in countries where human influence on natural habitats is high (e.g., the Philippines). The fact that some areas of high ecological value may already be significantly disturbed does not imply that mining is a com-

patible land use. Finer-scale analysis is required to determine whether potential mineral development will have a negative impact on these habitats.

Papua New Guinea's forests are vulnerable to mining.

ECOLOGICALLY VULNERABLE AREAS IN PAPUA NEW GUINEA

The island of New Guinea is considered a major tropical wilderness area, containing one of the world's largest tracts of intact tropical forest. These forests are home to unique plants and animals, including the world's largest butterfly (Queen Alexandra's Birdwing Butterfly) and 42 species of birds of paradise. Much of the wildlife found in New Guinean forests is highly dependent upon trees for its survival. Map 3 displays vulnerable ecosystems and mining, oil, and gas concessions in Papua New Guinea. Nearly 90 percent of the country is forested, with more than one third of all forests already allocated to oil, gas, or mining concessions. A significant proportion (30 percent) of remaining forests within concession boundaries is already fragmented, especially in the highlands region. These forests may be especially vulnerable to additional clearing from road building, land clearing, and human migration typically associated with mining in remote areas.

Papua New Guinea's mangroves may also be especially vulnerable to mining, oil, and gas development. Less than 1 percent of the country's forests is classified as mangroves, and 42 percent of mangrove forest areas have been allocated in mining, oil, and gas concessions. Located largely on the southern coast of the country, these large tracts of mangrove forests are considered to be internationally significant as spawning and nursery grounds for prawn and fin fisheries, and are a source of subsistence for a substantial artisanal fishery (Sekhran and Miller, 1994).

Establishing formal protected areas has posed unique challenges in Papua New Guinea, given that nearly all of the country's land is owned communally. Forty-seven protected areas have been established, more than half of which are community-controlled Wildlife Management Areas (WMAs). Although WMAs present a key conservation opportunity, management of such areas has been plagued by a lack of central government support, abuse of license fees and other management mechanisms, and a backlog in requests for new areas. Unfortunately, recent conservation efforts have focused mostly on the establishment of isolated, "pristine" wilderness areas rather than strengthening community-based approaches that are better suited to the cultural realities of Papua New Guinea (Hunnam, 2002).

Fragile forests are especially vulnerable to mining.

The government of Papua New Guinea has identified "fragile forests" that experience slow regeneration as a result of human-induced change. Occurring predominantly in the highlands region, these forests are likely to be especially vulnerable to mining, as the highlands contain a disproportionate share of the country's biodiversity and are subject to high population pressures. Slightly more than one quarter of the country's forests can be classified as fragile, with 26 percent of fragile forests occurring within oil, gas, and mining concessions.

High value ecosystems in the Philippines are critically threatened.

ECOLOGICALLY VULNERABLE AREAS IN THE PHILIPPINES

The Philippines has been designated by scientists as one of the world's top 20 "megadiversity" countries. The country is richly endowed with marine biodiversity; the archipelago boasts 500 of more than 800 known coral species, more than 2,000 fish species, and over 40 species of mangrove plants (Ong, 2002). However, only 5 percent of the country's coral reefs remain in excellent condition and mangroves and sea grasses have shrunk to less than one quarter of their original extent (Ong, 2002). Mining has been identified as a threat to the marine environment due to impacts from releases of mine waste, resulting in fish kills and coastal pollution (ESSC, 2003). Philippine terrestrial ecosystems are also critically threatened. More than 93 percent of Philippine forests have been lost in the last 500 years and 418 species are already listed as threatened.

Protected areas constitute the main legal mechanism through which the Philippine government has sought to conserve the nation's biodiversity. Approximately 8 percent of the country's total land area has been designated as protected areas, and is consequently off-limits to mineral development. Mining also is not allowed in the country's remaining intact forests, due to the highly fragmented state of these ecosystems. However, more than two thirds of existing protected areas have not been ratified by law and forest cover estimates are subject to large uncertainties due to lack of data. Moreover, according to the Philippine Biodiversity Priority Setting Program (PBCPP), only 41 percent of protected areas retain original vegetation and the protected areas system does not include some areas of high biodiversity (Mackinnon in Ong, 2002).

Lack of clarity can exacerbate conflicts between mining and conservation uses.

For this study we identified areas of high ecological value according to the location of existing protected areas and intact forests (see Map 4). These areas also correlate well with high-priority areas identified by the PBCPP. More than half (56 percent) of all exploration areas and mining leases overlap with areas of high ecological vulnerability shown on Map 4. Six percent of mining leases and exploration areas overlap with protected areas (see Table 4). More than one quarter of approved mining leases and 8 percent of exploration areas overlap with intact forests, covering an area of approximately 60,000 hectares. According to the terms of mineral agreements, protected areas and intact forests are excised from mineral contracts. In practice, however, the lack of clear delineation of protected area boundaries and uncertainty regarding the definition of intact forests provides the opportunity for land use conflicts between mining and conservation uses.

Access to clean water poses a significant challenge in some parts of the world.

WATERSHED STRESS

Mining is most likely to compete with other water users in places where water resources are already scarce and demand is high. According to some estimates, global industrial demand for water is projected to supersede that of agriculture by 2075 (Alcamo et al., 1997). At the same time, the availability of clean water for human consumption is declining due to industrial discharges and urban and agricultural runoff. This problem is especially serious in developing countries, where pollution regulations and water conservation technologies are less well developed (Reventa et al., 2000). Certain parts of the world, such as Africa, face considerable challenges in ensuring equitable and sustainable access to water resources, which can only be addressed through judicious management of water resources (Ashton et al., 2001).

Table 4. Overlaps Between Approved Mines And Protected Areas

License #	Contractor	Location	Area Affected	Overlap (%)	Date Granted
156-00-CAR	Philex Mining Corp.	Tuba & Itogon, Benguet	Lower Agno Watershed Forest Reserve	57	April 2000
157-00-CAR	Philex Mining Corp.	Tuba & Itogon, Benguet	Lower Agno Watershed Forest Reserve	31	April 2000
012-92-VIII	Hinatuan Mining Corp.	Manicani Island, Eastern Samar	Guiuan Protected Landscape and Seascape	98	October 1992
063-97-IX	Philex Gold Phil., Inc.	Sibutad, Zamboanga del Norte	Jose Rizal Memorial Protected Landscape	3	April 1997
094-97-XI	Alsons Development & Investment Co., Inc.	Nabunturan, Davao del Norte	Mainit Hotspring Protected Landscape	12	November 1997
EP-006-97VII	Philippine National Oil Company – Energy Development Corporation	Amlan to Valencia in Negros Oriental	Balinsasayao Twin Lakes National Park	47	November 1999
EP-007-00VII	Altai Phils. Mining Corporation	Amlan to Pamplona in Negros Oriental	Balinsasayao Twin Lakes National Park	6	July 1997

Source: ESSC, Case Study Analysis, 2003.

The Pilot Analysis of Global Ecosystems (PAGE) estimated current (1995) and projected (2025) water scarcity for individual river basins around the world, identifying “water stress” in watersheds where less than 1,700 cubic meters (m³) of water per capita per year is available (Falkenmark and Widstrand, 1992; Hinrichsen et al., 1998 in Revenga et al., 2000: 26).

Mining may be incompatible with other land uses in water-scarce areas.

We compared the PAGE dataset with active mines and exploration sites (see Map 5). According to this analysis, nearly 30 percent of active mines are currently located within stressed river basins. Of these 20 percent occur in highly stressed river basins. In stressed watersheds with competing demands for water, mining may prove to be incompatible with other land uses. Furthermore, absent strict water quality controls, water returned to river basins from mining operations may not be suitable for consumption, potentially reducing water availability in stressed watersheds. Watersheds near the cut-off for stress may also be especially vulnerable if a mine competes with other land uses.

WATERSHED STRESS IN THE PHILIPPINES

Watersheds in parts of the Philippines are stressed.

To understand the vulnerability of stressed watersheds to mining, we examined potential water stress in the Philippines, as defined by vulnerability to floods, water quality, and quantity. Papua New Guinea does not experience water scarcity; therefore watershed stress was not calculated for that country case study. As shown in Map 5, the Philippines is moderately vulnerable to water scarcity. Indeed, average annual precipitation is relatively high at approximately 2,300 millimeters per year. However, these generalized statistics mask important geographic and seasonal differences in rainfall across the country. Wide-scale alterations in the landscape and deforestation have increased the rate of erosion and flooding throughout the country, resulting in reduced dry-season stream flows (WRDP-WMIC, 1998:3). As a result, many areas experience water shortages during the dry season. Projections based on popula-

tion growth indicate that water usage is expected to increase by 250 percent, leading to massive water deficits by 2030 (Haman, 1999). In addition, nearly half of the annual rainfall occurs as a result of intense storm events (PAGASA, 2000), which contribute to increased runoff and erosion, especially in highly degraded watersheds.

There is some overlap between mining and protected watersheds.

The disastrous El Niño event in 1997-98 spurred the Philippine government to begin considering water consumption in land-use management decisions. Two land-use management designations were developed to protect watersheds: critical watersheds and proclaimed watersheds. Critical watersheds are those that support agriculture and industry, but are known to be severely degraded. Proclaimed watersheds encompass forests that are protected in order to maintain water quality and yield. Mining is prohibited in both categories. Aquifer recharge zones and other important groundwater resource areas are considered “environmentally sensitive” and categorized by the Mines and Geosciences Bureau as low, medium, and high vulnerability. Map 6 provides a summary of environmentally sensitive water resource areas as defined by the Philippine government. According to this map, 8 percent of approved mining contracts and exploration areas overlap with proclaimed watersheds but no contracts or exploration areas have been approved in critical watersheds.

More overlap occurs between mining and unprotected, stressed watersheds.

Although water quality and yield were the primary factors leading to the designation of proclaimed and critical watersheds, these protected area designations do not fully encompass water scarcity. Some watersheds may be especially stressed with regard to water availability, but have not been designated as proclaimed or critical watersheds. To account for these unprotected, vulnerable watersheds, we evaluated water demand and availability at a national scale. Areas where the demand-to-availability ratio exceeded 40 percent were defined as “highly stressed” (see Map 7).

Although the resulting analysis cannot establish a cause-effect relationship between water use and degree of stress, it does identify areas where land-use decisions will be especially critical to ensuring future water supply. As indicated in Map 7, 14 percent of mining and exploratory concessions overlap with areas of high watershed stress.

Chapter 4.

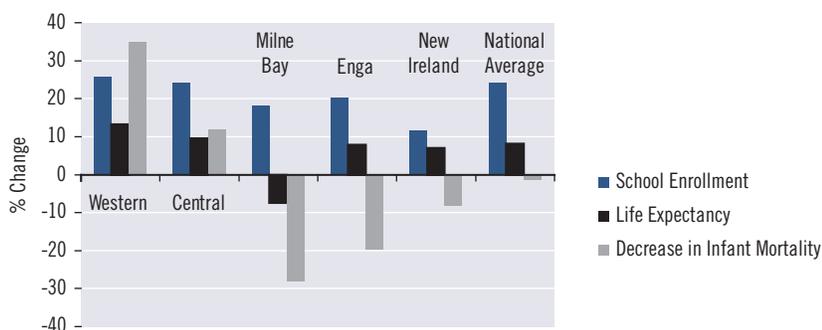
Mining in Socially Vulnerable Areas

Communities lacking the capacity to make informed decisions were considered vulnerable.

