The Extractive Sector and the Post-2015 Development Agenda: Cross sector cooperation to address environmental challenges

Paper presented to the United Nations Development Programme and Government of Brazil

Dialogue on the Extractive Sector and Sustainable Development – Enhancing Public-Private-Community Cooperation in the context of the Post-2015 Agenda,

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Contents

Executive Summary

This paper considers the implications of the emerging post-2015 Development Agenda and the proposed Sustainable Development Goals (SDGs) for the extractives sector. The paper is one of four foundation papers for a global dialogue event held by UNDP, in collaboration with the Government of Brazil and other partners, and is focused on the role of the extractive sector in protecting the environment. The United Nations sustainable development agenda has only relatively recently involved the extractive resource sector within the global agenda for change. The draft SDGs defined by the Open Working Group are relevant to the extractive sector and offer the opportunity for rejuvenation, however, cooperation is required to define goals specific to the sector and to the jurisdictions in which the sector operates.

Resource extraction continues to expand in developing countries. For example, when measured by value, 22% of global mineral extraction now occurs in resource rich developing countries (Chile, Brazil, Peru, South Africa, Zambia, DRC). Importantly from a development perspective there are a large number of countries where resource extraction (both minerals and hydrocarbons) plays a significant role in the economy of the country. While the expansion of resource extraction may present greater risks in some contexts, it is also potentially an opportunity to advance human development if well governed.

Corporate engagement in the sustainable development agenda is growing. Responsible companies have increased their capabilities to manage a range of environmental issues by employing sustainability professionals, developing environmental management systems, and adopting stronger corporate and industry-wide environmental standards. Peak industry organizations such as the ICMM and IPIECA have supported the

adoption of policies and practices that have improved performance. There is a key role for governments to tailor the regulation of the extractive industries to their specific environmental and governance context and build on the soft-regulatory approaches that have proliferated across the sector.

For a range of key environmental indicators, however, challenges remain. Environmental issues are increasingly generating conflict between the extractive sector and local communities in the vicinity of projects. Ore grades are in decline for most mineral commodities, meaning more rock must be mined to produce the same amount of resource. Offshore oil production is moving into deeper water and onshore unconventional gas production is growing. These trends are placing pressure on water, energy, greenhouse gas intensity and chemical inputs, and increasing the risks associated with spills of solid and liquid wastes. Successes have been realized. Oil spills from tankers, combined carriers and barges have dramatically declined coinciding with requirements for double hulled tankers. Improved engineering practice and environmental management have led to a decline in tailings dam failures, even while the number of tailings failure incidents remains unacceptably high.

The post-2015 Development Agenda is an opportunity to reverse the sustainability trends that have declined, and build on areas where the extractive sector has improved. What is now needed is dialogue to inform tailored SDGs and progress indicators. The institutional architecture exists to promote cooperation to meet this ambitious agenda, such that mineral and hydrocarbon resources are harnessed for sustainable and equitable global development.

Introduction

The extraction of mineral and hydrocarbon resources underpins global development yet simultaneously challenges its sustainability. In December 2012, the United Nations Development Program adopted a 'Strategy for Supporting Sustainable and Equitable Management of the Extractive Industries.' The strategy will assist countries to harness natural resource wealth for human and social development while reducing the associated environmental, social and economic risks. As members of the United Nations are debating the shape of the global development agenda beyond the Millennium Development Goals, UNDP, in collaboration with the Government of Brazil and other partners, are hosting a global dialogue on the 'Extractive Sector and Sustainable Development – Enhancing Public-Private-Community Cooperation in the context of the Post-2015 Agenda.'

This paper is one of four foundation papers for the dialogue event and is focused on the role of the extractive sector in protecting the environment, with special attention to conflict prevention, sustainable use of biodiversity, marine resources, forests, and ecosystems. The paper will consider the implications of the emerging post-2015 Development Agenda and the proposed Sustainable Development Goals (SDGs) for the extractives sector. It will take stock of progress within the extractive sector toward sustainable development and consider what can be learnt from the past to shape future action. Environmental indicators, where available, will chart the performance of the industry. The paper will then discuss the extent to which the private and public sectors are positioned to meet the governance challenge, by discussing existing initiatives, drivers of change, and areas where cooperative action could be scaled up into the future. Finally, the paper distills key questions for discussion at the dialogue.

The Relevance of the Post-2015 Development Agenda to the Extractive Industries

The global sustainable development agenda has long been relevant to the extractive sector, but only recently has the sector found a place within the defining international agreements and texts. Neither the World Commission on Environment and Development (1987), the outcomes document of the United Nations Conference on Environment and Development (1992; Rio Earth Summit), nor the Millennium Declaration (2000), made significant mention of the extractives sector's role in sustainable development or social development. However, with greater engagement by the sector in sustainability, has come greater awareness at the international level of the potential role of extractive resources in shaping a sustainable and equitable future. The World Summit on Sustainable Development (2002; Rio +10) and UN Conference on Sustainable Development (2012; Rio +20) both made lengthy reference to mining and energy and the potential role of the extractives sector "to catalyze broad-based economic development, reduce poverty and assist countries in meeting internationally agreed development goals, including the Millennium Development Goals, when managed effectively and properly" (UN, 2012, 45).

The United Nations is currently debating the successor to the Millennium Development Goals (MDGs), which expire in 2015. The Post-2015 Development Agenda will seek to integrate the MDGs into the broader sustainable development agenda and adopt a set of universal Sustainable Development Goals (SDGs). The merging of the agendas places inclusive development and poverty eradication at the heart of global efforts to maintain the integrity of ecosystems. In June, 2014 the 30 member Open Working Group released a draft set of SDGs to begin member negotiations. The draft goals call for the "sustainable management and efficient use of natural resources." While the extractive sector is not explicitly mentioned there are many goals that are relevant to the sector. **Table 1** lists a selection of the draft SDGs with relevance to the environmental impact of the extractive industries (the focus of this paper). The extractive industries are the foundation of industrial production and global consumption. While this paper focuses explicitly on extraction, the relevance of the sector goes far beyond its impact during the extraction phase. The transition to a green economy, for example, will require commodities, such as rare earth elements and lithium to drive low emissions technology. Linkages with other sectors will be important in shaping the impact of the sector in helping to achieve the SDGs.

As the SDG's take shape there will be a need to particularize the goals to the country level, but importantly also at the sectoral level. An opportunity now exists for the extractive sector and resource-rich governments to help define their role in the emerging Post-2015 Development Agenda. The UN Sustainable Development Solutions network has established a Thematic Group on Good Governance of Extractive and Land Resources to support and promote knowledge exchange about the future role of extractive resources in global development. The UNDP 'Extractive Sector and Sustainable Development' global dialogue is another opportunity to consider the relevance of the Post-2015 Development Agenda to the extractive industries. To assist in this process this paper tracks the environmental performance of the sector, and considers what can be learnt to advance future action. The following section provides a brief overview of global resource extraction.

Overview of Global Resource Extraction

The extractives sector refers to a very wide range of activities with distinct and varied impacts. Tracking the environmental performance of the sector necessarily requires a decision to focus on particular commodities, geographies or types of extraction. While global datasets are rare, and indicators may be sensitive to local context, the data described in this paper provides a snapshot of environmental performance for a number of important commodities. This section introduces the mining and hydrocarbon industries, the main types of resource extraction, and their impacts.

Conventional mining by open cut (also known as open cast) or underground mining methods are the predominant form of mining for precious metals (e.g. gold, silver), base metals (e.g copper, lead, nickel and zinc), and bulk commodities (e.g. coal and iron ore). Conventional mining typically has very intensive, but localized impacts over areas of tens of square kilometers with the potential for wider pollution of waterways due to discharge of pollutants outside of the mining lease and impacts along the logistics corridor of the development. Lateral ore bodies, such as bauxite (for the production of aluminium), or mineral sands tend to have intensive impacts over a more extensive land area and may pose more acute challenges for biodiversity due to land disturbance.

Table 1. Selected draft SDGs proposed by the UN General Assembly Open Working Group with relevance to the environmental impact of the extractive sector (UN, 2014).

Goal 1 End poverty in all its forms everywhere

1.5 by 2030 build the resilience of the poor and those in vulnerable situations, and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

Goal 6. Ensure availability and sustainable management of water and sanitation for all

6.1 by 2030, achieve universal and equitable access to safe and affordable drinking water for all

6.3 by 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and increasing recycling and safe reuse by x% globally

6.4 by 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity

6.5 by 2030 implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

6.6 by 2020 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

6.b support and strengthen the participation of local communities for improving water and sanitation management

Goal 12 Ensure sustainable consumption and production patterns

12.2 by 2030 achieve sustainable management and efficient use of natural resources

12.4 by 2020 achieve environmentally sound management of chemicals and all wastes throughout their life cycle in accordance with agreed international frameworks and significantly reduce their release to air, water and soil to minimize their adverse impacts on human health and the environment

12.5 by 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse

12.6 encourage companies, especially large and trans-national companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle

12.a support developing countries to strengthen their scientific and technological capacities to move towards more sustainable patterns of consumption and production

12.c rationalize inefficient fossil fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities.

Goal 13 Take urgent action to combat climate change and its impacts

13.2 integrate climate change measures into national policies, strategies, and planning

Goal 14 Conserve and sustainably use the oceans, seas and marine resources for sustainable development

14.1 by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution

14.2 by 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration, to achieve healthy and productive oceans

Goal 15 Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

15.1 by 2020 ensure conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and dry lands, in line with obligations under international agreements

15.2 by 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests, and increase afforestation and reforestation by x% globally

15.4 by 2030 ensure the conservation of mountain ecosystems, including their biodiversity, to enhance their capacity to provide benefits which are essential for sustainable development

15.5 take urgent and significant action to reduce degradation of natural habitat, halt the loss of biodiversity, and by 2020 protect and prevent the extinction of threatened species

Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

17.7 promote development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favorable terms, including on concessional and preferential terms, as mutually agreed

17.16 enhance the global partnership for sustainable development complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technologies and financial resources to support the achievement of sustainable development goals in all countries, particularly developing countries

Increasingly, the production of copper, and other commodities, such as uranium or lithium, are using leaching methods (heap and in-situ leaching) that use solutions to dissolve minerals of interest. Depending on how leaching fluids are contained these types of operations can pose risks for groundwater systems. Low-grade copper deposits are also increasingly using underground block-caving methods at larger scales, with the potential for significant surface subsidence. Deep-sea mining for polymetallic massive sulphide deposits, while still experimental, has opened up new areas to mineral exploration and potentially extraction, especially in the Pacific. Radioactive ores, such as uranium, and ores often associated with radioactive elements, such as rare earth elements, can pose unique health and environmental challenges. Alluvial ores may also be mined by artisanal and small-scale miners, who, while operating at a smaller scale, may be present in large numbers, with the potential for significant surface disturbance and the release of hazardous process chemicals, such as mercury.

The hydrocarbon industry is similarly diverse. Crude oil is still the predominant form of liquid fuel but its share of production has declined (from 53% in 1973 to 36% in 2012; IEA, 2014a). Conventional oil fields are usually drilled into relatively permeable sandstones with wells typically spaced kilometres apart. Conventional natural gas has increased significantly in recent decades, and may be condensed through cooling into Liquefied Natural Gas (LNG) for transportation. A major change in the sector over the past decade has been the rapid growth in unconventional production. Unconventional petroleum includes shale gas, coal bed methane (coal seam gas) and oil sands. Shale gas and coal bed methane target methane trapped in shale and coal with surface wells. Oil sands can be mined, or extracted through wells. Unconventional gas has a wide lateral extent of production, tighter well spacing, and a network of distribution infrastructure. Wells typically require dewatering to release methane, and may use hydraulic stimulation (fracturing of the reservoir) to increase permeability (as do some conventional fields), which may pose risks for the integrity of groundwater systems and seismic stability. The wide lateral extent of unconventional gas extraction can create land use conflicts.

Other experimental hydrocarbon technologies include coal to liquids and underground coal gasification.

Across both the mining and hydrocarbon sectors production has increased significantly over the past decade in response to increases in commodity prices. In 2003 global commodity prices began to rise and they remained high throughout the rest of the decade. Copper (482%), thermal coal (668%), iron ore (1276%), gold (405%) and crude oil (332%) all posted dramatic price rises as demand from China and to a lessor extent India outstripped the capacity of the industry to meet supply.[1]

New investments were made and production increased across the major commodities (see for example, **Figure 1**). Traditional mining economies, such as Australia, Brazil, Canada, Chile, Russia, South Africa and the USA, dominated mining investment, however, mining also expanded in Mongolia, Mozambique, Madagascar, Guinea, and Peru, among others. The minerals industry has continued to shift its location to the developing world. All of the BRIC economies are major mineral producers and feature in the top ten of production. BRIC economies have also become a source of outward investment in the minerals sector. When measured by value, 22% of global mineral extraction occurs in resource rich developing countries (Chile, Brazil, Peru, South Africa, Zambia, DRC), followed by Australia (13.3%), China (12.7%), the former Soviet Union (11%), the USA (4.2%), Europe (3.5%) and Canada (2.6%; 2011 data; ICMM, 2012).

