
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 This database contains records for 3,000 mines, but much of them are out of date.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/.