Mining may provide an important source of revenue to national governments, but the benefits do not always trickle down to local communities. This analysis uses basic human development indicators—such as education, welfare, access to services, and participation—to measure whether communities have benefited from mining in the past and the degree to which they are equipped to make informed decisions regarding future mineral development projects. Our results show that:

- Three of Papua New Guinea’s five mining provinces have fared worse than the national average when considering basic human development indicators, despite substantial payments companies have made to provincial governments (see Figure 6).
- Much of the developing world rates low in capacity for informed decision-making, with countries in sub-Saharan Africa and the Asia-Pacific region faring the worst.
- In the Philippines and Papua New Guinea, capacity for informed decision-making is lowest in remote, rural communities, where poverty rates are highest and education levels are low. These communities are among the most disadvantaged and least likely to benefit from mining without substantial investment in their education and welfare.

FIGURE 6. Change in Human Development Indices in Papua New Guinea’s Mining Provinces, 1980–1996



Source: UNDP, 1999.

Disadvantaged communities require additional investments.

Disadvantaged communities will require substantial investment to ensure that they are able to participate meaningfully in negotiations and stakeholder dialogues. Failure to make such investments may result in high costs to the company and its investors as a result of unrealistic expectations, disruptions to the mine, and—in a worst case scenario—civil unrest. The remainder of this chapter summarizes the social contributions of mining to communities in the Philippines and Papua New Guinea, and identifies populations (at the global and country case study scales) that may be especially vulnerable to the impacts of future mineral development, as measured by their capacity for informed decision-making.

THE SOCIAL CONTRIBUTIONS OF MINING IN THE PHILIPPINES AND PAPUA NEW GUINEA

Local communities are often in closest contact with mining companies. To understand how communities have benefited from mining in the case study countries, we examined economic and social indicators such as compensation, employment, and health and community welfare.

Mining has resulted in financial benefits for Papua New Guinea and the Philippines.

COMPENSATION

Mining has contributed substantial revenue in both Papua New Guinea and the Philippines. Communities living near the Porgera mine in Papua New Guinea have benefited from the mine through compensation payments, infrastructure, and employment (Biersack, 2001; Nita, 2001; Imbun and Morris, 2001). In 2001, the five active mines in Papua New Guinea contributed a total of over US\$32 million in compensation and benefits to local landowners and provincial governments (GoPNG, 2002).

But the benefits have not been equitably distributed.

However, despite this substantial revenue, the benefits have not been equitably distributed. For Papua New Guinea's Porgera mine, a minority of the clans living within the special mining lease receives most of the benefits (Nita, 2001; Biersack, 2001; Connell and Howitt, 1991). As a result, many of Papua New Guinea's mining provinces remain among the most disadvantaged in the country. Four out of five mines are located in districts defined by researchers as "extremely disadvantaged" or "severely disadvantaged," suggesting that the wealth generated from mining benefits only those living closest to the mine (Hanson et al., 2002). This inequitable distribution of wealth has exacerbated already existing tensions amongst local communities, especially since the wealth provided by mining far outweighs other income generating activities (Jacka, 2001; Filer, 1990).

Similar problems with revenue distribution have been documented in the Philippines. The central government receives 60 percent of the annual net revenue from mining, mostly in the form of excise taxes. In theory, the remainder is subdivided between local government agencies, with the national government remitting the community's share to local government treasuries. However, in practice this does not always happen (Cruz et al., 1999), prompting some local officials to reject proposed mining projects.

Employment in the mining sector is limited.

EMPLOYMENT

In 2000, mining employed approximately 9,000 people in Papua New Guinea (GoPNG, 2002) and more than 100,000 in the Philippines (ILO, 2003). The latter figure represents a drop of 62 percent from 1985 levels (Jennings, 2002).³ Unfortunately, competition for these jobs is fierce. In the Philippines, low-skilled mining jobs often attract an influx of migrants from other disadvantaged areas, marginalizing local residents (DOLE, 2002). Landowners living near Papua New Guinea's Porgera mine report having to bribe hiring committees to obtain jobs (Jacka, 2001).

HEALTH AND COMMUNITY WELFARE

In both Papua New Guinea and the Philippines, health care is lacking in remote areas and mining companies frequently build hospitals or provide much needed medical care. Even at the Bougainville mine in Papua New Guinea, where environmental degradation caused a social uprising, the general health of the population was reported to have improved (Connell and Howitt, 1991).

However, in Papua New Guinea, mineral development has not necessarily improved the health of residents in local communities, especially those living outside of the mining company's defined zone of influence. Western province appears to have made important strides in reducing infant mortality between 1980 and 1996, but Milne Bay and Enga provinces have performed poorly on most indicators despite contributions from mining during those years (see Figure 6).

In some cases, the biggest losers from mining development in Papua New Guinea have been women. Mining is typically dominated by men, and women's voices and rights are often ignored (Macintyre, 2002). For example, communities on the island of Bougainville are matrilineal and women own the land. However, mining officials negotiated with men when the mine lease was established, undermining the island's traditional matrilineal system. Women were never consulted nor did they give their permission for the mine to be established on their lands (Filer, 1990; Gillespie, 1996). Increased alcoholism and prostitution have also affected women. At the Misima mine, alcoholism has become a major problem, with men spending most of their paychecks on liquor (Gerritson and Macintyre, 1991). Men living near the Ok Tedi mine reportedly use their newfound wealth to purchase more wives (Hyndman, 1995).

IDENTIFYING VULNERABLE COMMUNITIES

In developing countries, human capital, especially education attainment, has been identified as a critical factor for economic progress (TFHES, 2000). Countries with greater percentages of higher education attainment among adult populations are more likely to contribute productively to society, earn higher incomes, and be able to critically evaluate development options. In addition, public participation can help ensure that costs and benefits of development projects are taken into account (Petkova et al., 2002).

It stands to reason, then, that communities lacking basic education and the ability to participate in decision-making will be less likely to benefit from mining projects. These communities are at a significant disadvantage, as they may not possess adequate skills and access to information to negotiate effectively in their own best interests. Thus, we developed an indicator for this study reflecting the capacity for informed decision-making, which is based on measures of education, functional literacy, income, access to services, and the degree of participation in civil society.

Low income communities lacking basic education are less likely to make informed decisions.

³ Philippine employment figure includes mining and quarrying for metallic and non-metallic minerals, as well as oil and gas development.

Citizens in much of the developing world have a low capacity for informed decision-making.

As shown in Map 8, most of sub-Saharan Africa, nearly all of South and Southeast Asia, and the least developed countries in Latin America (Guatemala, Haiti, and Nicaragua) have populations with low capacity for informed decision-making, while industrialized countries rate high in this capacity. The southern cone of the African continent (Botswana and South Africa), most of Latin America, Northern Africa and the Middle East, and the Newly Independent States (former Soviet Union) are characterized by medium capacity for informed decision-making.

Indigenous communities have the right to approve or reject mining in their claim areas.

VULNERABLE COMMUNITIES IN THE PHILIPPINES

The Philippines is characterized by a high population density (approximately 270 people per km²), with most communities having access to roads and other infrastructure. Indigenous peoples make up 16 percent of the population (CIPRAD, 1999) and their rights were only recently recognized formally through the Indigenous People's Rights Act (IPRA) and the establishment of ancestral domains. According to this law, indigenous communities have the right to approve or reject any development projects proposed within their claim areas. Approximately 1 percent of the land area registered in ancestral domain claims overlaps with approved mining or exploration areas.

High poverty rates in rural areas pose a human development challenge.

High poverty rates, especially in rural areas, are a major human development challenge in the Philippines. In 2000, approximately 45 percent of the population was living on less than US\$2 per day and the rural poverty rate was estimated at 37 percent (World Bank, 2001). The degree of welfare also appears to be linked to education levels; 75 percent of the poor in 1997 belonged to households where the head had not received more than an elementary school education (World Bank, 2002a). The number of peoples' organizations and NGOs is high. In 1995, there were 60,000 registered non-profit institutions in the country, indicating an active civil society sector (ESSC, 1999b).

Mining overlaps with areas that have low capacity for informed decision-making.

In the Philippines, capacity for informed decision-making was estimated using a combination of functional literacy, welfare, and the proportion of households with membership in a people's organization or NGO (see Map 9). As might be expected, capacity for informed decision-making is lowest in the most impoverished regions of the Philippines (e.g., Samar and Leyte), as well as areas in Mindanao that are plagued by ongoing security problems and conflict. More than half of exploratory and mining concessions overlap with areas of low capacity for informed decision-making, indicating that significant investments will be required to elevate community members' ability to participate effectively in decisions regarding mining in their communities.

Few communities have access to roads and other infrastructure.

VULNERABLE COMMUNITIES IN PAPUA NEW GUINEA

Papua New Guinea is one of the most culturally and linguistically diverse nations in the world, with more than 850 separate language groups. Approximately 85 percent of the country's population lives in rural communities based on a traditional village structure (Hanson et al., 2002:11) and more than 95 percent of the land is under customary ownership. Few communities have access to roads or other physical infrastructure and many of the existing road networks are in serious disrepair (UNDP, 1999: 123).

Road density has been shown to be somewhat correlated with school enrollment and life expectancy at the provincial level. Remote areas within provinces are more likely to rank lower in health and education, with the exception of the Highlands Region, where a high percentage of the population rates poorly in school enrollment and basic health indicators despite relatively high access to roads (UNDP, 1999: 126, 85).

Remote communities are more likely to have low capacity for informed decision-making.

Detailed information on education and access to health care is not publicly available at a sub-provincial level for Papua New Guinea. Thus, we sought to roughly identify potentially vulnerable communities by estimating the remoteness of communities, based on their access to roads and distance from one another (see Map 10). According to our analysis, communities living in Sandaun and Western Provinces are among the most remote and therefore are likely to have the lowest capacity for informed decision-making. These communities are more likely to engage in traditional subsistence livelihoods and the relatively large cash benefits associated with mining could disrupt traditional livelihoods, resulting in a greater incidence of social ills, such as prostitution, alcoholism, and domestic violence.

Chapter 5.

Natural Hazards and Mining

Tailings incidents continue to cause loss of life and property.

In 1928 an earthquake measuring 8.3 on the Richter scale occurred near the Barahona copper mine in Chile, causing a failure of the waste impoundment. Nearly 3 million cubic meters of toxic waste flowed down the valley, killing 54 people (ICOLD, 2001:110). Tailings impoundment design has improved considerably since the early days of industrial mining. However, accidents still occur with surprising frequency. According to a study by the International Council on Large Dams (ICOLD), about two mine structure accidents have occurred per year over the last 6 years (ICOLD, 2001:6). In the last 12 years, approximately 31 tailings incidents have been recorded, of which nearly 40 percent resulted in loss of life or property.⁴

Earthquakes and excessive moisture pose challenges for responsible mine management.