In the oil and gas sector, which unlike mining is dominated by state owned entities, annual capital expenditure more than doubled between 2000 and 2013 to $US950 billion (includes coal;

[1] Thermal coal rose from US$25/t in 2003 to a peak of US$192/t in 2008, before dropping to US$80/t in 2014. Iron Ore rose from US$13/t in 2003 to a peak of 179/t in 2011, before dropping to US$100/t in 2014. Copper rose from US$1700/t in 2003 to a peak of US$9,900/t in 2011, before dropping to US$6,800/t in 2014. Gold rose from US$350/ounce to US$1770/ounce in 2011, before dropping to US$1300/ounce in 2014. Crude oil (WTI) rose from US$31 in 2003 to US$134 in 2008, before dropping to US$93 in 2014 (World Bank, 2014).

IEA, 2014b). New investments were especially pronounced in LNG and unconventional gas production in Australia and North America, and conventional oil production in China, Russia, Eastern Europe and the Middle East (IEA, 2014b). Importantly from a development perspective there are a large number of countries where resource extraction (both minerals and hydrocarbons) plays a significant role in the economy of the country. **Table 2** lists countries where extractive resources represent a high proportion of exports or a significant source of fiscal revenues. Countries are ranked by income (low-income, lower-middle income, and upper-middle income) and their performance in the 2011 Human Development Index.

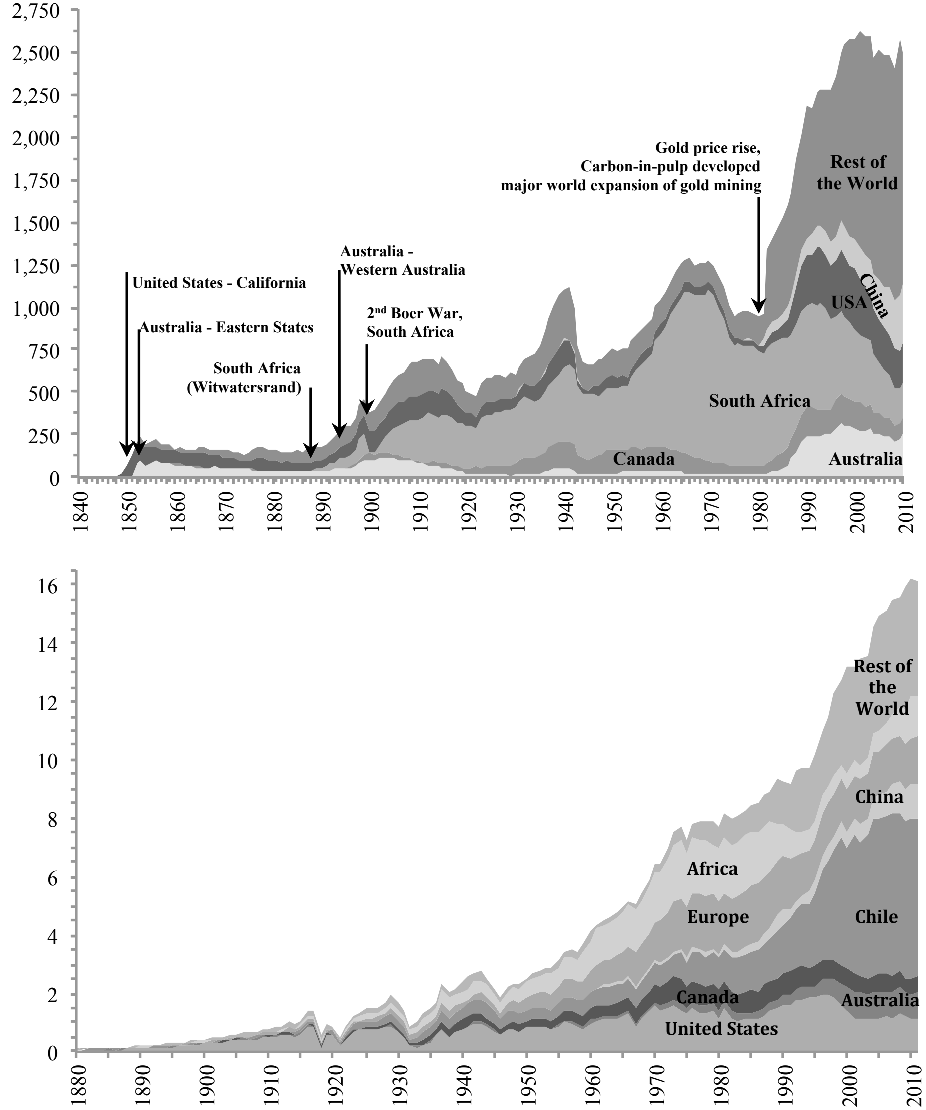
In the following sections, the paper tracks the progress of the extractive industries toward sustainable development, highlighting four key areas: conflict and livelihoods; waste, spills and hazardous chemicals; climate and air emissions; and biodiversity and rehabilitation.

Table 2. Resource rich low-income, lower-middle income, and upper-middle income countries (IMF, 2012; poverty measured as a function of proportion of people living at less than $2/day).

Country	Resource	Natural Resource Exports (% Total Exports; 2006-10)	Natural Resource Fiscal Revenue (% Total Revenue; 2006-10)	HDI 2011/ Poverty (%)
Low-income country				
Democratic Republic of Congo	minerals & oil	94	30	0.29/80
Liberia	gold, diamond, iron	NA	16	0.33/95
Niger	uranium	NA	NA	0.3/76
Guinea	mining products	93	23	0.34/70
Mali	gold	75	13	0.36/77
Chad	oil	89	67	0.33/83
Low-income country (prospective natural resource rich country)				
Sierra Leone	diamonds & iron ore	NA	NA	0.34/76
Afganistan	multi	NA	NA	0.4/NA
Madagascar	oil & gas	NA	NA	0.48/90
Mozambique	gas, bauxite, coal	NA	NA	0.32/82
Central African Republic	diamonds & gold	NA	NA	0.34/80
Uganda	oil	NA	NA	0.45/65
Tanzania	gold & gems	NA	NA	0.47/88
Togo	phosphate	NA	NA	0.44/69
São Tomé and Príncipe	oil	NA	NA	0.51/57
Kyrgyz Republic	gold	NA	NA	0.62/29
Lower-middle income country				
Mauritania	iron ore	24	22	0.45/44
Lao PDR	copper & gold	57	19	0.52/66
Zambia	copper	72	4	0.43/82
Vietnam	oil	14	22	0.59/38
Yemen	oil	82	68	0.46/47
Nigeria	oil	97	76	0.46/84
Cameroon	oil	47	27	0.48/30
Papua New Guinea	oil, copper, gold	77	21	0.47/57
Sudan	oil	97	55	0.41/NA
Uzbekistan	gold, gas	NA	NA	0.64/77
Côte d'Ivoire	oil, gas	NA	NA	0.4/46
Bolivia	gas	74	32	0.66/25
Mongolia	copper	81	29	0.65/49
Congo	oil	90	82	0.49/74

Iraq	oil	99	84	0.57/25
Indonesia	oil	10	23	0.62/51
Timor Leste	oil, gas	99	NA	0.5/73
Syrian Arab Republic	oil	36	25	0.63/17
Guyana	gold & bauxite	42	27	0.63/17
Turkmenistan	oil	91	54	0.69/50
Angola	oil	95	78	0.49/70
Ghana	gold, oil	NA	NA	0.54/54
Lower-middle income country (prospective natural resource rich country)				
Guatemala	multi	NA	NA	0.57/30
Upper-middle income country				
Gabon	oil	83	60	0.67/20
Ecuador	oil	55	24	0.72/13
Albania	oil & gas	NA	NA	0.74/4
Algeria	oil	98	73	0.7/NA
Iran	oil	79	66	0.71/8
Peru	copper & gold	8	19	0.73/15
Azerbaijan	oil	94	64	0.7/8
Botswana	diamonds	66	63	0.63/NA
Kazakhstan	oil	60	40	0.75/1
Suriname	minerals	11	29	0.68/NA
Mexico	oil	15	36	0.77/8
Russia	oil	50	29	0.76/0
Chile	copper	53	23	0.81/2
Venezuela	oil	93	58	0.74/10
Libya	oil	97	89	0.76/NA

Figure 1. World annual production of gold (top; tonnes) and copper (bottom; million tonnes; Mudd, 2013).



Taking Stock – The environmental impact of the extractive industries

Conflict and livelihoods

New mining and hydrocarbon investments have not found ready acceptance in many locations around the world with consequences for communities, governments and extractive sector companies. The impact of extractive projects on the livelihoods of local communities is a key driver of local-level community conflicts and is one measure of the environmental and social performance of the sector. The International Council on Mining and Metals (ICMM) has charted a dramatic rise in mining-community conflict over the course of the past decade (see

Figure 2). They found that the number of conflicts increased from 12, in 2002, to more than 70, in 2012.

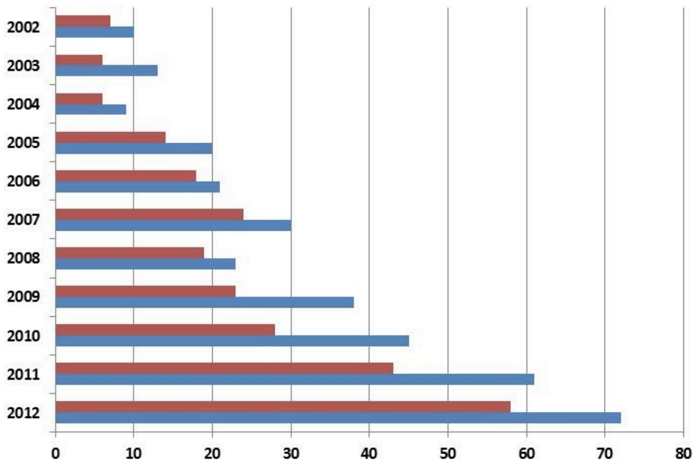


Figure 2. Preliminary data on mine-community conflict, 2002-2012. The red bars are a compilation of cases by the Business and Human Rights Resource Centre.

The blue bars represent cases compiled by ICMM. Source: ICMM, pers. comm.[2]

Similar trends are evident from data collected by the IFC Compliance Advisor Ombudsman (CAO) and the Fraser Institute. The extractive industries (mining, oil & gas and chemicals) accounted for 50% of the 120 cases brought to the CAO between 1999 and mid-2013. Mining projects represented 18 of the cases, with 37 complaints related to oil and gas (Taylor, 2013). The 2013 annual survey of mining companies published by the Fraser Institute for the first time asked about the effect of community opposition on mining. Thirty-six percent of the 489 respondents reported that public opposition had affected the permitting process of their operations over the prior year (Wilson and Cervantes, 2014).

Environmental issues are the most common issues precipitating conflict in the mining sector, but behind these, socio-economic issues, and unmet expectations about consultation and consent, play an important role in shaping the broader mine-community relationship (see

Figure 3; Davis and Franks, 2014).[3] Pollution and access to/competition over environmental resources are the most common triggers of conflict (especially water and access to land). The distribution of project benefits, changes to local culture and customs, and the quality of ongoing processes for consultation and communication are important underlying issues that affect

[2] The data from the ICMM and the Business and Human Rights Resource Centre is provided to demonstrate general trends, though the definitions and methodology used between these studies may be different. The correlation between data collected by a mining industry association, and a civil society group, adds to the confidence that there has been a general trend of increased conflict.

[3] Davis and Franks (2014) interviewed 45 corporate finance, legal and sustainability professionals in the mining and oil & gas industries to understand local community conflict in the extractive sector (Davis and Franks, 2014; Franks et al, 2014). They also analyzed 50 cases of mine-community conflict, across different commodities, geographies and types of company, to understand the issues in dispute, how conflicts manifest and the stage in the conflict cycle where conflict was most prevalent.

the nature of the relationship between parties, but do not necessarily precipitate the conflict.