Although global-level data are limited regarding hazard-prone areas, seismicity and excessive moisture can be used to identify areas that pose challenges for responsible mine management. Areas with high moisture availability are especially prone to water quality problems, because high rainfall can cause tailings impoundments to overflow. The results of our hazard analysis reveal that:

- At a global level, 12 percent of active mines and 7 percent of exploratory sites are located in areas characterized by high or very high seismic hazard.
- In the Philippines, however, much of the country and more than half of exploratory and mining concessions overlap with areas of high seismic risk. This is of particular concern for older operating mines, which may not have been built to current standards.
- Areas that may be predisposed to water quality problems include most of the tropics and the temperate coastal parts of North America and Europe. Approximately 10 percent of active mines and an additional 25 percent of exploration sites occur in such areas.

Natural hazards have been relatively well studied and documented at a global level. ICOLD has produced several bulletins defining risk parameters for tailings impoundments that include consideration of natural hazards. However, the analysis presented in this chapter represents the first time that a map has been produced comparing areas prone to natural hazard with active mines and exploration sites at a global level. The analysis is divided into two sections: seismic hazard and risk, and excessive moisture.

⁴ Calculation based on the number of metal and coal mine tailings incidents with recorded releases and known impacts. For a complete list see: UNEP (2002), "Chronology of Major Tailings Dam Failures," Available online at: <http://www.antenna.nl/wise/uranium/mdaf.html>. Last accessed June 5, 2003

SEISMIC HAZARD AND RISK

Seismic hazard is defined as the “probable level of ground shaking associated with earthquakes” (Giardini, 2000). Because earthquakes can disrupt buildings and other infrastructure, they are a major safety concern for mine development. Earthquakes are not the only geological hazards contributing to failure of mine infrastructure. Breaches in mining infrastructure, particularly mine waste dumps, can occur if mines are incorrectly sited near areas prone to mass wasting.⁵

The analysis conducted for this study estimated the potential for geological instability using global seismic hazard maps. Many countries and regional bodies develop such maps. From 1992 to 1998, the United Nations conducted a demonstration project called the Global Seismic Hazard Assessment Program, which initiated several regional seismic hazard assessment programs throughout the world. The resulting regional assessment maps were combined into a global seismic hazard map (see Map 11).

Building mines in earthquake prone zones implies increased costs.

Although seismicity may pose a hazard for many mines, Map 11 does not imply that tailings facilities at these mines will fail. Modern mining operations are required to incorporate design elements that account for seismic events. For example, ICOLD recommends that tailings facilities built in areas of high seismic hazard be designed to withstand the strongest earthquake expected to occur for many years (ICOLD, 1989:25). Thus, our analysis provides a rough guide of where mineral development may entail increased costs to protect against seismic hazard.

ESTIMATING SEISMIC RISK IN THE PHILIPPINES

According to Giardini et al. (2000), seismic risk is determined by combining seismic hazard with vulnerability factors, such as the age and structure of buildings, population density, and land use. In the Philippines, we estimated seismic risk by considering seismic hazard, soil properties, and existing building codes for mine structures, such as tailings impoundments. The objective was to identify areas where mining poses a risk due to the probability that a strong earthquake exceeding existing building codes for tailings impoundments will occur. Similarly detailed data were not available for Papua New Guinea or at a global level.

Seismic risk is high throughout much of the Philippines.

Inherent seismic risk remains high across much of the Philippines; two thirds of exploratory concessions and more than half of active concessions are located in areas of high seismic risk (see Map 12).

⁵ Mass wasting is a collective term for a variety of geotechnical phenomena whereby geological materials commonly move down-slope either gradually or catastrophically. The term covers the following processes: soil creep, rock falls, slides, slumping, flows, heaves, and debris avalanches. Montgomery C.,W. 1989 Environmental Geology 2nd Ed. by Wm.C. Brown Publishers.

Table 5. Known Tailings Incidents and Weinert Hazard Level, 1939–2002

Country/ State	Weinert Hazard Level
North America	
British Columbia, Canada	High-Very High
Ontario, Canada	High
New Brunswick, Canada	Very High
Texas, USA	Low-Very High
North Carolina, Florida, Pennsylvania, Missouri, Kentucky, USA	High-Very High
Nevada, Idaho, Wyoming, Montana, Colorado, New Mexico, Arizona, Utah, USA	Low
Europe/ Eurasia	
Ireland	High
Montenegro	Very High
Stava, North Italy	Very High
Nyukka Creek, USSR	Low
Derbyshire, UK	High-Very High
Southern Ukraine	Low
Bilbao and Santander, Spain	High
Los Frailes, Spain	Low
Baia Mare, Romania	High
Bekovsky, Western Siberia	Low
Asia/Pacific	
Philippines	High-Very High
Dashi, China	Very High
Shanxi Province, China	Low
Tasmania	Very High
Waitekauri Valley, New Zealand	High-Very High
Japan	Very High
Africa	
Zambia	Low
Arcturus, Zimbabwe	Low
South and Central America	
Guyana	High
Minas Gerais and Goias, Brazil	Very High

Note: Includes only metal and coal mines for which an approximate location is available.
Sources: ICOLD (2001); Map 13.

Mines in areas of high rainfall are more likely to encounter water quality problems.

FLOOD HAZARD AND WATER QUALITY PROBLEMS

One of the most common causes of tailings dam failures is “overtopping,” or overflow of the impoundment during high rainfall. According to ICOLD, the major reason for tailings impoundment failures in the past 60 years has been “lack of control of the hydrological regime,” particularly in flood-prone areas (ICOLD, 2001: 31). High rainfall may also interact with waste and ore piles at a mine site, creating acid drainage and the release of toxic metals and reagents.

Flood hazard maps are routinely provided to homeowners and insurance companies throughout the United States and in other countries to identify flood-prone areas. Although a global flood hazard map is not available, excessive moisture can be used as a proxy to identify where tailings impoundments are more likely to fail due to high rainfall. We used the Weinert Weathering Index to estimate potential water quality problems due to excess moisture (Weinert, 1964; Ashton et al., 2001). The Weinert Index is a mathematical model comparing net evaporation in the warmest month of the year to average annual precipitation. The resulting dimensionless value indicates where annual precipitation greatly exceeds the amount of moisture lost to evaporation (see Appendix 1 for details).

Rainfall is highest in the tropics and temperate coastal zones.

According to Map 13, areas prone to exceptionally high rainfall are found predominantly in the tropics and in the temperate coastal zones of the Americas, Europe, and the Pacific. This is consistent with the predominantly warm, humid, and wet landscapes found in these areas. Indeed, historical tailings dam failures tend to coincide with areas where Weinert hazard levels are high (see Table 5).

Mining in other areas may also result in serious water quality problems.

The map, however, does not fully capture all areas where water quality problems are likely to occur and it is not a suitable proxy for estimating potential acid drainage problems. For example, mines located in much of the western United States are known to have generated acid drainage and have reported tailings incidents, even though these areas appear to have low vulnerability. This is likely due to the coarseness of the data used in this study. In addition, the Weinert Index does not capture the effects of high elevations on monthly and annual precipitation (Weinert, 1964). Although mines developed in these areas are likely to encounter water quality challenges, mines built in areas with low hazard ratings according to the Weinert Index may also experience serious water quality problems.

Both the Philippines and Papua New Guinea have high hazard ratings. In essence, any mine constructed in either country can be expected to confront significant water quality management challenges relating to high moisture levels and heavy rainfall.

Chapter 6

Other Contributing Factors

Governance and certain mine practices may expose vulnerable areas to hazards.

The previous three chapters have highlighted areas that are environmentally and socially vulnerable to mining. However, the degree to which these areas are exposed to negative impacts from mining depends in large part on the quality of national regulations, governance (as defined by transparency, accountability, and the rule of law), and the relative footprint of certain mine practices. Good governance practices help to ensure that mining companies are held accountable and that citizens have a hand in shaping positive development outcomes. On the other hand, weak governance indicates a lack of important safeguards to ensure that responsible mining occurs. Therefore, we chose to analyze determining factors that may increase the exposure of environmentally and socially vulnerable areas to the potential hazards posed by mining, as defined by: 1) governance and 2) certain mine practices. The results of this analysis indicate that:

- Many countries, especially in the developing world, are plagued by corruption, civil unrest, and lack of opportunity for civil society to participate meaningfully in defining development options that are most likely to benefit them.
- Nearly one quarter of active mines and exploration sites are located in countries exhibiting the weakest governance structures, indicating that mining in these countries is less likely to contribute positively to economic development.
- Disposing of mine waste in rivers has resulted in particularly high environmental and social costs. Dumping waste in the deep-sea environment carries with it great uncertainty regarding potential environmental impacts and should only be considered if there is a high degree of assurance that such practice would not damage vulnerable ecosystems, especially in the case of small islands.

A complete analysis of governance would include an evaluation of the quality of environmental regulations. Unfortunately, such an assessment has not been conducted globally and data were limited for both case studies, making it difficult to measure the quality of regulations in each country. For this reason, the analysis presented in this chapter focuses largely on global governance datasets, supplemented by information collected in the Philippines and in Papua New Guinea.

GOVERNANCE

Strong governance structures are important.

Transparent and democratic governance structures are a critical element in ensuring that corporations and governments are held accountable for their actions (MMSD, 2002; TI, 2002; Kaufmann et al. 1999a, 1999b, 2002; Petkova, 2002). A recent study of the relationship between governance and national economic performance found that countries with weak governance are less likely to experience economic growth, although economic growth by itself does not lead to better governance. In other words, the increased revenue that may accrue from mining will not result in economic growth if a country lacks good governance in

part because of “state capture,” a phenomenon the authors define as, “the undue and illicit influence of the elite in shaping the laws, policies and regulations of the state” (Kaufmann and Kray, 2002: 31).

Governance may be measured by examining a country’s political and civil liberties, transparency, control of corruption, and rule of law. While it appears obvious that developing countries struggle more with governance issues than developed countries, countries such as the U.S. are by no means immune from governance problems. We sought to portray areas where governance may be weakest and hence, represent areas where mines may be less likely to contribute positively to the welfare of a country’s citizens. Three aspects of governance are reviewed: control of corruption, voice and accountability, and rule of law. These elements of governance, as well as indicators reflecting government effectiveness and political stability, have also been aggregated into a global governance index.

CONTROL OF CORRUPTION

Corruption impedes the mining industry’s contribution to economic growth.

Corruption represents a major impediment to ensuring that revenues from mining contribute to national economic growth and has been identified by the World Bank as the single greatest obstacle to poverty reduction. A recent study by Transparency International found that mining, oil, and gas rated among the industries most likely to pay bribes, with the oil and gas sector ranking the third most corrupt (TI, 2003: 268). In Papua New Guinea, weak governance and rampant corruption have been recognized as the principal deterrent to the wise use of revenues from the extractive industries. A World Bank report recommended that continued investments in extractive industries in Papua New Guinea occur only if governance problems are addressed (World Bank, 2002b:7).

Corruption appears to be related to a country’s reliance on mineral wealth; of the 32 mineral-dependant countries listed in Transparency International’s corruption index, nearly three quarters scored less than 5 on a scale of 0-10, where 0 is considered highly corrupt (MMSD, 2002). Nowhere is this clearer than in Nigeria, where oil development fuels a well-developed network of corruption, which permeates every level of society. One Shell Oil executive remarked to a major European newspaper that the company spends more money on bribes and corruption than on implementing community development projects (Human Rights Watch, 1999: 9).

Corruption is most problematic in parts of the developing world.

Map 14 summarizes corruption according to Kauffman et al. (2002). Control of corruption is most problematic in parts of Southeast Asia (Indonesia, Papua New Guinea, and Vietnam) and throughout Africa (e.g., Angola, Cameroon, Kenya, Libya, Madagascar, Mauritania, Niger, Nigeria, Somalia, Uganda, Zambia, and Zimbabwe). In Latin America, controlling corruption appears to be most challenging in Bolivia, Ecuador, Guatemala, Nicaragua, and Paraguay. Control of corruption also appears to be poor in Russia and many of the newly independent states (Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan), as well as in Afghanistan and Pakistan. Countries with the lowest levels of corruption include many of the industrialized countries of the OECD (Organisation for Economic Co-operation and Development). Countries in the southern cone of Africa and in parts of Latin America and the Baltics also show strong performance, particularly Chile and Namibia, which appear to perform as strongly as the OECD nations.

Papua New Guinea and the Philippines do not enforce rigorous rules.

RULE OF LAW

The degree to which citizens abide by the law is related to a country's ability to control corruption. At the global level, the resulting map for this indicator largely resembled Map 14. According to this dataset, both Papua New Guinea and the Philippines score in the second lowest quartile for this indicator. Data collected for this study in Papua New Guinea and the Philippines underscored problems in this area of governance. The largest mines in Papua New Guinea—Ok Tedi and Porgera—have been subject to their own legislation, which supersedes national law (Shearman, 2001). In the Philippines, nearly one mine-related pollution incident has been reported per year in the past 18 years. In nearly 40 percent of the cases, the government did not impose a fine. Even when fines were levied, these were minimal (less than \$5,000) with the exception of three cases, in which fines and/or compensation exceeded \$50,000. In the highest profile pollution case (Marcopper), the company offered a \$2 million compensation payment, but this did not cover even 5 percent of the estimated cost of clean-up (DENR-PAB, 2000).

VOICE AND ACCOUNTABILITY

The UN considers civil and political liberties essential for human development (UNDP, 2002). A broad range of such liberties is reflected in the Kaufmann et al. (2002) voice and accountability aggregate indicator, which measures the degree to which a country's citizens are able to participate in the selection of governments, including civil liberties, political rights, and independence of the media. Another measure of civil liberties is the degree to which environmental impact assessments (EIAs) are subjected to public comment and review, although EIAs suffer from poor quality and inherent conflicts of interest (see Box 4).

Box 4. Environmental Impact Assessments and Public Participation

Many countries require environmental impact assessments (EIAs) for mine development. In some countries, EIAs are subject to public review, allowing citizens an opportunity to comment on the potential impacts of projects before they are constructed. In practice, however, public consultation on EIAs often occurs late in the project development process and some countries do not guarantee sufficient time for citizens to comment. An analysis of the EIA process in Latin America revealed that half of the countries in that region do not require public consultation until governments have formally approved EIAs (Petkova et al., 2002: 76). In the Philippines, public consultation is required at several stages of EIA development, including during initial drafting. In Papua New Guinea, public consultation is required by law; however, in practice, this is commonly ignored or circumvented.

Although EIAs are an important component of minimizing negative environmental and social impacts, other problems may render them ineffective. In most cases, EIAs are pre-

pared by company consultants and generally include an analysis of anticipated environmental and social impacts as well as plans to mitigate negative environmental and social impacts. Independent review is necessary to ensure that any potential environmental and social problems have not been downplayed. However, many developing countries lack trained personnel to review EIAs and ensure they comply with the highest scientific standards (ESMAP, 1999:23).

In addition, estimating potential impacts requires data collection prior to development to establish baseline levels for environmental quality. However, baseline data may not exist, forcing environmental managers to set arbitrary standards based on what little information is available. For example, the "mixing zone" set by the Papua New Guinea government for the Porgera mine was based on ease of access to the nearest collection point for baseline flow data, rather than scientific analysis of aquatic biodiversity in the river (CSIRO, 1996).

Some developing countries also fare poorly in measures of voice and accountability.

Many of the same countries that perform poorly in terms of corruption also fare poorly in measures of voice and accountability (e.g., Afghanistan, Angola, Cameroon, Iraq, Libya, the Newly Independent States, Pakistan, Somalia, Syria, Uganda, Vietnam, and Zimbabwe), although civil and political liberties appear to be a greater problem for some than corruption (e.g., China, Guinea, Guinea-Bissau, Saudi Arabia, and Sierra Leone). Citizens in most of Latin America appear to have greater civil and political liberties than in other parts of the developing world, with the exception of Cuba (see Map 15).

Multiple vulnerabilities may pose additional challenges where governance is weak.

MULTIPLE VULNERABILITIES

Because an adequate regulatory framework, public participation, and freedom from corruption are important for ensuring environmentally and socially responsible mining, it stands to reason that weak governance exposes environmentally and socially vulnerable areas to potential hazards from mining. Proposed mines in areas with multiple hazards and vulnerabilities may be especially problematic, as they imply the need for careful and deliberate decision-making that may be less likely in areas of weak governance. Unfortunately, due to the coarse and unreliable nature of governance data, it is not possible to combine the ecological and social vulnerability maps developed for this study with the governance maps presented in this chapter. However, some inferences can be made by examining the results of both analyses.

To examine these relationships, we combined all of the aggregate governance indicators developed by Kaufmann et al. (2002) except regulatory burden to create a combined indicator of governance. We then compared global indicators measuring seismicity, watershed stress, and ecological value to the InfoMine database to estimate the degree to which mines face multiple vulnerabilities or hazards.⁶ This analysis revealed that:

- Nearly one quarter of active mines and exploration sites are located in countries with weak governance.
- Nearly one third of the countries for which data are available rank poorly in both governance and capacity for informed decision-making, indicating that mining may be less likely to improve the human development of citizens in these countries.
- Nearly one third of countries with high watershed stress also rate poorly in governance, reducing the likelihood of sound water resource management.
- Approximately 4 percent of active mines and exploration sites face multiple vulnerabilities, including seismicity, watershed stress, and ecological value.

In Papua New Guinea and the Philippines, an analysis of multiple vulnerabilities revealed that a significant proportion of mining and exploratory concessions are exposed to more than one vulnerability or risk:

⁶ We did not include excessive moisture in this analysis due to the coarseness of the evaporation dataset.

- In Papua New Guinea, 71 percent of exploratory and mining concessions overlap with areas of low capacity for informed decision-making and fragile forests. More than 80 percent of all mining concessions overlap with areas of low capacity for informed decision-making and intact forests.
- In the Philippines, 40 percent of exploratory and mining concessions overlap with high vulnerability or risk areas in more than one indicator, including watershed stress, seismic risk, ecological value, and capacity for informed decision-making.

Multiple vulnerabilities imply higher costs for companies.

The vulnerabilities analyzed in this study may not be directly linked to one another; however, the presence of multiple vulnerabilities implies higher costs for companies developing or investing in a potential mine. If mining occurs in areas with multiple vulnerabilities and weak governance, these costs may be borne by citizens unless adequate safeguards are put in place to ensure that mining revenues are managed for the benefit of the majority of citizens.

Some waste disposal practices may pose problems for vulnerable areas.

ENVIRONMENTALLY AND SOCIALLY RISKY MINE PRACTICES

Certain mine practices are more likely to increase the exposure of vulnerable ecosystems and communities to the potential hazards of mining. In some cases, the type of mine constructed (e.g., underground versus open pit) is determined primarily by the characteristics of the deposit. In others, the choice of engineering design for mine structures has a direct bearing on the exposure of nearby critical ecosystems or communities to mine-related hazards. For example, most tailings impoundment failures in seismically active zones have been associated with the upstream method of construction, rather than downstream or centerline construction (ICOLD, 2001:47-48). This section examines the waste disposal practices that may be especially problematic for sensitive ecosystems and communities.

RIVERINE TAILINGS DISPOSAL

In some parts of the world, seismic instability and high landslide probability have led companies to abandon the construction of tailings impoundments in favor of dumping treated wastes directly into rivers, a practice known as riverine tailings disposal. For example, BHP argued that dumping tailings into the Ok Tedi River was the only viable option at the company's copper and gold mine in Papua New Guinea, given that a tailings impoundment had failed due to landslides in the region (BHP, 1997:37). Few mines around the world currently utilize riverine tailings disposal for waste management, and all are located on the island of New Guinea.

The environmental costs of riverine tailings disposal have been high.

The environmental costs of riverine tailings disposal have been high. The Panguna copper mine in Papua New Guinea dumped approximately 150,000 tonnes of waste rock and tailings per day into the Jaba River. The practice of riverine tailings disposal resulted in significant negative impacts on the river and surrounding local communities, including the loss of fish in the entire 480 km² watershed, declines in local wildlife populations, loss of agricultural land, and declines in coastal fish stocks (Boge, 1998:212). More than 60 percent of the tailings and waste rock deposited in the Jaba River have been carried out to sea and aquatic

species in the upper tributaries of the Jaba River were unable to migrate to the sea to spawn (Brown, 1974:25-26).

By the company's own admission, nearly two decades of riverine tailings disposal at the Ok Tedi mine has resulted in the degradation of more than 2,000 km² of forests. Approximately 50,000 residents in 120 villages have been affected by the 70 million tonnes of tailings and waste rock dumped into the Ok Tedi River. Fish stocks are estimated to have declined 70-90 percent. As a result, BHP divested itself of the Ok Tedi mine, leaving management to a government-owned subsidiary. The company has since committed never to develop another mine using riverine tailings disposal as a waste management option (WRI, 2003: 188-197).

Papua New Guinea legislation facilitates such practices by allowing companies large exemptions from meeting water quality standards in discharge areas known as "mixing zones." The mixing zones for the Ok Tedi and Porgera mines are 200 and 150 kilometers, respectively. According to analysis conducted in this study, more than 37,000 people live within 5 kilometers of these mixing zones, suggesting that they may suffer lower water quality.

MARINE TAILINGS DISPOSAL

Waste disposal in the marine environment has resulted in environmental damage.