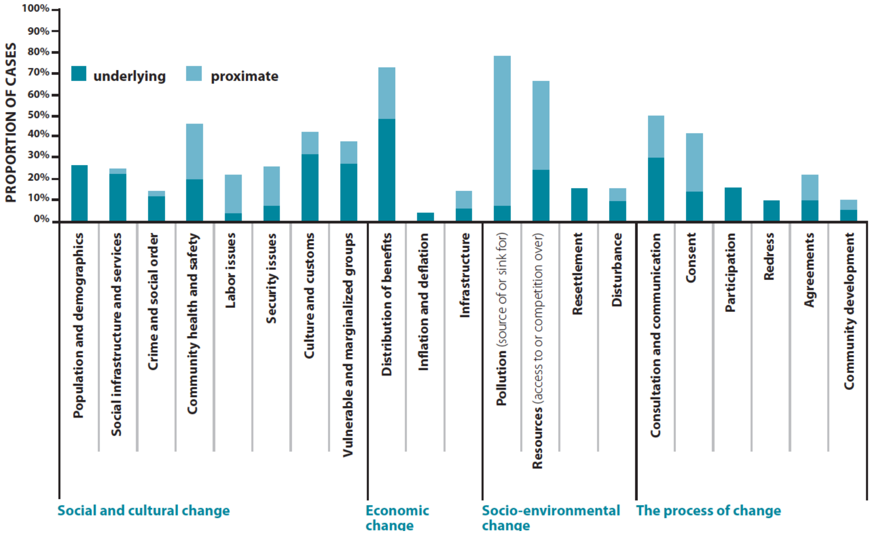


Figure 3. Cases of mine-community conflict: Issues in dispute (*n=50*; after Davis and Franks, 2014).

Conflicts with local communities can lead to major costs for extractive companies. Delays of world-class mining investments (worth between 3-5 billion dollars) will cost a company roughly US$20 million per week as a result of conflict (in Net Present Value terms). The greatest costs of conflict, however, are the opportunity costs arising from the inability to pursue projects and/or opportunities for expansion or for sale. An internal company analysis of non-technical (social and political) risks from one of the international oil majors found a staggering loss of >US$6 billion over a 2-year period – a double-digit percentage of operating profits. The company examined the costs of non-technical risks across 12 of their projects, and scaled the results to the remainder (Davis and Franks, 2014; Franks et al., 2014). Other recent studies are reporting similar findings. An empirical study of 19 publicly traded junior gold mining companies, undertaken by Witold Henisz and colleagues at The Wharton School, at The University of Pennsylvania (2013), found that two thirds of the market capitalization of these firms is a function of the individual firm's stakeholder engagement practices, whereas only one third of the market capitalization is a function of the value of the gold in the ground. A 2012 study by Credit Suisse calculated ESG (Environmental, Social & Governance) impacts on share price for the Australian Stock Exchange and found AUS$21.4 billion in negative valuation impact (hydrocarbon and mining represented AUS$8.4 billion; an average of 2.2% impact on the target price; Credit Suisse, 2012).

Costs are also experienced by communities as a result of conflict and there are situations where communities are not in a position to translate the risks that they may be experiencing into business risks for a company. Social actors commonly mobilise at personal risks to themselves. In the 50 cases of mining conflict analysed by Davis and Franks (2014) 21 cases involved a fatality. The vast majority of these deaths were community members who typically died at the hands of state security forces called into defend mining and mineral processing operations from riots and blockades.

There are a number of reasons why the extractives sector was, and continues to be, subject to local level conflict. Communities are now far more connected than they have ever been. Communication technologies are driving advances in global democracy. Campaigns on one side of the world are now easily visible to people on the other and the pulse of investment in extractives has dramatically increased the number of projects in the early, more vulnerable stages of the project development cycle. However, the performance and the response of the industry is also a major factor. The following section surveys the environmental performance of the extractives sector in the area of waste and spills.

Waste, spills and hazardous chemicals

Arguably the greatest impact to the environment associated with the extractive industries occurs as a result of the generation of solid and liquid wastes and the release of wastes (and product) onto land and into waterways. Transportation (tanker and pipeline) spills, well blowouts and releases, tailings dam failures and direct discharge of mining and hydrocarbon wastes into rivers and oceans, can result in extensive environmental damage.
In the oil industry large-scale marine pollution events arising from tanker spills were synonymous with the industry in the 1970s and 1980s. The annual frequency of oil spills from tankers, combined carriers and barges tracked seaborne oil trade up until the mid-1980s. The introduction of double hulled tankers, and the 1992 decision by the International Maritime Organization to mandatorily require double hulls for tankers above 5000 dead weight tonnage, contributed to a dramatic reduction in spill incidents (**Figure 4**) and total oil spilt (**Figure 5**) from tankers despite rising seaborne trade.

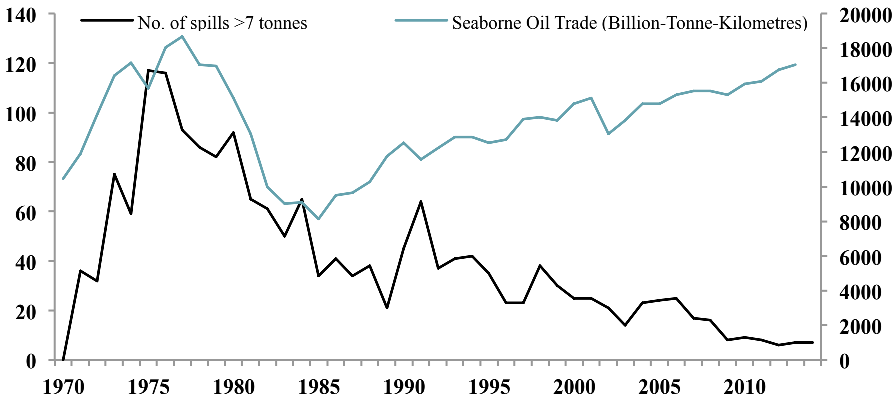


Figure 4. Annual frequency of oil spills from tankers, combined carriers and barges compared to seaborne oil trade (ITOPF, 2013).

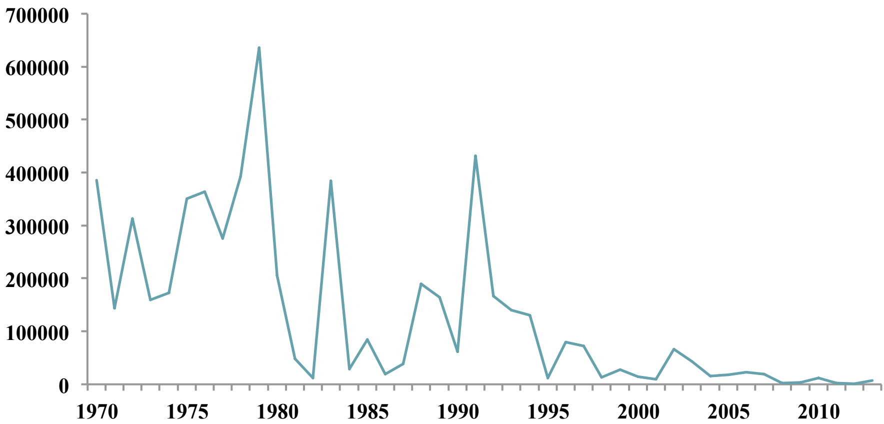


Figure 5. Total oil spilt (tonnes) from tankers, combined carriers and barges (ITOPF, 2013).

Major pollution of marine and terrestrial ecosystems in the oil and gas industries can also result from well blowouts and well releases. A blowout is an uncontrolled release of oil or natural gas from a well. Blowouts and rig incidents are rare but their impact can be catastrophic with major pollution of marine and shoreline ecosystems, the loss of human life, major costs for business, and health and livelihood impacts for people. Three of the top four accidental oil spills of the past 50 years have been offshore well blowouts, with Deepwater Horizon (2010) and Ixtoc 1 (1979) the two largest, both occurring in the Gulf of Mexico (European Commission, 2011).

Recent events have demonstrated that well blowouts are a contemporary feature of the oil and gas sector in both shallow and deep waters, in OECD and non-OECD countries. The Montara oil field in the Timor Sea, off the North coast of Western Australia, experienced an uncontrolled oil and gas release from a blowout of the well-head platform on the 21st of August, 2009. The uncontrolled release lasted 105 days, discharging around 48,000 barrels of oil over a 90,000 square kilometer expanse of sea before the leak was plugged on the 3 November 2009 (Borthwick, 2010; Australian Government, 2011).[4] The Montara oilfield was in relatively shallow waters of less than 100 meters depth. The cause of the blow out was found to be the failure of a well control barrier (a cemented casing shoe), cementing problems and the absence of one of the two secondary control barriers. None of the well control barriers met the company's well construction standards. The Australian Government enquiry that reviewed the causes and response to the disaster found that the incident was a "failure of sensible oilfield practice 101...The prevailing philosophy...appears to have been to get the job done without delay" (Borthwick, 2010, 7, 11; Australian Government, 2011).

The Montara disaster was closely followed by the Deepwater Horizon blowout, which developed in almost the same way (Deepwater Horizon Study Group, 2011, 9). On the 20th of April 2010 a blowout occurred at the Macondo Prospect in the Gulf of Mexico, off the coast of Louisiana, USA. The incident resulted in the largest accidental oil spill in history. A subsequent explosion occurred on the Deepwater Horizon rig killing 11 people and causing the rig to burn and sink. The blowout, in deep waters (approx. 1500m), lasted for 87 days. The well initially released 62,000 barrels per day, declining to 53,000 barrels per day, for a total release of 4.9 million barrels of oil (US Department of Interior, 2011). During the later part of the incident 25,000 barrels per day of oil (plus natural gas) were contained to surface ships, totaling approximately 800,000 barrels of oil (US Department of Interior, 2011). On July 12 a 'capping stack' was finally installed on

[4] The Borthwick enquiry found that 1,000 to 1500 barrels a day was discharged in the early days of the 105 day spill dropping to 400 barrels per day. To estimate a total discharge figure, 10 days of 1000 barrels per day and 95 days of 400 barrels per day discharge have been assumed for a total discharge of around 48,000 barrels (Borthwick, 2010).

the well and the ‘choke valve’ was closed 3 days later to stop oil flowing into the gulf.

Like the Montara incident the cause of the Deepwater Horizon blowout was a failure of the cement in the production casing. Only one barrier was in place despite the difficult well conditions (BOEMRE, 2011). The final report of the Deepwater Horizon Study Group found that the disaster was preventable using existing practices and that failures were the result of a corporate culture of cost cutting (Deepwater Horizon Study Group, 2011, 5). "The consequences of this cascade of failures” argued the report, “exceeded by several orders of magnitude those previously experienced or thought possible" (2011, 9). The report continued: "The organizational causes of this disaster are deeply rooted in the histories and cultures of the offshore oil and gas industry and the governance provided by the associated public regulatory agencies" (2011, 9).

Increasingly oil exploration is being pushed into deeper waters where the risks and consequences of uncontrolled blowouts are greater. The Deepwater Horizon Study Group (2011,11) concluded that the next generation oil and gas exploration in ultra-deep waters "pose risks (likelihoods and consequences of major system failures) much greater than generally recognized," due to technical complexity, increased geologic, oceanographic and reservoir hazards and the sensitivity of the marine environment to very large quantities of hydrocarbons. The consequences are argued to be several orders of magnitude greater than the previous generations.

Data on the frequency of well blowout and well release incidents worldwide (as recorded in the SINTEF database) appear to show a peak in the number of well blowouts and well releases in the 1980s (**Figure 6**). The global database, however, is incomplete and constraining data, for example the number of wells drilled during the period of analysis, are not publicly available. A more complete SINTEF dataset is available for well blowouts and well releases for offshore Norway, UK and US between 1980-2009 (**Figure 7**). This data demonstrates that the number of well blowouts as a function of the total number of wells drilled over time has been irregular but over the period of 1980-2009 the trend has been stable and has not showed significant improvement. The extent to which improvements in environmental awareness, risk management and technology have been offset by the increased risks of deepwater drilling is unknown. The quality of planned water discharges into the environment, however, has improved (**Figure 8**).

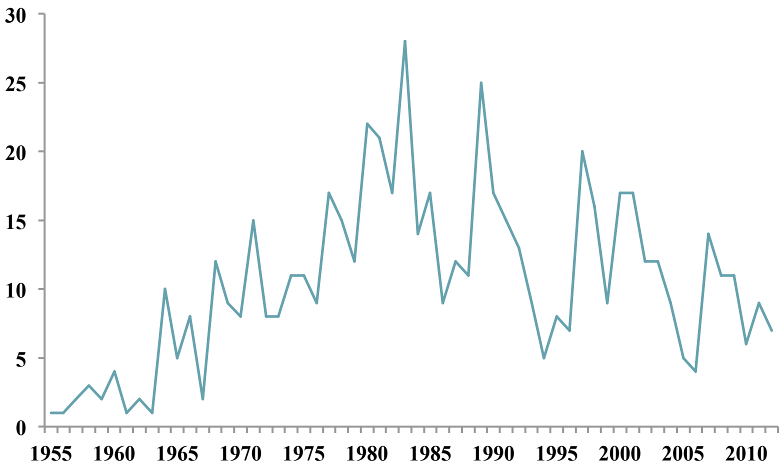


Figure 6. Number of well blowouts and well releases recorded in SINTEF database worldwide (SINTEF, pers. comm.).