Disposing mine tailings in the marine environment has been used as an alternative to riverine tailings disposal, especially for mines located in coastal areas. Impacts from marine disposal systems have consistently included increased water turbidity, seabed smothering, and trace metal accumulation (Ellis, 1998:94; Ripley, 1996; Loring and Asmund, 1989). The shallower waste disposal systems are among the most destructive because tailings are dumped in areas of greatest marine biodiversity (MMSD, 2002). However, even tailings disposal at greater depths may produce significant impacts on aquatic biodiversity, as pipes used to transport waste to deep sea environments have been known to break at shallower depths, causing a loss of fish and other aquatic organisms (MMSD, 2002; Coumans, 2002).

Deep-sea tailings disposal requires deposition of mine waste below the euphotic zone (i.e., sufficient light is not available for photosynthesis). In theory, the impacts of such disposal should be minimal, given that the deep sea is generally more stable than coastal environments and the lack of light would preclude the existence of highly diverse aquatic organisms. Although this has been found to be true for some mines practicing this method (Jones and Ellis, 1995), one study found short-term reductions in growth rate and avoidance of mine tailings in juvenile yellowfin tuna, suggesting that aquatic organisms that depend on the seabed floor may have difficulty adapting to the disposal of mine tailings (Johnson, 1997).

Not enough is known about the impacts of tailings deposited in the deep-sea environment.

To date, there have been few independent, peer-reviewed studies on the impacts of submarine tailings disposal on the deep-sea environment. Scientists point to a high degree of uncertainty regarding the nature of the deep-sea environment, due to lack of data on how deep-sea benthic organisms react to human-induced changes. Predicting the behavior of tailings deposited in the deep-sea environment is hampered by a general lack of knowledge regarding the physics of sediment transport in the marine environment (Coumans, 2002). Some have noted that the deep-sea environment is characterized by significantly diverse microbial activity, the loss of which could result in the decline and extinction of specific taxa, some of which may be critically important for the maintenance of fisheries (Mooney et al., 1995).

Some areas may be too vulnerable to justify the use of submarine tailings disposal systems.

Despite the scientific uncertainties regarding the deep-sea environment and the recorded incidents of pipe breaks at shallower depths, this waste management practice is increasingly proposed for new mines, especially in the Asia-Pacific region. Four mines in Indonesia and Papua New Guinea use submarine tailings disposal systems and six of eight mines proposing submarine tailings disposal are in the Asia-Pacific region. Because the Asia-Pacific region is endowed with the world's greatest coastal and marine biodiversity, submarine tailing disposal should only be considered if there is a high degree of assurance that these vulnerable ecosystems will not be damaged.

Chapter 7.

Financial Institutions Exposed to Environmental and Social Risks

Financial institutions play an important role by supporting mining projects.

Many institutions are exposed to environmental and social risks from mining: mining companies, financial institutions, insurance companies, and metal product buyers whose product lines are potentially subject to consumer pressure. Mining projects require large amounts of capital investment. Although financial institutions are not directly involved in mining, without the much-needed capital they provide, many mining projects would not be built. As such, these institutions are an important part of establishing accountability between the global capital investments they support and local environmental and social impacts. The participation of public financial institutions in particular can leverage additional domestic and private investment in this sector. Public financial institutions are bound by social and environmental mandates requiring them to meet poverty reduction and ecosystem protection goals. As such, pressure is building on these institutions to better assess the social and environmental risks of their lending and intermediation.

Unfortunately, there is no global dataset that identifies the mining investments of most of these actors. Although it is possible to cull some information from corporate annual reports, no comprehensive list of mining-related investments in all active and potential mines is publicly available. The mine location database used for this project did not contain any information on ownership of individual mineral properties. Researching the ownership of each mine, while technically possible, was beyond the available resources of this project. For this reason, this chapter focuses on a limited subset of public and private financial institutions investing in Papua New Guinea, for which some information is available.

The results of the Papua New Guinea analysis revealed the following:

- Three out of five active mines and one advanced exploration site fall within areas of high ecological vulnerability, as defined by the presence of intact and fragile forests within concession boundaries.
- Major international financial institutions, such as Citibank, ABN AMRO, Overseas Private Investment Corporation, EFIC (Australia) and the Export Development Corporation (Canada) have invested in the country's major mining projects and are thus potentially exposed to environmental and social risks.

TYPES OF FINANCIAL INSTITUTIONS

Financial institutions that lend to the mining sector can be categorized into three types: export credit agencies (ECAs), multi-lateral development banks, and private banks (lending and investment banking). These institutions can be briefly summarized as follows:

- **Export Credit Agencies (ECAs):** ECAs are generally state-supported financial institutions whose main goal is to promote exports of equipment and services from their home countries. A company seeking to purchase capital equipment for a mine may seek a short-term loan from an export credit agency in the country where the equipment will be purchased. ECAs also provide longer-term project finance (5- to 10-year loans) for overseas projects, political risk and currency transfer risk guarantees, as well as insurance. (Maurer and Bhandari, 2000; Maurer, 2002)
- **Development Finance Institutions:** The World Bank Group provides private sector loans and guarantees through the International Finance Corporation (IFC) and the Multilateral Investment Guarantee Agency (MIGA). Lending practices in both institutions require compliance with World Bank policies and operating procedures. The IFC promotes private sector investment in developing countries by providing direct project finance, as well as other services, such as underwriting and security placement. MIGA provides political and currency transfer risk guarantees, much like ECAs. Other regional banks, such as the Asian Development Bank (ADB) also provide private sector loans and guarantees, usually for investments in their focal region.
- **Commercial (private) banks:** Commercial banks provide debt finance for projects as well as some equity financing. They may also provide advice and other services, such as assisting a company to raise equity through a public offering. Insurance companies insure against risks associated with mine construction and operation, as well as against political risks.

Data on the participation of financial institutions in mining projects are lacking.

The level of importance of each category for mine financing is difficult to determine because information is not publicly available, especially for export credit agencies and private commercial banks. Mining companies in many developing countries (e.g., the Philippines) also receive financing from domestic financial institutions, but even less information is available detailing these investments because most developing countries do not require these institutions to publicly release independently audited account statements or annual reports. National development banks often support state-owned mining companies, but information on the portfolio of projects supported by these institutions is not publicly accessible.

Notwithstanding this lack of information, anecdotal evidence suggests that ECAs have provided a significant proportion of the financing for many mining projects. For example, nearly half of the total debt financing for the Antamina mine in Peru came from export credit agencies (Grieg-Gran, 2003:124). The IFC plays an important role among development financial institutions not only through direct investment in mining projects, which in 2001 made up 7 percent of its committed portfolio (Grieg-Gran, 2003: 122), but also because many other public and private financial institutions adopt IFC standards and guidelines when assessing potential environmental and social risks. Among regional development banks, the European Bank for Reconstruction and Development (EBRD) provides significant financing for mining projects, which make up the largest segment of the bank's portfolio after oil and gas (UNEP, 2002a:19).

HOW FINANCIAL INSTITUTIONS CONSIDER ENVIRONMENTAL AND SOCIAL RISKS

Financial institutions have difficulty distinguishing between “good” and “bad” projects.

Many financial institutions use a system of categories, ranging from A-C, to designate whether a project is environmentally or socially sensitive. Category A projects typically are the most sensitive, triggering the highest level of scrutiny by investors. Often a company proposing a category A project is required to provide an environmental impact assessment. Category B projects are deemed to have less serious potential environmental and social impact than category A projects, while category C projects are considered to have minimal potential impacts. Financial institutions often have difficulty distinguishing between “good” and “bad” projects due in part to the fact that they rely on environmental impact assessments provided by the company, and these are rarely evaluated for quality by independent experts (Grieg-Gran, 2003: 137-138). Indeed, an internal review of the application of IFC safeguard policies found that bank staff tend to assign category B status to many projects to avoid the additional requirements associated with category A projects (CAO, 2003).

Some institutions have internal policies guiding investments in mining.

A few financial institutions state flatly that they will not invest in certain types of mining activities. Both of the U.S. export credit agencies (OPIC and Export Import Bank) state that they will not support projects located within IUCN I-IV protected areas or in “primary tropical forests,” although little guidance is provided regarding the operational definition of the latter classification. In 2001, the private Dutch bank, ABN AMRO adopted an internal forestry policy that “... precludes financing projects or operations which will result in resource extraction from, or the clearing of, either primary or high conservation value forests” (ABN AMRO, 2001).⁷

FINANCIAL INSTITUTIONS EXPOSED TO RISKS IN PAPUA NEW GUINEA

Much of the information regarding financial institution investment in mining is only available at a project level. We undertook an analysis to identify the financial actors connected to active mining projects in Papua New Guinea (see Table 6).⁸ Although significant project financing was likely raised for the Porgera and Misima mines, the information provided in Table 6 underrepresents investments. Most project financing for these mines was raised prior to 1995, the earliest year for which financial databases list transactions. A large number of banks financed the Ok Tedi mine, although it is unclear whether these loans remain active. Since 1998, financing for mines in Papua New Guinea appears to have diminished significantly, likely as a result of lower levels of investment by the mining industry in this country. One recent exception (2003) is US\$25 million in equity raised for the Kainantu advanced exploration project by ABN AMRO Morgans, a retail broker partially owned by ABN AMRO.

⁷ The ABN AMRO Forestry Policy is primarily tailored to debt engagements governed by risk management processes. However, it is the bank’s goal to apply it to other sectors, such as equity and advisory engagements. At this time, the policy does not formally apply to minority shareholdings in which the bank has no management control. Source: ABN AMRO Environmental and Social Risk Management Unit.

⁸ Unfortunately, insufficient data exist regarding the financing of most active mines in the mines database. A search through project finance software (ProjectWare) revealed no current financing for active mines in the Philippines, due to the fact that ProjectWare covers financial transactions with participation from international financial institutions and most of the mines are operated by national companies that receive national financing.