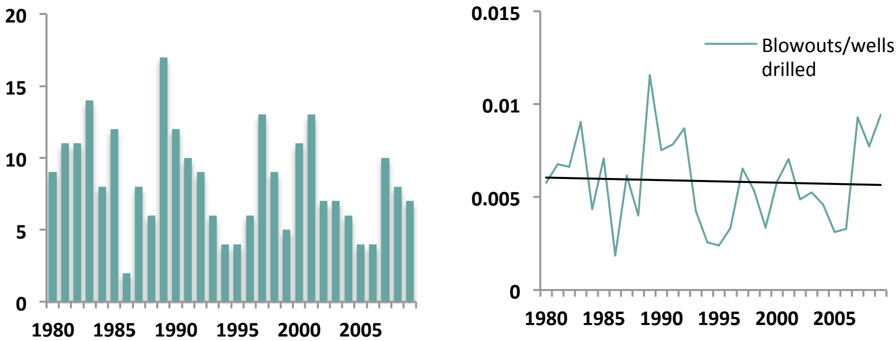


Figure 7. Number of well blowouts and well releases per year (left) and as a function of total number of wells drilled (right) for offshore Norway, UK and US (1980-2009; Holand, 2011; OGP, 2010a; 2010b).

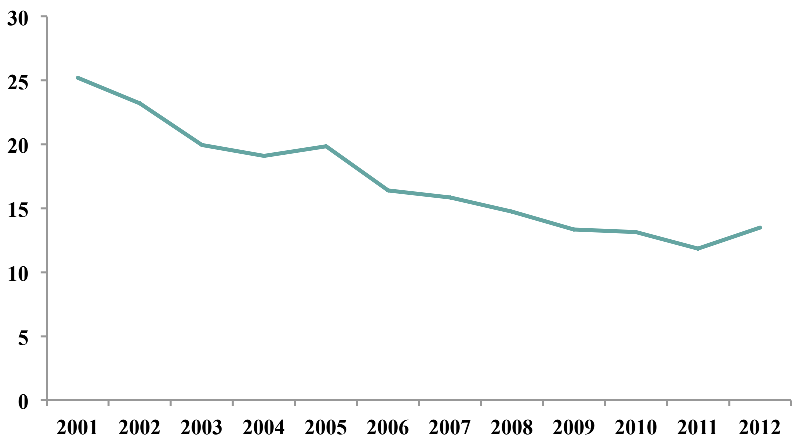


Figure 8. Oil discharged per unit of produced water (milligrams oil per liter of produced water discharged; OGP, 2002-2013).

Large-scale mining is also subject to significant pollution incidents associated with engineering failures. There are two principle types of solid mining wastes: waste rock and tailings. Waste rock is rock removed during mining that does not contain economic concentrations of ore. This waste is usually stored in a waste rock dump. Waste rock may contain sulphide minerals that break down when exposed to water and oxygen at the surface and generate acid and metaliferous drainage (AMD), which can contaminate surface and ground water systems. AMD can present long term, even perpetual, water management challenges (Franks et al., 2011). Tailings refers to the ground up waste rock that remains after the processing of ore. Tailings are commonly stored in a Tailings Storage Facility, also known as a tailings dam. They too can generate AMD, however, the most significant pollution incidents associated with tailings dams result from the failure of the dam and the dispersal of tailings into nearby ecosystems.

Tailings dam failures, like well blowouts, are relatively uncommon, however, they can result in catastrophic environmental and social impacts and are a feature of the contemporary global mining industry. Major incidents in recent history include Mount Polley, Canada (2014; 7.3 million m^3 discharged into Polley Lake), Kolontár, Hungary (2010; 700,000 m^3 of red mud flooding several towns; 10 fatalities), Cerro Negro, Chile (2003; 50,000 tonnes of tails discharged, with tails flowing 20km downstream in the Rio La Ligua), Baia Mare, Romania (2000; 100,000 m^3 of cyanide contaminated liquid spilt into a tributary of the Somes, Tisza and Danube Rivers), Aznalcóllar, Spain (1998; 4-5 million m^3 of liquid and slurry released), Marinduque, Philippines (1996 & 1993; silt catchment dam and drainage tunnel failures; tunnel failure resulted in 1.6 million m^3 discharged; 1200 people evacuated; catchment dam failure resulted in 2 fatalities; see **Figure 9**) and Merriespruit, South Africa (1994; 600,000 m^3 of tails; 17 fatalities; WISE, 2014).

Figure 9. Acid and metaliferous drainage, Mogpog River, Marinduque, The Philippines. Image by David Sproule (Macdonald and Southall, 2005).

Between 1990 and 2009, 39 tailings dam failure events occurred, averaging 1.95 incidents per year (**Figure 10**; Azam and Li, 2010). More than 25% of failure incidents involve a loss of life and this trend has continued in the period since 2000 (Azam ad Li, 2010). The rate of tailings dam failure has declined since a peak in the 1960s, 1970s and 1980s. Mining production increased substantially after the Second World War and the increase in dam failures followed the trend of increased production. Advances in engineering and environmental management in the 1980s contributed to a subsequent reduction in tailings dam failures despite increases in production. While these trends are welcome, further reductions in the 2000s have not materialized against the improvement in the 1990s. The slow replacement of long-term infrastructure is one potential explanation, as is the cumulative presence of old tailings dams. A significant majority of contemporary dam failures are attributed to unusual weather and water management issues. Australia, North America and South America have reduced the incidence of failures in contemporary times while Asia has increased and Europe and Africa have remained steady (Azam and Li, 2010).

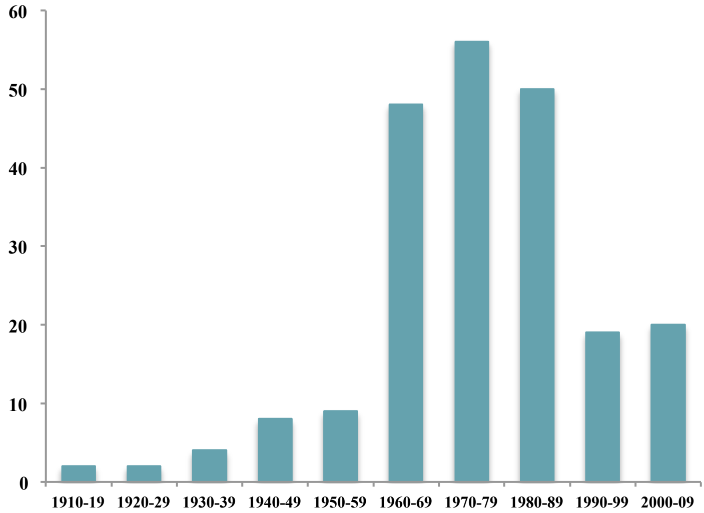


Figure 10. Tailings dam failure by decade. Source: UNEP; WISE; USCOLD; USEPA (Azam and Li, 2010).

Direct discharge of mine waste into waterways (lakes, rivers and oceans) is permitted at a small number of jurisdictions worldwide leading to some of the largest instances of industrial pollution (Franks et al. 2011). Three large scale mines currently practice riverine tailings disposal (Grasberg, Indonesia; Ok Tedi, PNG; and Porgera, PNG). Mudd and Boger (forthcoming) report cumulative mine waste disposal into these three river systems to be 2.2 billion tonnes of tailings and 6 billion tonnes of waste rock. Other historical examples include Panguna (PNG) and El Salvador (Chile). Over the past decade disposal of mine wastes into rivers has increased with production increases of existing mines, however, no new large-scale mines have opened using the technique. Marine tailings disposal has, however, undergone a renaissance of sorts with the opening of one recent large-scale mine using sub-marine tailings disposal (Simberi, PNG). Another mine using sub-marine tailings disposal has closed (Minahasa

Raya, Indonesia), while three continue to operate (Lihir, PNG; Batu Hijau, Indonesia; and Çayeli Bakir, Turkey). Ocean surface tailings disposal at Marinduque (Philippines) and El Salvador (Chile) have left lasting environmental legacies with UNEP describing the pollution from El Salvador at Chañaral as one of the most serious examples of industrial marine pollution in the Pacific (UNEP, 1997). Franks and colleagues (2011) argued that greater leadership in tailings management is needed at the international level, and noted that the ICMM has not undertaken a major tailings initiative in the decade since its establishment. This is despite tailings management being identified as a significant theme in the global dialogue (MMSD) that led to the establishment of ICMM. A step change in tailings management could come from mainstreaming of new technologies such as paste and thickened tailings (Boger, 2013), optimizing mineral processing for tailings design outcomes (Edraki et al., 2014) and reform of mine accounting practices that discount long-term legacies (such as Net Present Value).

The mining industry is the largest annual producer of solid wastes by orders of magnitude. Mudd and Boger (forthcoming) have estimated annual global mine waste generation for 2012, finding that the industry produced approximately 7.3 billion tonnes of tailings and 8.42 billion tonnes of waste rock. Mine waste production is a growing challenge. Ore grades for most major commodities are in decline and the industry is producing more waste (tailings and waste rock) per unit of metal produced (**Figure 11** and **12**; Mudd, 2009; 2010; Mudd and Boger, forthcoming; ICMM, 2012). Gavin Mudd (2009; 2010), using historical data for Australia, demonstrated that declining grades, and the associated increase in waste rock (and its haulage) and ore milled per unit of metal, has placed pressure on the environmental performance of the industry and increased the water, process chemical (e.g. cyanide), energy and greenhouse gas intensity of mining per unit of production. Improvements have been made, with water recycling and emissions reduction programs, however, as mined ore grades continue to fall in the future both the *absolute* and *relative* indicators of environmental performance are likely to continue to *decline* on a global scale.

Case study: The Cyanide Code

More than 90% of all gold produced is done so using sodium cyanide as a process chemical. The use of cyanide in gold and silver mining has been a controversial topic (Moran, 2001). Cyanide is an environmentally sensitive chemical compound that can cause acute toxicity. Thousands of bird mortalities were associated with cyanide use in the mining industry in the 1980s, particularly in the United States, however, reductions in concentration and physical covers on solution ponds have since reduced exposure and bird mortality (Mudder et al., 2006). Terry Mudder and colleagues (2004; 2006) reported on environmental incidents in the mining industry between 1965-2004 to identify major incidents involving cyanide. Of the 67 total environmental incidents analysed over 4 decades (an average of 1.7 incidents per year) 12 of those incidents involved the presence of cyanide (an average of 3 major incidents per decade).

The January 2000 cyanide spill in Baia Mare, Hungary, proved the catalyst for greater international action on the management of cyanide in mining. The spill released 50-100 tons of cyanide into the environment, killing around 1240 tons of fish, and affecting 2,000 kilometres of the Danube catchment area (UNEP and OCHA, 2000). In the aftermath of the tragedy, UNEP and the International Council on Metals and the Environment (the precursor to the ICMM) co-hosted a workshop in Paris to consider the development of a code of practice. The effort led to the establishment of an industry wide certification scheme, the International Cyanide Management Code For the Manufacture, Transport, and Use of Cyanide In the Production of Gold. Forty gold companies, 20 cyanide producers and 109 transporters are now signatories to the code (ICMI, 2014). Since certification to the code began in 2005 there have been no major environmental incidents involving cyanide at any certified gold operation.

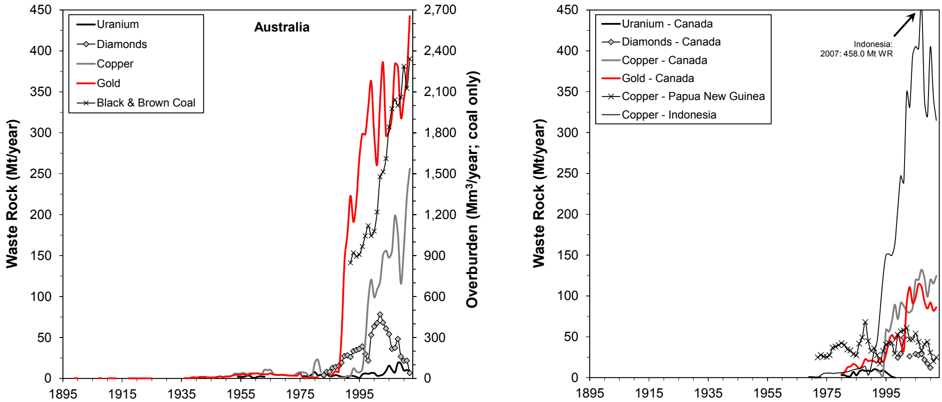


Figure 11. Minimum waste rock for Australia (left) and Canada (right) for selected commodities (Mudd and Boger, forthcoming).