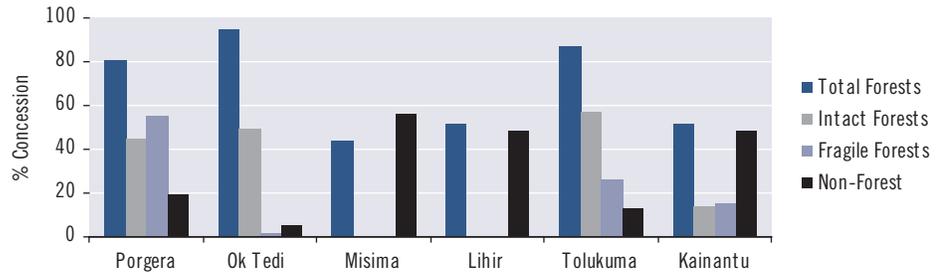
TABLE 6. Financial Actors Involved in Mines in Papua New Guinea

Financial Institution	Mine	Amount of Exposure (millions of US\$)	Status
ABN Amro	Kainantu	25 (equity facility)	Active
	Lihir	50	Active
	Orogen Minerals (Misima, Porgera, and Lihir)	10	Active
Citigroup	Ok Tedi	150	Unknown
	Lihir	20	Active
Bank of South Pacific	Tolukuma	2	Active
Union Bank of Switzerland	Lihir	24.33	Active
CIBC Asia Ltd	Lihir	14.75	Active
Bayerische Vereinsbank AG	Lihir	12	Active
Banque Bruxelles Lambert France	Lihir	12	Active
AIDC Ltd.	Lihir	16.66	Active
Dresdner Bank	Lihir (Dresdner Australia)	20	Active
	Orogen Minerals (Misima, Porgera, and Lihir)	15	Active
ANZ Banking Group Ltd	Lihir	14.75	Active
	Orogen Minerals (Misima, Porgera, and Lihir)	27.5	Active
Royal Bank of Scotland	Lihir	14.75	Active
Bank of Nova Scotia	Lihir	14.75	Active
KBC Bank	Orogen Minerals (Misima, Porgera, and Lihir)	10	Active
West LB	Orogen Minerals (Misima, Porgera, and Lihir)	20	Active
Warburg Dillon Read	Orogen Minerals (Misima, Porgera, and Lihir)	27.5	Active
Credit Agricole Indosuez	Orogen Minerals (Misima, Porgera, and Lihir)	15	Active
Export Finance and Insurance Corporation (EFIC) – Australia	Lihir	Export credit	Active
	Ok Tedi	250	Unknown
Multilateral Investment Guarantee Agency (MIGA)	Lihir	Unknown amount	Active
Export Development Corporation (EDC) – Canada	Lihir	Unknown amount	Active
	Ok Tedi	88	Unknown
Overseas Private Investment Corporation (OPIC)	Ok Tedi	50	Unknown
Kreditanstalt für Wiederaufbau (KfW) – Germany	Ok Tedi	100	Unknown
Oesterreichische Kontrollbank AG (OeKB) – Austria	Ok Tedi	50	Unknown

Source: Company annual reports; Project FinanceWare; Ok Tedi investments from McGill (1983).

Note: For Lihir, includes banks investing more than US\$10 million. Financing listed may include both debt and equity transactions.

FIGURE 7. Ecological Vulnerability in Papua New Guinea by Active Mine



Note: Fragile Forests includes both intact and fragmented forests. Thus there is overlap between intact and fragile forest categories. The Misima and Lihir concessions contain fragmented, non-fragile forests.

Internal policies adopted by financial institutions have not been fully implemented.

An analysis of forest cover within mining concessions revealed that all of the active mining concessions except Misima and Lihir overlap with fragile or intact forests (see Figure 7). The Kainantu concession contains both fragile and intact forests, albeit in a smaller proportion than Porgera, Tolukuma, and Ok Tedi. This appears to contradict ABN AMRO’s forestry policy, suggesting that even though financial institutions have policies relating to environmental and social risk, these policies may not yet apply to every area of practice within the organization.

Chapter 8.

Conclusions and Recommendations

Destructive mine practices pose a threat to vulnerable ecosystems and communities.

To date, mining has had a poor record in terms of its contribution to sustainable development. While some communities and nations have benefited significantly from mining, many who should have benefited have not. More alarmingly, the environmental footprint in some cases is disproportionately large. Based on the global analysis conducted in this study, we conclude that:

- Although global and national policy debates often center on “no go” areas on land that is already subject to legal protection, mining in important ecosystems that are not adequately protected may pose an even greater threat. Three quarters of active mines and exploratory sites appear to overlap with areas of high conservation value and areas of high watershed stress.
- Many mineral-dependent countries in the developing world lack important safeguards to ensure that responsible mining occurs, such as the ability to enforce laws, control corruption, and foster a strong civil society. In countries where governance is weakest, continued investment in mining will be less likely to contribute positively to economic development unless governance improves.

In Papua New Guinea and the Philippines, we conclude that:

- Although mining in legally protected areas and ancestral domain claims is difficult to justify in the Philippines, some mine claims overlap with these areas, producing latent claim conflicts.
- Three quarters of active mining and exploratory concessions in Papua New Guinea and 40 percent of concessions in the Philippines exhibit multiple vulnerabilities and hazards, indicating that investment in mining projects in these countries is likely to require greater due diligence to ensure that development does not result in high environmental and social costs.
- The Porgera and Ok Tedi mines in Papua New Guinea demonstrate the danger of dealing with multiple hazards by adopting environmentally risky alternatives in a country where governance and capacity for informed decision-making are weak.

METHODOLOGICAL STRENGTHS AND LIMITATIONS

The methodology in this report was limited by the quality of the data.

The research conducted for this report was limited by the quality of the data and the scale at which the analysis was conducted. While the country case studies allowed finer-scale definition of ecological and social vulnerabilities, the global datasets are too coarse to justify final decisions to mine in areas of “low” vulnerability or to prohibit mining in areas of “high” vulnerability. Although they cannot provide the definitive answer to a “go/no-go” question, the

indicators developed for this study can be used as a coarse-scale filter to highlight “red flag” areas. Based on rigorous assessment of these sensitivities, “go/no-go” decisions can then be made in the context of a fair and just process that includes stakeholder consultation.

Although a final synthesis map summarizing all environmental and social vulnerabilities and hazards at the global level would be a useful tool for decisionmakers, we did not create such a map because of differences in the units of analysis at the global scale (e.g., watersheds, countries, one kilometer pixels). Aggregating environmental and social vulnerabilities presented in the national datasets must be done with extreme caution due to qualitative differences in the indicators. For example, areas of high seismic hazard may overlap with areas of ecological or social vulnerability, but the actual exposure of these ecosystems and communities to potential mine-related hazards depends on the direction in which liquefied waste would travel as a result of an earthquake.

Notwithstanding these limitations, several indicators developed for this report proved particularly robust and merit further development. These include ecological value as defined in the case studies (especially Papua New Guinea), watershed stress, seismicity, and capacity for informed decision-making at the national scale. Better sub-national data for education and income would enhance the identification of vulnerable communities at the global level.

USING THE FRAMEWORK TO SUPPORT OPEN AND TRANSPARENT CONSULTATIVE PROCESSES

Companies already make “no go” decisions regarding potential investments.

Identifying “no go” areas is inherently part of a successful business strategy, especially in the extractive industries sector. Mining companies routinely assess whether investments pose greater corporate risks (e.g., loss of reputation, loss of social license to operate, disruptions in operations) than financial benefits. Besides mining companies, the indicators should also be useful to insurers and providers of project finance, which are especially sensitive to potential risks posed by mining, as they stand to lose the most if the consequences of these risks result in disrupted operations and/or large claims.

This framework can help financial institutions implement standards and commitments.

In particular, these indicators could prove useful to banks that are signatories to the so-called Equator Principles. Recently agreed to by several major private banks, these principles commit signatories to adhering to standards set by the International Finance Corporation (IFC) in making project finance decisions about environmentally sensitive projects. The Equator Principles apply to project finance in excess of \$50 million and are most likely to affect investments in the infrastructure, oil, gas, and mining sectors (see Chapter 7 for details).

The indicators developed for this study could also be relevant in the context of the World Bank’s Extractive Industries Review (see Box 1). The report produced as a result of this process will include recommendations to the Bank regarding “no go” areas. In addition, it is apparent that IFC guidelines and standards for project finance may come under review in the near future. Our framework indicators could provide a tool for actors involved in these reviews to identify areas that are environmentally and socially vulnerable to the impacts of mining and to help identify what constitutes a “no go” decision.

For example, project evaluators can use the data provided in this report to answer the following questions:

Course-Scale Screen of Environmental and Social Sensitivity

Question	Maps	Sample Indicators*
1. Does the proposed project coincide with areas of high conservation value?	2, 3, 4	<ul style="list-style-type: none"> ■ Officially designated protected areas ■ Intact, unique, or rare ecosystems ■ Areas representing the last or most important examples of habitat types ■ Fragile forests of Papua New Guinea ■ Protected/ critical watersheds in the Philippines
2. Does the proposed project coincide with other environmentally vulnerable areas?	5, 6, 7	<ul style="list-style-type: none"> ■ Stressed watersheds ■ Groundwater availability in the Philippines
3. Does the proposed project involve environmentally risky practices?	2, 3, 4, 9, 10	<ul style="list-style-type: none"> ■ Riverine tailings disposal ■ Submarine tailings disposal in areas of environmental or social vulnerability
4. Is the project located in an area of high natural hazards?	11, 12, 13	<ul style="list-style-type: none"> ■ Earthquake-prone areas ■ Predominantly wet, humid climates
5. Is the project located in areas with disadvantaged communities?	8, 9, 10	<ul style="list-style-type: none"> ■ Impoverished communities with low levels of education
6. Is the project located in a country with weak governance?	14, 15	<ul style="list-style-type: none"> ■ High corruption levels ■ Low adherence to the rule of law ■ Lack of freedom of expression in civil society

*Note: These examples are by no means exhaustive, but rather reflect the indicators incorporated in this study. They are meant to be illustrative of the types of information that risk evaluators can use in their coarse-scale analyses.

The questions listed can be used to screen projects for their sensitivity.

Answering positively to one or more of the above questions should trigger additional investigation, including consultation with local NGOs and stakeholders to determine if the proposed project conflicts with regional conservation or social objectives. In addition, the above table can be used to identify some probable “no go” issues, such as projects proposed in officially designated protected areas or those with proposed riverine tailings disposal systems. It may also be easier to justify “no go” decisions for projects proposed in areas where finer-scale information indicates that high conservation values exist (e.g., fragile forests of Papua New Guinea or protected/critical watersheds in the Philippines). However, determining whether a project is a “no go” in some situations will require examining the relationship between questions. For example, any project with a proposed submarine tailings disposal system warrants careful investigation, but one in which the site is near an area of high conservation value may qualify for a “no go” decision.

Because the process of deciding whether a project warrants a “no go” decision is complex, it should not be reduced to a checklist approach. Such decisions will require careful information gathering, thoughtful analysis, and stakeholder engagement. Although the above questions can be used as an initial filter for project evaluation, the list is not comprehensive and project evaluators may need to consider additional issues.

RECOMMENDATIONS

FOR THE FINANCIAL SECTOR

- 1. Banks and insurers should use indicators like those developed for this study to rate the environmental and social sensitivity of mining projects.** Although banks and insurance companies routinely apply environmental screens to identify sensitive projects, the criteria for and application of such tests appear to vary broadly and depend upon the discretion of project evaluators. A more rigorous approach would be to systematically develop and use indicators that would assess proposed mining projects and classify any with characteristics such as those listed in the table above as “environmentally or socially sensitive.” Additional investigation might also be required to determine whether regional planning efforts have identified overlaps between proposed mining or exploration activities with areas of high conservation value, or whether local communities oppose the project. For example, the International Finance Corporation has “safeguard policies” in place requiring assessment of the sensitivity of proposed projects, and systematic use of indicators like the ones developed for this study would enable project evaluators to conduct more rigorous evaluations.
- 2. Financial institutions should subject all environmental and social impact assessments of proposed mining projects to review by an independent, external panel of experts.** A key weakness of current risk evaluation procedures used by the financial sector is reliance on company-funded environmental impact assessments to evaluate the potential risks to investors. Environmental impact assessments can underestimate or deemphasize potential environmental and social impacts. Some consultants hired by companies to prepare such assessments have an interest in providing future business services to the company and may be tempted to downplay environmental and social vulnerabilities to ensure project approval. A more rigorous risk evaluation process would entail external review of all environmental and social impact assessments by a panel of experts not employed by the mining company and preferably independent of the institution considering project finance.
- 3. These expert reviews should be made publicly available, further raising the level of oversight.** For especially sensitive projects, free prior informed consent with local stakeholders should be considered a necessary condition for project financing. Client confidentiality rules may make some private banks reluctant to require transparency as a condition of project finance. However, failure to identify potential environmental and social pitfalls may prove more costly in the long term, especially if community opposition is strong enough to halt operations.

FOR GOVERNMENTS AND CIVIL SOCIETY

- 4. Government policymakers and NGOs should use methodologies like the one developed for this study to identify areas that may be socially and environmentally sensitive to mining.** The development of international standards for companies and financial institutions engaged in the mining sector has received considerable attention in recent years. However, mining projects operate over a relatively short time period. Governments and civil society will continue to bear the primary responsibility for ensuring the long-term

health of ecosystems and communities long after mine closure. Thorough, rigorous assessments by governments and NGOs of areas that are environmentally and socially vulnerable to mining could lead to more informed debates and better environmental and social outcomes.

For instance, the government of Papua New Guinea could use a similar approach to identify areas that are ecologically constrained with respect to a range of industries, including mining, oil, and gas. Papua New Guinea has no effective mechanism for protecting areas using national parks, “no-go zones,” or enforceable protected species legislation. Despite this, most of the country’s ecosystems remain intact, and support a largely rural population. Conservation organizations have led several attempts to define and protect areas of biological importance, but these efforts have failed to gain traction largely due to their lack of acknowledgment of the country’s unique social context.

Notwithstanding these challenges, policymakers in Papua New Guinea are faced with a unique mandate to consider areas that may be too sensitive for mining. The 1991 Forest Act stipulates that areas with steep slopes, areas dominated by polygonal karst landforms, or those that are permanently or semi-permanently inundated are too ecologically sensitive for logging. Constraints-based land-use planning would be especially useful in Papua New Guinea, as it would sidestep difficulties associated with land tenure conflicts, allowing decision-makers to set aside ecologically valuable areas before exploration occurs. It would also avoid the dilemma of identifying conservation priorities in a country where the vast majority of land is held in customary title, by allowing areas to be set aside by default or by virtue of their intrinsic unsuitability for mining.

In the Philippines, decisionmakers could use better information on areas that are vulnerable to the impacts from mining to help them determine where mining activities conflict with other land uses. Because much of the Philippines can be considered environmentally or socially sensitive, the potential impacts of poorly planned mining could be especially costly to ecosystems and those who depend upon them for natural services such as clean water and flood protection.

5. **Governments should support anti-corruption measures aimed at the mining sector, such as mandatory disclosure of payments made to governments by mining companies. Such information should be disaggregated to show individual company revenue flows as well as the distribution of payments at a sub-national level.** Lack of transparency is a major problem in the mining sector, especially in countries that depend heavily on mineral wealth. Launched by the U.K. government at the World Summit on Sustainable Development, the Extractive Industries Transparency Initiative seeks to address corruption in the mining, oil and gas sectors by encouraging companies to disclose payments made to governments. NGOs are campaigning to make the disclosure of such information a requirement mandated by security exchange regulators in Europe and the United States.

Many governments and natural resource companies are reluctant to support a mandatory approach, arguing that a voluntary approach would reflect a true commitment to transparency. Additional questions remain regarding what information should be disclosed and whether disaggregating the data would violate corporate confidentiality. Mandatory

measures will be far more likely to ensure that benefits are used effectively to promote development. Financial institutions can assist by requiring their clients to disclose payments made to governments.

FOR THE MINING INDUSTRY AND METAL PRODUCT BUYERS

6. **The mining industry should use indicators like the ones developed for this study to identify areas that are environmentally and socially vulnerable to the impacts of mining and to identify probable “no go” areas.** In May 2003, the International Council on Metals and Mining (ICMM), a global industry association, released a Sustainable Development Framework outlining key environmental and social principles that member companies agree to abide by. While adoption of these principles is an important first step, more needs to be done to make them operationally relevant through providing metrics and benchmarks against which company performance can be evaluated. Principle #4 commits the industry to “implement[ing] risk management strategies based on valid data and sound science.” Using the framework indicators developed for this study to identify environmentally and socially vulnerable areas would be a good start toward operationalizing this principle.
7. **Mining companies should make firm commitments not to develop mines in an expanded set of “no go” areas, including those identified using this and related methodologies.** The ICMM principles also call on mining companies to “respect legally protected areas.” As a first step, ICMM members should support IUCN Amman Resolution 2.82 and commit not to develop mines in strictly protected areas, that is, IUCN categories I-IV. Moreover, this study demonstrates the need for companies to go beyond the Amman Resolution to consider other areas that are environmentally and/or socially sensitive to mining and should be designated probable “no go” areas. Our results show that active mines and exploratory sites also overlap areas of high conservation value that are not yet subject to strict legal protection. Companies should use the framework indicators developed for this study to help them identify other environmentally and/or socially sensitive areas. Such “pre-investment” criteria would help companies avoid costly investments in properties that are likely to be unfeasible for environmental or social reasons.
8. **Mining companies should also agree to disclose payments made to governments as called for in the Extractive Industries Transparency Initiative.** Such action would be in keeping with ICMM principles, which commit member companies to “implement policies and practices that seek to prevent bribery and corruption.”
9. **Metal product buyers, such as jewelry retailers, electronics manufacturers, and telecommunications companies, should commit to sourcing their materials only from environmentally and socially responsible mines.** Such a commitment would require metal product buyers to consider the environmental and social risks associated with sourcing materials from specific mines and thus could help persuade mining companies to change their practices. Although further detailed analysis is necessary to identify site-specific risks, mines located in areas that are environmentally or socially vulnerable, or that use risky practices, should be of concern to metal product buyers seeking to implement responsible purchasing commitments.

Future studies could provide insights on vulnerabilities and the exposure of companies to risks.

AREAS FOR FUTURE ANALYSIS

This report was the culmination of a 2-year effort aimed at providing guidance for the private sector and policymakers on areas that are environmentally and socially vulnerable to the impacts of mining. Because this was the first such attempt at a global scale, the results are coarse and limited by the quality of available data. Future efforts could improve and build upon this initial analysis in the following ways:

- *Additional case study analysis.* Identifying environmental and social vulnerabilities requires detailed analysis at the case study level. The approach tested in this report could be applied to other countries, thereby refining and improving upon the methodology. Better quality data (e.g., global location of mineral resource potential, biodiversity information, more complete and accurate mines database) would greatly enhance the global analysis as well.
- *Further detailed analysis in Papua New Guinea and the Philippines.* Satellite imagery and better data regarding the extent of environmental and social impacts from current mines would help verify the most vulnerable areas and provide decisionmakers with guidance on what may constitute “no go” areas.
- *More precise analysis of the financial exposure of specific companies.* Additional research and analysis could highlight the degree to which specific companies are exposed to the vulnerabilities and risks highlighted in this report. Such information could trigger investors to critically evaluate whether companies exposed to these risks have adequately accounted for them in their ledger books.
- *Critical evaluation of the quality of environmental impact assessments (EIAs).* Financial institutions routinely rely upon EIAs as a key decision-making tool when evaluating potential project finance. A rapid, indicator-based assessment could evaluate the extent to which EIAs accurately anticipated potential environmental and social impacts, thus examining the utility of EIAs as a tool for guiding project finance.
- *Analysis of mining revenue flows and compliance with environmental performance indicators.* Assuming the Extractive Industries Transparency Initiative is adopted by governments and companies, analysis will be required to identify how payments were made, who received them, and whether benefits flowed to communities. Additional information regarding environmental infractions, fines, and compliance with environmental and social regulations would provide investors and metal product buyers with information regarding compliance of specific companies with norms and regulations.

Appendix 1. Mining and Critical Ecosystems Methodology

The following is a brief summary of the methodology for the global analysis of mining and critical ecosystems. For an expanded version of the technical notes and data sources, including data descriptions for the Papua New Guinea and Philippines case studies see www.wri.org/.

GEOGRAPHIC EXTENT AND RESOLUTION

The maps presented in this report summarize the results of global and case study analyses. The data integration and analysis for the global indicators were performed in Mollweide projection at a 1-kilometer resolution. The Papua New Guinea case study analysis was performed using a UTM Zone 55, Spheroid Australian National Datum, Australian Geodetic 1984 (AGD 84) projection. The resolution of the digital elevation model was 90 meters. However, the remoteness and ecological value analyses were performed at a 1-kilometer resolution. Analysis for the Philippine case study was conducted using a UTM, Zone 51 Spheroid Clarke 1866 projection. Because the Philippine case study was performed using vector-based analysis, the scale varies based on the source of the data.

MINES DATABASES

The global mines database used in this study was provided by the private information firm InfoMine. This database contains latitude and longitude coordinates for over 4,400 active mines and exploratory sites of the approximately 9,500 records in InfoMine's electronic archives. The database includes precious and base metals, diamonds, other precious stones, and uranium mines. InfoMine staff estimate the margin of error of the data to be ± 10 kilometers.

The U.S. Geological Survey (USGS) also maintains a global database of mine points. This database contains records for 3,000 mines, but much of them are out of date. For example, the dataset contains records for 37 producing mines in the Philippines and only two active mines in Papua New Guinea. Updated government data indicate that there are two large mines and seven medium-sized mines in operation in the Philippines and four active mines in Papua New Guinea. The InfoMine dataset reflects the same number of active mines for Papua New Guinea, although no active mines are identified in the Philippines. Thus, the InfoMine dataset likely underrepresents mine sites globally.

InfoMine collects mine location data from company annual reports and other corporate documents. Unless specific coordinates are given in these documents, InfoMine estimates mine location based on the mine's average distance and approximate direction from a known landmark. Thus the mine points are prone to error, especially when the mine is far from a known landmark. Given that InfoMine depends on company annual reports for its information, the dataset is biased towards companies that report mine locations in their corporate documents. Companies that trade on stock exchanges requiring transparent reporting (e.g., in the U.S., Canada, and Europe) are more likely to be represented than national private companies, government-run companies, or national companies that do not trade on international exchanges.

PAPUA NEW GUINEA MINES DATASET

Mines data for Papua New Guinea were collected from the Department of Mining. The largest mines in Papua New Guinea are allocated according to "special mine leases." Medium-sized mines are allocated mine leases and smaller mines receive alluvial mine leases. Exploration occurs through exploratory licenses. Some preliminary exploration activity may occur in properties not under license. The database includes all exploration licenses and mining leases, except for alluvial mine leases. Exploratory oil and gas licenses have also been included, although for the purposes of display they have been grouped together on the maps. The dataset does not include exploration licenses or mining leases for small-scale mining operations. Updated oil and gas exploration licenses were not publicly available.