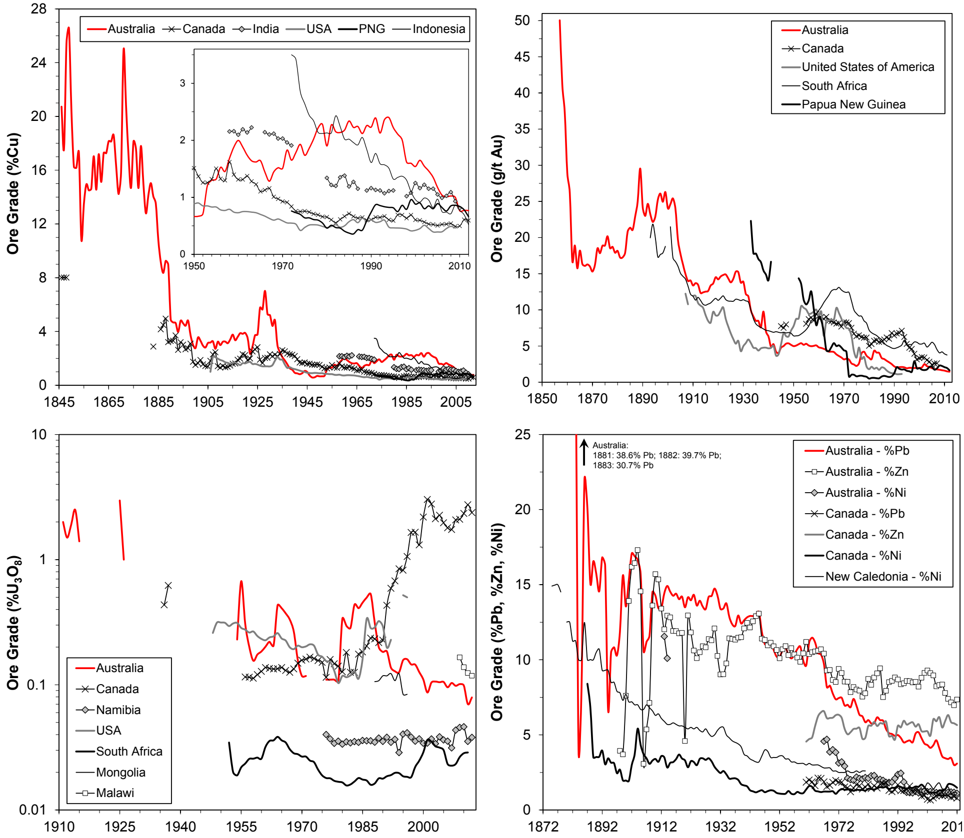
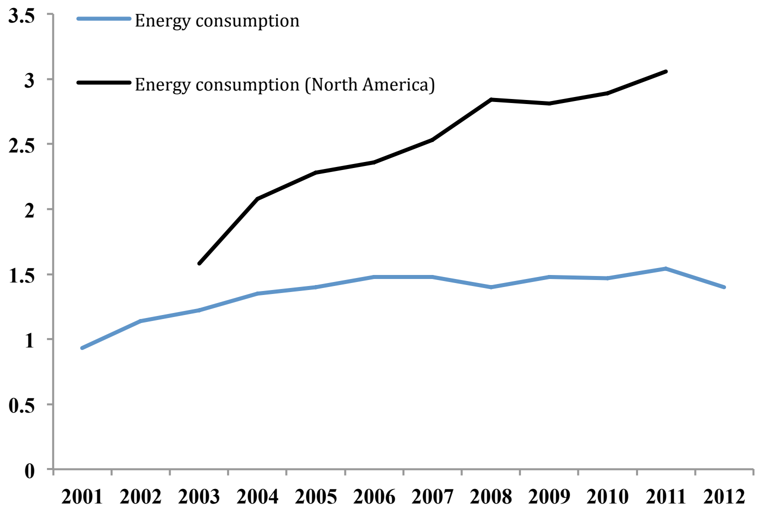


Figure 12. Average ore grades for selected metals and countries over time (i) copper (top left); (ii) gold (top right); (iii) uranium (bottom left); (iv) lead-zinc-nickel (bottom right); Mudd and Boger, forthcoming.

Climate and emissions

The impact of air emissions from resource extraction may be local, in the case of dust, nitrous oxide, or sulphur dioxide, or global in scale (e.g. greenhouse gases). Air emissions data for the oil and gas industry are available from the International Association of Oil and Gas Producers (OGP). The OGP represent publicly traded private, and state-owned, oil and gas companies, including the oil majors. Data is contributed by around 40 OGP member companies (depending on the year), representing approximately 30% of global production.

Greenhouse gas emissions (carbon dioxide and methane) per unit of hydrocarbon production remained relatively steady during the period of 2001 to 2012 (**Figure 13**). Rising energy consumption was offset by reductions in hydrocarbon flaring (particularly in Africa). Flaring is influenced by the availability of gas sales infrastructure. Production in North America shows the highest energy and greenhouse intensity of all oil producing regions. Steadily rising greenhouse gas emissions and energy consumption in North America are due to the growing influence of unconventional oil and gas production (**Figure 14**). Oil sands (Canada), coal bed methane and shale gas (USA) require higher levels of processing and pumping, increasing the emissions profile of the industry. Sulphur dioxide emissions have remained steady, while nitrous oxide emissions have risen slightly (**Figure 15**). Both are dependent on the quality of oil and gas and are released through flaring.



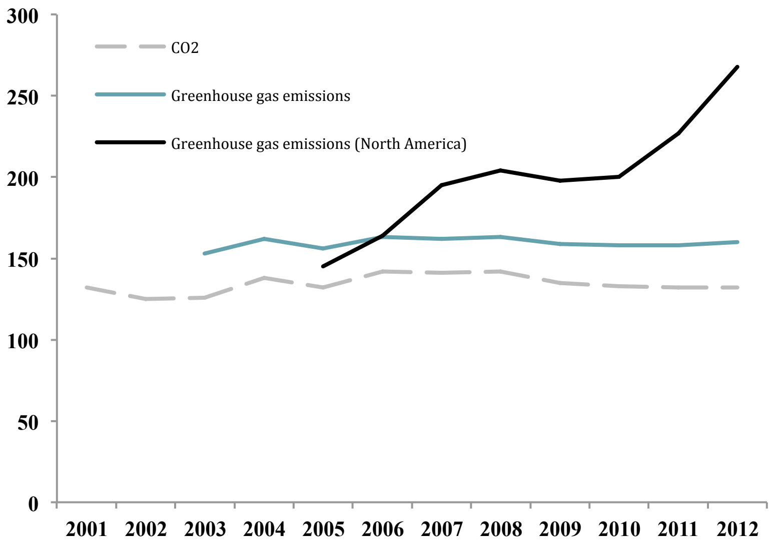


Figure 13. Greenhouse gas emissions (CO_2 and methane) per unit of production (tonnes per thousand tonnes of hydrocarbon production; OGP, 2002-2013).

Figure 14. Energy consumption per unit of production (gigajoules per tonne; OGP, 2002-2013).

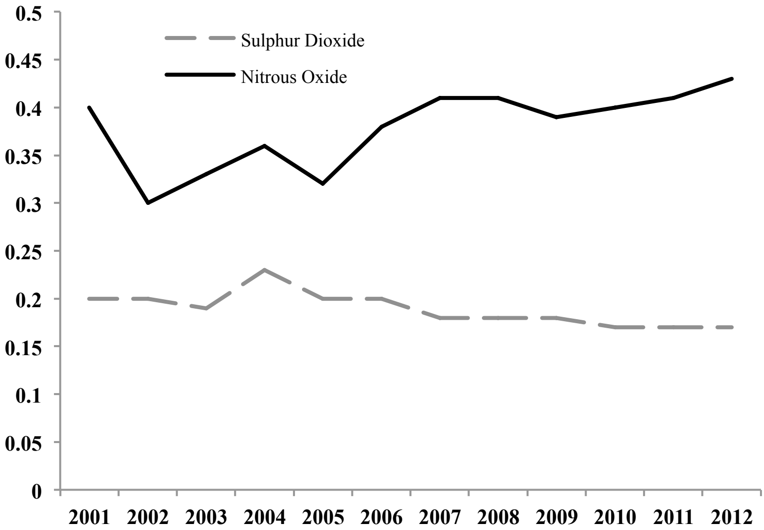


Figure 15. Nitrous oxide and sulphur dioxide emissions per unit of production (tonnes per thousand tonnes of production; OGP, 2002-2013).

There is the potential for the dramatic expansion of unconventional gas to play out on a global scale. **Table 3** shows technically recoverable shale gas resources for the largest twenty countries by resource. In addition to the greenhouse gas emissions intensity of unconventional gas, described above, there are a number of significant climate constraints that may shape the location of shale gas development. The World Resources Institute mapped water availability against global shale gas resources. Shale gas development requires significant pumping of formation groundwater during production. WRI found that 38% of the area where shale gas resources are located globally is arid or under water-related stress, with 386 million people living above these areas (Reig et al., 2014). The confluence of shale gas resources and environmental risks and constraints may present future sustainability challenges in a number of countries.

Country	Natural gas production (2011)	Unproved wet shale gas technically recoverable resources (2013)	Average exposure to water stress over shale play area (WRI)
China	4	1115	High
Argentina	2	802	Low to medium
Algeria	3	707	Arid and low water use
Canada	6	573	Low to medium
United States	24	567	Medium to high
Mexico	2	545	High
Australia	2	437	Low
South Africa	0	390	High
Russia	24	287	Low
Brazil	1	245	Low
Venezuela	1	167	Low
Poland	0	148	Low to medium
France	0	137	Low to medium
Ukraine	1	128	Low to medium
Libya	0	122	Arid and low water use
Pakistan	1	105	Extremely high
Egypt	2	100	Arid and low water use
India	2	96	High
Paraguay	0	75	Medium to high
Colombia	0	55	Low

Table 3. Wet natural gas production and resources (trillion cubic feet) for largest 20 countries by resource (US EIA, 2013) and average exposure to water stress across shale play area (Reig et al. 2014).

Mining and quarrying represent 2.7% of worldwide industrial energy use (Bourgouin, 2014). The green house intensity of minerals and metals extraction is influenced significantly by ore grades. Haulage (diesel), crushing and grinding (electricity) are large contributors to the greenhouse gas intensity of mining. Declining ore grades are placing pressure on the emissions profile of many commodities as more waste rock and ore are handled. For example, Mudd (2012) reported time series data for Platinum Group Metals. Of the ten mines analysed only one demonstrated a decline in greenhouse intensity over the period analysed (**Figure 16**). Innovations in clean technology, such as electric vehicles and solar power have been adopted at a handful of mining sites (e.g. photovoltaic power at Chuquicamata, Chile). Emissions intensity is also influenced by associated land-use change. For example, steel making is a source of greenhouse gas emissions and some countries have substituted coal with plantation charcoal, to mitigate emissions. There is a potential, however, for carbon leakage and other forms of indirect emissions to arise due to associated deforestation of native forests for the production of charcoal.

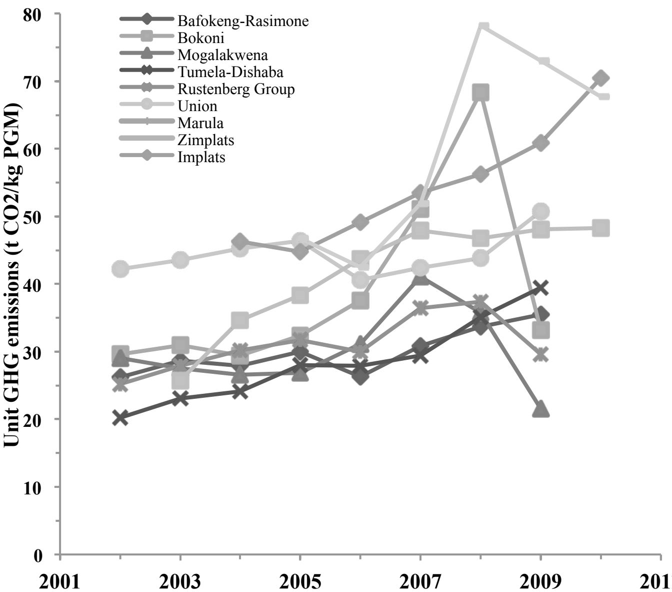


Figure 16. Greenhouse gas emissions per unit of production for the Platinum Group Metals industry (Mudd, 2012).