PHILIPPINES MINES DATASET

In the Philippines, four main types of permits are allocated for mining activity: exploration permits (EP), Mineral Agreements (MA), Financial and Technical Assistance Agreements (FTAA), and Mineral Processing Permits (MPP). An EP provides exploration rights only. If an economic mineral deposit is found, the permittee may then apply for an MA or an FTAA, which are contracts between the government and a mining company. FTAA's are typically drawn up for large mining projects. The database used in this study includes FTAA applications, exploration permits, and Mineral Production Sharing Agreements (MPSAs). A total of 111 exploratory and mining concessions are represented, of which 40 are exploratory and 71 are active

mining concessions. The data include only approved exploration and mining permits. Digital data for licenses under application were not publicly available.

INDICATOR SUMMARY

The Mining and Critical Ecosystems framework is divided into three main categories: environmental and social vulnerabilities, natural hazards, and other contributing factors (see Figure 5). Indicators were developed for six sub-categories—ecological value, watersheds, capacity for informed decision-making, earthquakes, excessive moisture, and governance—each of which is described below.

ECOLOGICAL VALUE

Ecological value incorporates an aggregated conservation value layer defined as:

- WWF Global 200 Ecoregions: A set of natural landscapes whose conservation is deemed by WWF to be critical for maintaining a representative sample of habitats and species around the world. See: <http://www.worldwildlife.org/science/global200.cfm>
- Conservation International “Hotspots”: The 25 richest global reservoirs of biodiversity as defined by high degrees of species endemism and levels of threat. CI defines these areas as among their global conservation priorities. See: <http://www.conservation.org/xp/CIWEB/strategies/hotspots/hotspots.xml>
- BirdLife “Endemic Bird Areas”: 218 regions of the world where the distribution of two or more restricted-range bird species overlap. These regions are deemed to be relatively rich in endemic bird species compared to other parts of the world. See: http://www.birdlife.org/action/science/endemic_bird_areas/index.html
- WRI Forest Frontiers: The last large tracts of intact forest which are deemed to be sufficiently large to maintain their habitat and species intact in the face of a once-in-a-century natural disturbance. See: Bryant et al., 1997.

There is no comprehensive analysis of the condition of aquatic ecosystems. Thus the ecological value sub-category used in the Mining and Critical Ecosystems project underrepresents these ecosystems.

The Human Footprint map developed by Sanderson et al. (2002) was used to determine the condition of the aggregate conservation layer. The Human Footprint map estimates the relative condition of the world’s ecosystems by using global datasets to map human influence (e.g., settlements, infrastructure, and land use). However, the map overestimates degree of human influence in New Guinea (see <http://wcs.org/humanfootprint> for further details on limitations).

WATERSHEDS

The watershed sub-category encompasses a watershed stress indicator. Watershed stress was defined according to the PAGE water scarcity model developed by the University of New Hampshire in collaboration with the World Resources Institute (see Revenga et al., 2000). This dataset does not take into account the effects of pollution, climate change, impoundment and evaporation of water supply. Thus, the data likely overestimate future availability of water per capita. In addition, the PAGE analysis assumes constant water supply, with benchmarks of available water to identify watersheds that may experience water shortages.

CAPACITY FOR INFORMED DECISION-MAKING

The global indicator of capacity for informed decision-making incorporates measures of education attainment and income. Education attainment was measured through indicators on adult literacy, functional literacy rates, and tertiary education attainment rates. Adult literacy is defined as the percentage of people older than 15 years who can both read and write a short statement about their lives. Functional literacy reflects a higher degree of understanding, but it has not been systematically measured at a global level. Functional literacy was estimated using data for the average number of years of education of a country’s population and tertiary education attainment rates. Tertiary education attainment reflects the proportion of the population that has attained (but not necessarily completed) some form of post-secondary education. An educational attainment index was developed and combined with World Bank income classification categories by country.

The data used in the global analysis were only available at a national scale and do not take into consideration sub-national variation. The resulting indicator of capacity for informed decision-making is coarse and should be used with caution when combining it with point data, such as the location of mine operations. However, the indicator can be used to summarize general trends and it roughly corresponds to similar global indicators (e.g., UNDP’s Human Development Index).

EARTHQUAKES

Global seismicity was defined according to the Global Seismic Hazard map developed by the USGS (Giardini et al., 2000). The framework does not consider risk from landslides or mass wasting. To some degree, earthquakes and landslides are linked; areas with high seismicity tend to result in slopes that are highly sheared, unstable, and prone to erosion. Furthermore, mass erosion of such slopes contributes to sedimentation within rivers and downstream flooding. Although steep slopes and sharp breaks in slopes can be considered indicators for landslide and slope failure, the available elevation data were deemed too coarse to identify areas with potential for mass wasting.

EXCESSIVE MOISTURE

To estimate areas where mines will face water quality challenges, the framework incorporates the Weinert N Weathering Index, which describes the weathering characteristics of an area (Weinert, 1964). The index ranges in value from 1 (predominance of chemical weathering) to 5 (predominance of physical weathering). Areas with low values (< 2.0) are characterized by wet, warm climates year round whereas those with high values (> 4.0) are predominantly dry. Values in the moderate range (2.0-4.0) indicate seasonal periods of high rainfall that may create water quality problems during peak rainfall months.

The Weinert Index was developed to estimate the suitability of igneous rocks for road building in South Africa. To date, the index has not been applied outside of the African context and may not accurately reflect water quality problems in all parts of the world. The model does not take into account the stability of other rock types and their ancillary minerals. In addition, topography can affect monthly and annual precipitation resulting in inaccurate N values.

GOVERNANCE

Governance data were derived from aggregate governance indicators developed by Kaufmann et al. (1999a, 1999b, 2002). Based on a wide variety of available private and public governance surveys, the dataset groups the indicators according to “voice and accountability,” “political instability,” “regulatory burden,” “rule of law,” “control of corruption,” and “government effectiveness.”

Kaufmann et al. rank countries on a scale of -2.5 (poor) to 2.5 (good) for each aggregate indicator. Because the indicators are based on subjective measures, the numeric values assigned to each country cannot be meaningfully compared to one another, except in broad country groupings. The standard deviations tend to be large relative to the average value that defines performance for many countries represented in the aggregate indicators. However, the advantage of this dataset is that it covers more countries (175) than any other governance dataset: Transparency International’s 2002 Corruption Perceptions Index, which includes the second largest number of countries, only ranks 102 countries.

COMPARING MINES WITH VULNERABILITY AND RISK INDICATORS

The Mining and Critical Ecosystems report provides statistical comparisons of the proportion of mines that intersect with each of the vulnerability, hazard, and risk indicators. At a global scale, the analysis of mines compared to vulnerabilities and hazards consisted of

simple statistical calculations relating the point data available from InfoMine to each of the indicators. Because the point data represent approximate locations, error may occur when overlaying global mines with small polygons. For this reason, we buffered protected areas by 10 kilometers (the estimated overall error of the mines dataset) when comparing the mines to protected areas. For the remaining global indicators (seismicity, watershed stress, intact ecological value, excessive moisture, capacity for informed decision-making, governance) we compared the points to each indicator without buffering vulnerable areas. These indicators were represented by large polygons, such that buffering them was not necessary. Although seismicity was represented by smaller grid-based areas, buffering mines by 10 kilometers would not have changed the results significantly. We recognize that overlaying mine points or concessions with vulnerability indicators may not fully capture all areas vulnerable to mining. Indeed, a mine will present different hazards depending upon whether it is located upstream or downstream of an ecologically or socially vulnerable area and the types of waste management practices employed (see Box 2). Therefore, the statistics reporting overlap between these vulnerable areas should be used for illustrative purposes only, rather than to convey the degree of threat that environmentally or socially vulnerable areas face.

For the case studies of Papua New Guinea and the Philippines, we compared concession boundaries with vulnerability and hazard indicators. We estimated the percentage of all concessions for each country that are located in high vulnerability areas (e.g., protected areas, fragile forests, intact forests, low capacity for informed decision-making). These percentages reflect simple comparisons between the vulnerability layers and their intersections with concessions. The overlap between mining concessions and areas of vulnerability does not *necessarily* mean that mining will have an impact on these areas; rather, it indicates the *potential* vulnerability of these areas to mining. For both case studies, we also calculated the percentage of each concession that overlaps with areas of high ecological value.

OVERALL DATA QUALITY ASSESSMENT

Indicators developed for this report incorporated the best available data. The quality of the maps and indicators varies according to the resolution of the analysis. Variation amongst units of analysis was greatest at the global scale. For this reason, combining indicators at the global scale with data on mine sites should be done for illustrative purposes only. Although this analysis can shed light on areas of high vulnerability, further fine-scale analysis is required to determine the degree to which these areas are exposed to the potential hazards of mining. For more details on the limitations of specific datasets, see the detailed technical notes available at www.wri.org/.

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WORLD RESOURCES INSTITUTE (WRI)

World Resources Institute is an environmental research and policy organization that creates solutions to protect the Earth and improve people's lives.

Our work is concentrated on achieving progress toward four key goals:

- protect Earth's living systems
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- create sustainable enterprise and opportunity
- reverse global warming.

Our strength is our ability to catalyze permanent change through partnerships that implement innovative, incentive-based solutions that are founded upon hard, objective data. We know that harnessing the power of markets will ensure real, not cosmetic, change.

We are an independent and non-partisan organization. Yet, we work closely with governments, the private sector, and civil society groups around the world, because that guarantees ownership of solutions and yields far greater impact than any other way of operating.

ENVIRONMENTAL SCIENCE FOR SOCIAL CHANGE (ESSC)

ESSC is a Jesuit environmental research institute in the Philippines with offices in Luzon, Visayas, and Mindanao working primarily with communities and local governments to promote community-based natural resource management and planning. ESSC activities are organized according to five themes encompassing the major elements of natural resource management: forests, water, culture, mining, and engagement with local government units. ESSC accomplishes its objectives through:

- thematic spatial illustrations and analysis of various natural resource management situations across the country;
- national discussions and dialogues;
- policy and program level engagement with government agencies, non-governmental organizations, and international development agencies; and
- environmental brokering for more effective governance.

PAPUA NEW GUINEA NGO ENVIRONMENTAL WATCH GROUP (NEWG)

Established in 1999, NEWG is an umbrella organization for PNG environmental NGOs that aims to inform its members about environmental issues, particularly in relation to sustainability within the natural resource sectors. Within this area, NEWG has four core objectives;

- develop and encourage skill-share programs among NGOs and the wider civil society;
- inform key environmental NGOs on natural resource issues in the country;
- carry out awareness and training programs in areas affected by mining and forestry activities; and
- negotiate with and lobby government and international institutions on legislative changes regarding natural resource management.

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