Biodiversity and rehabilitation

The extractive resource industries are often argued to have a lower impact on biodiversity than other more extensive land-uses such as agriculture and urban development. Mining and quarrying are estimated to have disturbed 0.3% of the Earth's ice-free land area in comparison to 13% for cropland, and 23% for pastures (Hooke et al., 2012). While the global extent of land impacted is relatively low, the disturbance (and clearing) of land for resource extraction can be locally and regionally very significant. The intensive nature of extraction, and persistence of associated wastes, can have an acute impact on biodiversity. Furthermore, the extent of land-use change that is driven by associated extraction and processing infrastructure, is often under-recognized. For example, in Brazil's Iron Quadrangle, in the state of Minas Gerais, global demand for steel has driven extensive land-use change through expansion of mining, increased charcoal production (for coking of iron) and associated plantation expansion (Sonter et al., 2014). Between 1990 and 2010, greater than 9500 ha (0.5%) of land transitioned to mining and 41,000 ha (9%) transitioned to plantations to produce charcoal (Sonter et al., 2014).

The Natural Value Initiative benchmarked 30 mining, oil and gas companies on their biodiversity impact and the extent to which the companies incorporate ecosystem services management into the organization (NVI, 2011). Seventy-nine percent of mining companies and 84% of oil & gas companies had a policy commitment on biodiversity, only 21% of mining companies and 31% of oil & gas companies had developed biodiversity risk assessments for all sites, and 29% of mining and 38% of oil and gas companies had piloted ecosystem services tools. Only one company has committed to causing no net loss of biodiversity.

The rehabilitation of mined land has proved problematic at many sites and few have been relinquished to government following successful rehabilitation. There is a debate to be had about whether the most effective use of resources is to attempt to rehabilitate and restore mining impacted landscapes to a pre-impact condition, or whether restoration to stable, non-polluting landforms, coupled with off-lease investment to restore biodiversity corridors offers a better outcome from an environmental perspective (Erskine, 2014; Sonter et al., 2013). A scientific study of on- and off-lease biodiversity restoration programs found that off-lease programs could offer greater outcomes if coordinated across the sector (Barrett et al., 2010).

Rehabilitation challenges, are not just confined to contemporary mines. Abandoned mines present ongoing environmental legacies and are an indicator of the historical performance of the sector. A recent inventory of abandoned mine sites in Australia, for example, identified 52, 534 legacy mine sites (Unger et al., 2012). In Canada, close to CAN$1 billion of public funds were spent between 2002 and 2012 on rehabilitation of abandoned and orphaned mines (Tremblay and Hogan, 2012). Much larger investments will be needed, with just one Canadian regional program, the Northern Contaminated Sites Program, calculating a liability of around CAN$1.755 billion (Tremblay and Hogan, 2012).

There is potential for effective management of biodiversity on mining and hydrocarbon leases, which are often much larger than the area needed for infrastructure and extraction, to lead to positive impacts on biodiversity. Evidence for this argument comes from programs such as the Arid Recovery partnership on the Olympic Dam mining lease in remote South Australia, where a 123 km^2 fenced reserve is restoring the arid ecosystem through the removal of feral foxes, rabbits and cats (Commonwealth DoE, 2014). The extractive industries may also contribute to better knowledge about ecosystems through baseline flora and fauna surveys. In 2013, IPIECA (the peak oil and gas industry association focused on environmental and social performance) in partnership with the ICMM, and the Equator Principles Association, launched a Cross Sector Biodiversity Initiative and charter to share good practices on biodiversity conservation.

ICMM, with the support of the IUCN, has also committed its members (who represent approximately 30-40% of global mining production) to respect designated protected areas and not explore or mine in World Heritage (WH) properties (ICMM, 2003). The confluence of mining and hydrocarbon development and the 217 properties of the World Heritage list was investigated by the UNEP-WCMC (2013). They found that of the 12,592 mining projects analyzed, 10 were inside a WH site (7 in exploration and 3 in production). Fifty-five producing mines were located within 10 km of a WH site, 18 within 25km and 4 were located within less than a kilometer of a site.

With respect to hydrocarbon extraction, the UNEP-WCMC study found 16 completed wells were located within a WH site, with 31 WH sites hosting an inactive well. Three wells with field development were found to be within less than a kilometer of a WH site. Sixty-three WH sites are overlapped by oil and gas concessions, representing around a third of all World Heritage sites.[5] Nine of the instances have an overlap less than 1% of the WH site land area; 22 have an overlap of more than 50% and 6 WH sites have 100% of their land covered by concessions. In terms of the proportion of concessions, 180 concessions, a little under 1% of total oil and gas concessions worldwide overlap with a WH site. Sixteen concessions were found to have the majority of their tenure within 8 different WH sites (UNEP-WCMC, 2013).

Perhaps of more consequence is the presence of Artisanal and Small-Scale Mining (ASM) in protected areas. Villegas et al., (2012) found that ASM is occurring in at least 7 WH sites, and 96 of the 147 protected areas evaluated. ASM is an important rural livelihood activity in many countries of the world, but it can present risks for biodiversity. ASM is estimated to directly involve 20-30 million people (Buxton, 2013; see **Table**) and produce up to 25 percent of global minerals and metals production, for commodities such as gold, tin and tantalum (Levin, 2012; ICMM, 2012). An additional 3-5 times as many people are believed to

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[5] The overlap of the concession and the WH site may not necessarily constitute any activities actually taking place within the area.

indirectly support the sector (Buxton, 2013). Due to the very large numbers of people involved, ASM is simultaneously a significant source of development and a driver of environmental change. Water pollution, deforestation, community health, safety, child labour and in-migration have long been raised as issues of concern in the ASM sector (Hentschel et al., 2002). ASM can generate up to 5 times of the income of other rural poverty driven vocations in agriculture and forestry (Buxton, 2013), and the role of the sector as a potential source of development is only slowly being realized.

The issues that have garnered the most attention within the scientific and development communities are the use of mercury in alluvial gold mining and deforestation associated with ASM extraction. Mercury is widely used as an amalgamation agent for the processing of alluvial ores. Telmer and Veiga (2009) estimate that one third of all mercury release to the environment can be attributed to ASM – approximately 1000 tones per year, from at least 70 countries. The issue of mercury contamination has dominated the governance response to ASM, however, a lack of understanding and knowledge about the social dynamics of artisanal mining (Hilson, 2006) has hampered the success of education and alternative technology programs designed to reduce mercury use.

Case study: Madre de Dios, Peru

The Madre de Dios region of southeastern Peru is estimated to host between 14,000 and 30,000 artisanal gold miners (Fraser, 2009; Pachas C, 2013). ASM in the region represents roughly 70% of Peru's ASM gold production (Brooks et al., 2007), or about 14% of total gold production in Peru (Pachas C, 2013; Gardner, 2012). The miners operate a mixture of legal and illegal alluvial gold concessions predominantly along the Madre de Dios, Colorado, Inabari and Malinowski Rivers. Sixty-five percent of mining activity in the region occurs outside of permitted concessions (Elmes et al., 2014; **see Figure 17**).

Table 4. Estimated number of artisanal and small-scale miners worldwide (modified after Buxton, 2013; additional figures UNEP, 2010; Fraser, 2009).

Country	Number of miners
Bolivia	72,000
Brazil	10,000
Burkino Faso	100,000-200,000
Central African Republic	>100,000
China	3,000,000-15,000,000
Democratic Republic of Congo	2,000,000
Ecuador	92,000
Ghana	180,000-200,000
India	12,000,000
Indonesia	109,000
Malawi	40,000
Mali	200,000
Mongolia	40,000-60,000
Mozambique	60,000
Nepal	120,000
Pakistan	400,000
Philippines	185,400-300,000
Papua New Guinea	50,000-60,000
Peru	30,000
Sierra Leone	150,000-250,000
South Africa	10,000
Sri Lanka	165,000
Tanzania	550,000
Uganda	196,000
Zambia	30,000
Zimbabwe	350,000-500,000

Figure 17. The Madres De Dios region of Peru showing deforestation as a result of alluvial gold mining. Image courtesy of Carnegie Airborne Observatory.

The Amazonian tropical forests of Madre de Dios are high in biodiversity. Mining has resulted in both deforestation and water pollution, with activities encroaching on protected areas, such as the Tambopata National Reserve, the Amarakaeri Communal Reserve, the Los Amigos Conservation Concession and the World Heritage listed Manu National Park (Asner et al., 2012; Gardner, 2012). Swenson et al. (2011), found mining to be the fastest deforestation activity in Madre de Dios, showing a six-fold increase between 2003 and 2009 (to a rate of 1,915 hectares per year), with 6,600 hectares of wetlands and tropical forest cleared during the time period studied. The rate of deforestation was found to be closely associated with the price of gold (Swenson et al., 2011). The Peruvian Ministry of Environment reported in 2013 that deforestation associated with gold mining in the region was worse than previously thought, with the footprint increasing from less than 10,000 hectares in 1999 to more than 50,000 hectares in September of 2012. The study was undertaken in collaboration with the Carnegie Institution for Science, and combined satellite mapping, ground truthing and airborne surveys (Asner et al., 2013; see Figure 18).

Mercury is widely used as a process chemical by the miners. Between 45-50 tones of mercury are used each year in the region (Swenson, 2011), with associated river pollution and health impacts, particularly as a result of fish consumption (Ashe, 2012). In 2011 and 2012 the Peruvian government issued decrees that established a 500,000 hectare ‘Permissible Mining Corridor’, and enforced the decree with military incursions, evictions and confiscation of equipment in operation outside of the mining zone. The government has also progressed formalization of the sector, requiring all miners to register with the government (Gardner, 2012). The administrative process accompanying formalization has proved difficult for a significant proportion of the miners and has been met with resistance. Negotiated access (through a mining corridor) and formalization are commonly cited as best practice approaches to management of the sector, however, the case of Madre de Dios demonstrates the complexity and limitations of managing biodiversity and human development in the context of ASM (Fisher, pers comm.). Since a peak in mid-2011 the price of gold has declined more than 30%. While still high by historical standards, the decline in the value of gold may have the largest impact on the future extent of mining in the region.

Case study: Kono, Sierra Leone

Alluvial diamond mining has created large areas of disturbed land in eastern Sierra Leone. Few sites have attempted rehabilitation and there is a widely held view that rehabilitation poses significant technical challenges. This view was challenged by an assessment of mine-site rehabilitation in Sierra Leone undertaken by Franks and Erskine (2012). The study had the support of the International

Mining for Development Centre (an initiative of the Australian Department of Foreign Affairs and Trade), the United Nations Environment Programme, and the Environmental Protection Agency – Sierra Leone. The study found that reclamation of artisanal diamond sites to agriculture did not present significant technical difficulties and can be done so at relatively low cost. For example, a project undertaken by the Foundation for Environmental Security and Sustainability (FESS) with funding provided by Tiffany & Co. Foundation and the United States Agency for International Development reclaimed a number of sites using a community-led approach. The rehabilitation did not require major modification of the soil substrates and demonstrated good rates of agricultural productivity. Alluvial diamond ore bodies do not present acid or metaliferous drainage problems and the mining of diamonds does not require process chemicals. The success of the program, however, was undermined by social and institutional challenges that did not ensure reclaimed sites were not re-mined (**Figure 18**). Collaborative governance involving government agencies, Chiefdoms, communities, diamond traders and miners is needed to address the social and institutional challenges for long-term reclamation success.

Figure 18. Artisanal diamond mining in Sierra Leone. Top left: Miners re-mine previously reclaimed land, Kono. Top right: Mined land reclaimed for agriculture, Kono. Bottom: Disturbed mining land, Tongo Fields. Images courtesy of D. Franks and P. Erskine

Meeting the Governance Challenge – Cooperation to realise the Sustainable Development Goals

When positioned against the ambition of the draft Sustainable Development Goals it is clear that extractive industry environmental performance has been mixed and newed effort is needed. Both the mining and hydrocarbon industries face long-wave trends that are challenging global sustainability. Ore grades are in decline for most commodities, offshore oil production is moving into deeper water and onshore unconventional gas production is growing. These trends are placing pressure on water, energy and chemical inputs or increasing the risks associated with spills of solid and liquid wastes. Areas of particular concern include greenhouse gas emissions intensity, the frequency and magnitude of well releases, and slow progress in the area of mine site rehabilitation. Resource extraction also continues to expand in country contexts where there are potentially greater risks associated with development for people and the environment. In addressing these issues it could be illustrative to look at the areas where progress has been made and learn from the approaches that were successful.

The Cyanide Code is one of the case studies outlined above that was able to successfully galvanize international action on a key environmental performance issue and achieve a measure of success. The initiative was convened by the UNEP and supported by the peak mining industry body at the time (ICME). The initiative harnessed the momentum of a major cyanide incident to spur action. One of the success factors of the initiative was that it took a cooperative approach to environmental governance. The early meetings of the initiative included wide representation from civil society, the US Environmental Protection Agency, the governments of Australia, France, Hungary and Romania, leading gold companies and cyanide producers. The code is implemented voluntarily but certification to the code, and the transparency of the certification process, ensure a level of trust that the provisions will be followed. Certification is also a condition of receiving project finance from the International Finance Corporation.[6]

[6] The IFC Performance Standards (IFC PS) are widely viewed as a key driver of improved sustainability performance in the sector. The standards cover a wide range of environment, human rights, and social issues and are the basis for a parallel set of standards in the banking sector, The Equator Principles. Seventy-nine financial institutions in 34 countries are now signatories of the Equator Principles, covering around 70% of project finance debt in emerging markets (Equator Principles, 2014). An interesting issue to watch will be the extent to which outward investment by BRIC financial institutions (e.g. the Asia Infrastructure Investment Bank) adopts environmental and social performance criteria as a condition of project finance.

Collaborative initiatives are a common way to address environmental and social issues in the extractive industries.[7] Collaborative efforts at the local level typically take more than two years to establish and require significant commitment of time and resources and are therefore most suitable when addressing issues of priority concern. **Table 5** lists industry-led and multi-stakeholder standards that have been developed to address environmental and social issues within the global extractives sector. The majority of these standards demand performance above what is required by government regulation and as such can encourage progressive improvement and support governance in contexts where domestic legislation and regulation is weak. The Kimberley Process is one of the few global initiatives that is enforced through domestic legislation with most standards voluntary in nature. Pressure from civil society and local communities are important drivers of the uptake of voluntary schemes. Again, because of resource constraints the majority of the standards listed in Table 5 operate at the global level. Regional schemes such as the International Conference on the Great Lakes Region Regional Certification Mechanism are often nested in larger efforts.

[7] Porter and colleagues (2013) analyzed 30 cases of collaboration to address the impacts of the resources sector in Australia. They distinguished between initiatives that focused on information exchange and coordination to higher degrees of collaboration that involve shared resources and shared risks (such as participatory water monitoring). Governments (state and local) and resource companies often played an important role to establish, support and steer multi-stakeholder groups (Porter et al., 2013).

Year	Standard	Commodity/scope	Focus
1996	International Standards Organization 14000	All	Environmental management
2000	International Cyanide Management Code	Gold & silver	Safety & environment
2000	Kimberley Process Certification Scheme	Diamonds	Conflict
2004	Alliance for Responsible Mining/ Fairmined	Artisanal gold, silver, platinum	Environment, social, labour
2005	Responsible Jewellery Council	Precious metals & stones	Environment, social, labour
2005	Green Lead Project	Lead	Environmental management
2006	Initiative for Responsible Mining Assurance	Large scale mining	Environment & social
2006	Diamond Development Initiative	Artisanal diamond miners	Livelihoods & development
2007	Responsible Steel	Australian steel (full lifecycle)	Environment & social
2008	ITRI Tin Supply Chain Initiative	Tin (mine to smelter)	Conflict
2009	OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas	Tin, tantalum, tungsten & gold	Conflict
2009	Equitable Origin EO1000	Oil & gas	Environment & social
2010	International Standards Organization 26000	All	Social responsibility
2010	EICC-GESI Conflict Free Smelter program	Smelters & refiners	Conflict
2011	International Conference on the Great Lakes Region Regional Certification Mechanism	Tin, tantalum, tungsten & gold	Conflict
2011	World Gold Council Conflict-Free Gold Standard	Gold	Conflict

2011	Centre for Sustainable Shale Development Standards	Shale gas	Environment
2012	Bettercoal	Coal mining	Environment, social, labour
2012	Aluminium Stewardship Initiative	Aluminium (full lifecycle)	Environmental & social

Table 5. Selected industry-led and multi-stakeholder standards (certifiable and non-certifiable) relevant to the mining, minerals and hydrocarbon sectors.

Industry-led and multi-stakeholder standards, however, are not a substitute for government regulation. The uptake of double hulled tankers, for example, was supported by the United States Oil Pollution Act (1990), which imposed deadlines for the phasing out of single-hulled tankers. The US decision built momentum toward international action by the International Maritime Organization to mandatorily require the technology. Command and control regulation is sometimes disparaged as inflexible, however, in cases like the above, specifying technology can result in positive change.[8] Slow progress in the uptake of paste and thickened tailings technology (a technology that could dramatically improve mine waste management and reduce tailings dam failure incidents) offers a parallel example where technology specification could help to address a major industry challenge relevant to the achievement of the SDGs. Environmental regulation is most effective when coordinated across multiple jurisdictions and in some jurisdictions it may be difficult to find the support for the adoption of standards above those adopted by other jurisdictions. Even common regulatory instruments such as impact assessment (strategic and project level assessment),

[8] Other regulatory approaches include: suasive instruments (e.g. charters and good practice handbooks), market based mechanisms, (e.g. emissions trading schemes and environmental bonds) and agreement making (e.g. Impact and Benefit Agreements and Community Development Agreements).

emissions standards and environmental and social management plans have been scaled back at the urging of business groups in countries, such as Australia and Canada. Notwithstanding these pressures, a number of jurisdictions have implemented, or attempted to implement, home-state obligations on extractive sector companies (e.g. the US Dodd-Frank Act imposed transparency and conflict minerals requirements on US registered companies).

Like environmental governance in general, action toward the SDGs, must be particularized to the specific country and sector context. The draft SDGs are necessarily high level, and are not likely to make specific reference to the extractive sector. While this presents a translation challenge the relevance of the SDGs to the extractive sector is obvious. What is needed is dialogue to inform tailored goals and progress indicators. The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development is one platform for government-to-government cooperation that could be used to accomplish this task. The World Resources Forum is another candidate, however, to date the forum has not focused strongly on the issues faced by countries, particularly of the global south, involved in the extraction of natural resources vis-à-vis the issues associated with resource use and consumption. In Latin America a cross-sector movement has emerged to foster dialogue in the extractives sector that may be an appropriate forum to discuss the SDGs. So called 'dialogue tables' are now active in Peru, Argentina, Chile, Ecuador, Brazil and Colombia, and there is interest in establishing dialogue processes in Guatemala, Dominican Republic and Panama (Arbeláez-Ruiz and Franks, 2014).

Increased involvement of global and national development agencies in the extractive sector is another welcome development in this regard. Programs, such as the Oil for Development Programme (Norway), Mining for Development

Initiative (Australia), the Canadian International Resources and Development Institute (CIRDI), as well as GIZ (Germany), USAID (USA), DFID (UK), UNEP, The African Minerals Development Centre, and UNDP have increased their support of resource-rich governments through knowledge sharing and action research. The country visions of the African Mining Vision, and the UNSDSN Thematic Group on Good Governance of Extractive and Land Resources are additional platforms for cooperative action toward meeting the SDGs.

The Future We Want – Conclusion

This paper has considered the implications of the emerging post-2015 Development Agenda and the proposed Sustainable Development Goals (SDGs) for the extractives sector. The paper has found that:

- The UN Sustainable Development Agenda has only relatively recently begun to meaningfully involve the extractive resource sector within the global agenda for change. The draft SDGs defined by the Open Working Group are highly relevant to the extractive sector and offer the opportunity to re-energize an agenda for change, however, cooperation is required to define goals specific to the sector and to the jurisdictions in which the sector operates.
- For a range of key environmental indicators challenges remain. Ore grades are in decline for most commodities, offshore oil production is moving into deeper water and onshore unconventional gas production is growing, thus placing pressure on water, energy and chemical inputs and increasing the risks associated with spills of solid and

liquid wastes. Environmental issues have generated conflict between the extractive sector and local communities in the vicinity of projects.

- Resource extraction continues to expand in developing countries where the integrity of ecosystems is vital to the livelihoods of millions of people. While the expansion of resource extraction may present greater risks in some contexts, it is also potentially an opportunity to advance human development if well governed.
- Corporate engagement in the sustainable development agenda is growing. Leading practice companies have increased their capabilities to manage a range of environmental issues by employing sustainability professionals (recent downsizing within the industry notwithstanding), developing environmental management systems, and adopting stronger corporate and industry-wide environmental standards. Peak industry organizations such as the ICMM and IPIECA have supported the adoption of policies and practices that have improved performance. There is a key role for governments to tailor the regulation of the extractive industries to their specific environmental and governance context and build on the soft-regulatory approaches that have proliferated across the sector.

In light of these findings a number of key questions emerge:

- What would greater cooperation look like to improve the environmental performance of the extractives sector? How can potentially transformative technologies (like paste and thickened tailings), innovations in public participation and governance (like participatory water monitoring and dialogue tables) and the lessons of successful multi-stakeholder initiatives be identified, promoted, shared and scaled-up to promote future action?

- How can the global SDGs and targets be operationalized at national, regional, local and project levels? What would the performance measures for the extractives sector be and how would these measures be defined and implemented? How would such measures be integrated with existing standards and targets defined within legislation, corporate policy, industry standards and certification schemes?
- What are the responsibilities of companies, governments, civil society, investors, development partners and the consumers of mining and hydrocarbon products to contribute solutions to long-term sustainability challenges in the sector? How would these contributions be convened?
- How can actors not commonly engaged in the sustainable development agenda (e.g. state-owned companies, artisanal miners, juniors, local communities in resource-rich regions) be mobilized and supported to define the relevance of the SDGs for their own circumstances?

The institutional architecture exists to promote cooperation to meet the ambitious agenda that is likely to be articulated by the SDGs. The test for extractive sector companies, the governments of resource-endowed countries and civil society will be whether the opportunity to reverse the sustainability trends that have declined, and build on areas where the sector has improved, can be realized and mineral and hydrocarbon resources can be harnessed for sustainable and equitable global development.

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References

Arbeláez-Ruiz, D, and D, Franks. 2014. Getting to the Table: How a new generation of organisations is improving dialogue and recording conflict over mining in Latin America. Americas Quarterly, 8(2):111–113.

Ashe K. 2012. Elevated Mercury Concentrations in Humans of Madre de Dios, Peru. PLoS ONE 7(3): e33305.

Asner, G, Llactayo, W, Tupayachi, R and E Ráez Luna. 2013. Elevated rates of gold mining in the Amazon revealed through high-resolution monitoring. Proceedings of the National Academy of Sciences,110(46):18454-18459.

Atkins, D., and S. Wildau. 2008. Participatory water monitoring: A guide for preventing and managing conflict. Advisory note. Compliance Advisor Ombudsman. Washington, USA.

Australian Government. 2011. Final Government Response to the Report of the Montara Commission of Inquiry. Department of Resources, Energy and Tourism, Canberra.

Azam, S and Li, Q. 2010. Tailings Dam Failures: A review of the last one hundred years. Geotechnical News, December, 50-53.

Barrett, D, Sonter, L, Almarza, A, Franks, DM, Moran, CJ, Cohen, T and C Hedemann. 2010. Quantitative Approach to Improving the Business of Biodiversity Investment. Final Report. Centre for Water in the Minerals Industry, University of Queensland. Australian Coal Association Research Program. Project Number: C17030. http://www.acarp.com.au/abstracts.aspx?repId=C17030

Boger, D. 2013. Rheology of Slurries and Environmental Impacts in the Mining Industry, *Annual Review of Chemical and Biomolecular Engineering*, 4: 239-257.

Borthwick, D. 2010. Report of the Montara Commission of Inquiry. June. Commonwealth of Australia. June.391p.

Bourgouin, F. 2014. Climate Change: Implications for Extractive and Primary Industries. Intergovernmental Panel on Climate Change Fifth Assessment Report. Cambridge Institute for Sustainability Leadership and Business for Social Responsibility. 15p.

Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE). 2011. Report Regarding the Causes of the April 20, 2010 Macondo Well Blowout. September. 212p.

Buxton, A. 2013. Responding to the challenge of artisanal and small-scale mining. How can knowledge networks help? International Institute for Environment and Development, London.
Collins, N and L Lawson. 2014. Investigating approaches to Working with Artisanal and Small-scale Miners: A compendium of strategies and reports from the field. International Mining for Development Centre. 122p.
Commonwealth Department of the Environment (DoE). 2014. Australia's Biodiversity Conservation Strategy - Case studies. Online resoucre: http://www.environment.gov.au/biodiversity/conservation/strategy/case-studies Accessed: 8 November, 2014.
Credit Suisse. 2012. Australian ESG/SRI. Online resource: http://www.credit-suisse.com/conferences/aic/2012/doc/web/20120731_esg_sri.pdf. Accessed: 20 December, 2013. 51p.
Davis, R and D.M. Franks. 2014. Costs of Company-Community Conflict in the Extractive Sector. Corporate Social Responsibility Initiative Report No. 66. Cambridge, MA: Harvard Kennedy School.
Deepwater Horizon Study Group. 2011. Final Report on the Investigation of the Macondo Well Blowout. March. 124p.
Edraki, M, Baumgartl, T, Manlapig, E, Bradshaw, D, Franks, D, and C Moran. 2014. Designing mine tailings for better environmental, social and economic outcomes: a review of alternative approaches. *Journal of Cleaner Production*. DOI: 10.1016/j.jclepro.2014.04.079
Elmes, A, Yarlequé Ipanaqué, JG, Rogan, J, Cuba, N and A Bebbington. 2014. Mapping licit and illicit mining activity in the Madre de Dios region of Peru, *Remote Sensing Letters*, 5(10): 882–891.
Equator Principles. 2014. About the Equator Principles. Online resource: http://www.equator-principles.com/index.php/about-ep/about-ep Accessed: 23 June, 2014.
Erskine, P. 2014. Ecological rehabilitation, past, present and future. Keynote presentation to Best Practice Ecological Rehabilitation of Mined Lands 2014, 25 September, Singleton.

European Commission. 2011. Proposal for a Regulation of the European Parliament and of the Council on Safety of Offshore Oil and Gas Prospection, Exploration and Production Activities. Commission Staff Working Paper: Impact Assessment. Annex 1. Brussels, October.

Franks, D and P Erskine. 2012. Mine site rehabilitation in Sierra Leone – A rapid appraisal of selected sites. International Mining for Development Centre. Brisbane, Australia.

Franks, D, Boger, D, Côte, C, and D Mulligan. 2011. Sustainable development principles for the disposal of mining and mineral processing wastes, *Resources Policy*, 36(2):114-122.

Franks, D.M., Davis, R., Bebbington, A.J., Ali, S.H., Kemp, D and Scurrah, M. 2014. Conflict translates environmental and social risk into business costs, *Proceedings of the National Academy of Sciences*, 111(21):7576-81.

Fraser B. 2009. Peruvian Gold Rush Threatens Health and the Environment. *Environmental Science and Technology*. 43(19): 7162–7164.

Gardner, E. 2012. Peru battles the golden curse of Madre de Dios. *Nature*, 386:306-07.

Henisz, W., Dorobantu S. and Nartey, L. 2013. Spinning Gold: The Financial Returns to Stakeholder Engagement, Strategic Management Journal, September 2013 (online version).

Hentschel, T, Hruschk, F and M Priester. 2002. Global Report on Artisanal & Small-Scale Mining. Report for the Mining, Minerals and Sustainable Development Project, No. 70. International Institute for Environment and Development and World Business Council for Sustainable Development. January, London.

Hilson, G. 2006. Abatement of mercury pollution in the small-scale gold mining industry: Restructuring the policy and research agendas. Science of The Total Environment 362(1-3):1–14.

Holand, P. 2011. Blowout and well release characteristics and frequencies, 2011. SINTEF Technology and Society Safety Research. 85p.

Hooke, R, Martín-Duque, J and J, Pedraza. 2012. Land transformation by humans: A review. GSA Today, 22(12):4-10.

International Association of Oil and Gas Producers (OGP). 2002-13. Environmental Performance Indicators. OGP Data Series.

International Association of Oil and Gas Producers (OGP). 2010a. Risk Assessment Data Directory - Major Accidents. No. 434-17. March. London 32p.
International Association of Oil and Gas Producers. 2010b. Risk Assessment Data Directory - Blowout Frequencies. No. 434-2. March. London 13p.
International Council on Mining and Metals (ICMM). 2003. Mining and Protected Areas. Position Statement. September.
International Council on Mining and Metals (ICMM). 2012. Trends in the mining and metals industry. Mining's contribution to sustainable development. October. London.
International Cyanide Management Institute (ICMI). 2014. Directory of signatory companies. Online resource: http://www.cyanidecode.org/signatory-companies/directory-of-signatory-companies Accessed: 10 November, 2014.
International Energy Agency (IEA). 2014a. Key World Energy Statistics. Paris, 80p.
International Energy Agency. 2014b. Special Report: World energy investment outlook. Paris, 185p.
International Maritime Organization (IMO). 2014. Construction requirements for oil tankers. Online resource: http://www.imo.org/OurWork/Environment/PollutionPrevention/OilPollution/Pages/constructionrequirements.aspx Accessed: November 1, 2014.
International Monetary Fund. 2012. Macroeconomic policy frameworks for resource-rich developing countries. August. 55p.
Levin, E. 2012. Understanding Artisanal & Smallscale Mining in Protected Areas and Critical Ecosystems: A growing global phenomenon. Presentation for ASM Protected and Critical Ecosystems London Roundtable. November.
Macdonald, I and K Southall. 2005. Mining Ombudsman Case Report: Marinduque Island. Oxfam Australia. March, Fitzroy. 40p.
Moran, R. 2001. More cyanide uncertainties: Lessons from the Baia Mare, Romania, spill - water quality and politics. Mineral Policy Centre Issue Paper No. 3. 15p. Online resource: http://www.earthworksaction.org/files/publications/mcu_final.pdf Accessed: 9 November, 2014.

Mudd, G and D Boger (forthcoming). Meeting the Challenges of Declining Ore Grades and Mega-Mines: Towards More Sustainable Management of Massive Mine Wastes.
Mudd, G. 2007. Global trends in gold mining: Towards quantifying environmental and resource sustainability? *Resources Policy* 32:42-56.
Mudd, G. 2009. The Sustainability of Mining in Australia : Key Production Trends and Their Environmental Implications for the Future. Research Report No RR5, Department of Civil Engineering, Monash University and Mineral Policy Institute, Revised - April 2009.
Mudd, G. 2010. The Environmental sustainability of mining in Australia: key mega-trends and looming constraints. *Resources Policy*, 35:98–115.
Mudd, G. 2012. Sustainability Reporting and the Platinum Group Metals: A Global Mining Industry Leader? *Platinum Metals Review* 56(1):2-19
Mudd, G. 2013. The limits to growth and 'finite' mineral resources: re-visiting the assumptions and drinking from that half-empty glass. *International Journal of Sustainable Development*, 16(3/4):204-220.
Mudder, T and M, Botz. 2004. Cyanide and Society: A critical review. The European Journal of Mineral Processing and Environmental Protection, 4(1):62-74.
Mudder, T, Botz, M and K Hagelstein. 2006. Cyanide Science and Society. Unpublished manuscript. TIMES Limited, Wyoming. 21p
Natural Value Initiative (NVI). 2011. Tread Lightly: Biodiversity and ecosystem services risk and opportunity management within the extractive industry. October.
Pachas C., VH. 2013. A vision for ecological gold mining in Peru. ASM-PACE blog. 19 July. Online resource: http://www.asm-pace.org/blog/item/9-peru-madre-dios-artisanal-mining-biodiversity.html Accessed: 3 November, 2014.
Porter, M, Franks, D and J Everingham. 2013. Cultivating collaboration: Lessons from initiatives to understand and manage cumulative impacts in Australian resource regions, *Resources Policy*, 38(4):657–669.
Reig, P, Luo, T, and JN Proctor. 2014. Global shale gas development: Water availability and business risks. World Resources Institute (WRI). September.

Sonter, L, Barrett, D, Moran, C and B, Soares-Filho (forthcoming). Carbon emissions due to deforestation from charcoal use in Brazil's steel industry.Sonter, L, Barrett, D, Soares-Filho, B and C Moran. 2014. Global demand for steel drives extensive land-use change in Brazil's Iron Quadrangle, Global Environmental Change, 26: 63-72.
Sonter, L, Moran, C and D Barrett. 2013. Modelling the impact of revegetation on regional water quality: a collective approach to manage the cumulative impacts of mining in the Bowen Basin, Australia, Resources Policy, 38(4):670-677.
Swenson J, Carter C, Domec J-C, Delgado C. 2011. Gold Mining in the Peruvian Amazon: Global Prices, Deforestation, and Mercury Imports. *PLoS ONE* 6(4): e18875.
Taylor, M. 2013. Indigenous People and the Resource Extraction Industry: Towards Public, Transparent and Human Rights Compliance Standards. Compliance Advisor Ombudsman (CAO). Presentation to the ATNS Symposium, University of Melbourne, June 25, 2013. Online resource: http://atns.net.au/symposium/Day%20One/Dame%20Meg%20Taylor%20ATNS%20Symposium%2025%20June%202013.pdf Accessed: 28 July, 2014.
Telmer K, Veiga M (2009) World emissions of mercury from small scale and artisanal gold mining. In Mason R Pirrone N (eds), Mercury Fate and Transport in the Global Atmosphere: Emissions, Measurements and Models. New York: Springer. pp. 131–172.
The International Tanker Owners Pollution Federation Limited (ITOPF). 2013. Oil Tanker Spill Statistics. London, 12p. http://www.itopf.com/fileadmin/data/Documents/Company_Lit/OilSpillstats_2013.pdf
Tremblay, G and C, Hogan. 2012. Canada's National Orphaned and Abandoned Mines Initiative. Natural Resources Canada. Presentation to the Managing Mining Legacies Forum, 16-17 July. Online resource: https://www.cmlr.uq.edu.au/Portals/0/MMLF/Canada’s%20National%20Orphaned%20and%20Abandoned%20Mines%20Initiative%20(NOAMI).pdf Accessed: 9 November, 2014.
Unger, C, Lechner, A, Glennn V, Edraki, M and D, Mulligan. 2012. Mapping and Prioritising Rehabilitation of Abandoned Mines in Australia. Proceedings of the Life of Mine Conference, Online

resource:
https://www.cmlr.uq.edu.au/Portals/0/MMLF/LOM%20Paper%20Unger%20et%20al%20July%202012.pdf Accessed: 9 November, 2014.

United Nations Environment Program (UNEP). 1997. Compendium of Summaries of Judicial Decisions in Environment Related Cases: Chile – Environmental Protection, Mining Operations. Pedro Flores y Otros v. Corporacion del Cobre, CODELCO, Division Salvador. Recurso de Proteccion, Copiapo. Supreme Court of Chile, ROL.12.753.FS.641 (1998). SACEP, UNEP, NORAD Publication Series on Environmental Law and Policy. No. 3. Online Resource:
http://www.unescap.org/drpad/vc/document/compendium/ch1.htm. Accessed: February 20, 2007.

United Nations Environment Programme (UNEP) and Office for the Co-ordination of Humanitarian Affairs (OCHA). 2000. Spill of liquid and suspended waste at the Aurul SA retreatment plant in Baia Mare. Cyanide Spill at Baia Mare Romania Assessment Mission 23 Februaru - 6 March. Geneva. 57p.

United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC). 2013. Identifying potential overlap between extractive industries (mining, oil and gas) and natural World Heritage Sites. December. 62p.

United Nations Sustainable Development Solutions Network. 2013. Harnessing natural resources for sustainable development: Challenges and solutions. Good Governance of Extractive and Land Resources Thematic Group, United Nations Sustainable Development Solutions Network. Technical report for the post-2015 development agenda. September. Online resource: http://unsdsn.org/wp-content/uploads/2014/02/TG10-Final-Report.pdf Accessed: 11 July, 2014.

United Nations. 2012. Report of the United Nations Conference on Sustainable Development Rio de Janeiro, Brazil, 20-22 June. A/CONF.216/16, New York.

United Nations. 2014. Open Working Group proposal for Sustainable Development Goals. Full report of the Open Working Group of the General Assembly on Sustainable Development Goals. A/68/970.

United States Department of Interior. 2011. Assessment of Flow Rate Estimates for the Deepwater Horizon/Macondo Well Oil Spill. National Incident Command, Interagency Solutions Group, Flow Rate Technical Group. March 10. 22p.
United States Energy Information Administration (US EIA). 2013. Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States. June.
Villegas, C, Weinberg, R, Levin, E and K Hund. 2012. Global Solutions Study, Artisanal and Small-Scale Mining in Protected Areas and Critical Ecosystems Programme (ASM-PACE). September.
Wilson, A. and Cervantes, M. 2014. Fraser Institute Annual Survey of Mining Companies 2013. The Fraser Institute, Vancouver Canada. 134p. Online resource: http://www.fraserinstitute.org/uploadedFiles/fraser-ca/Content/research-news/research/publications/mining-survey-2013.pdf Accessed: 28 July, 2014.
World Bank. 2014. Global Economic Monitor (GEM) Commodities. Online resource: http://data.worldbank.org/data-catalog/commodity-price-data Accessed: 24 June, 2014.
World Information Service on Energy (WISE). 2014. Chronology of major tailings dam failures, 1960-2014. Online resource: http://www.wise-uranium.org/mdaf.html Accessed: 7 November, 2014.

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