Inter-American
Development Bank

Energy Division (ENE)

TECHNICAL NOTE

No. IDB-TN-612

Incentivizing Clean Technology in the Mining Sector in Latin America and the Caribbean

The Role of Public Mining Institutions

Malaika Masson
Martin Walter
Michael Priester

December 2013

Incentivizing Clean Technology in the Mining Sector in Latin America and the Caribbean

The Role of Public Mining Institutions

Malaika Masson
Martin Walter
Michael Priester

Inter-American Development Bank
2013

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Masson, Malaika.
Incentivizing clean technology in the mining sector in Latin America and the Caribbean : the role of public mining institutions / Malaika Masson, Martin Walter, Martin, Michael Priester.
p. cm. — (IDB Technical Note ; 612)
Includes bibliographic references.
1. Mineral industries—Environmental aspects—Latin America. 2. Environmental policy—Latin America. I. Walter, Martin. II. Priester, Michael. III. Inter-American Development Bank. Energy Division. IV. Title. V. Series.
IDB-TN-612

JEL Codes: N56; O13; O38; Q58

Keywords: Extractive Industries; Clean Technology; Clean Production; Mining; Public Policy; Public Mining Institutions; Incentives; Latin America and the Caribbean

http://www.iadb.org

Malaika Masson (malaikac@iadb.org); Martin Walter (martinw@iadb.org)

"Incentivizing Clean Technology in the Mining Sector in Latin America and the Caribbean: The Role of Public Mining Institutions"

Malaika Masson, Martin Walter, and Michael Priester

Introduction

This discussion paper highlights the results of the regional study, "Incentivizing Clean Technology in the Mining Sector in Latin America and the Caribbean: Role of Public Mining Institutions," financed and coordinated by the Energy Division of the Inter-American Development Bank. The global objective of the project was to answer the following question: How can LAC governments promote the use of cleaner technology to reduce the impact of mining activities on the environment? This project resulted in a comprehensive report investigating two aspects of this issue: clean technology and mining processes and the role of governments in promoting their use in the LAC. The report drew on information gathered from extensive field work missions in Bolivia, Guyana, and Peru[1] and highlighted a number of proposals for the development of cleaner mining practices in the region. Its main findings are presented here for discussion with a wider audience.

Mining has been and continues to be an important economic activity in the Latin America and Caribbean (LAC) Region. The region is a world leader in the production of key minerals, including copper, gold, silver, iron ore, and nickel. LAC is the main target for global exploration investment and holds most of the world's mining investment portfolio (MEG 2012; ECLAC 2013; USDI and USGS 2013). Years of mining and mineral-processing activities, however, have not come without environmental costs (Oxfam America 2010; Gunningham, Kagan, and Thornton 2003; Soares, Cunha, and Yokohama 2004). Mining can have a big impact on its physical and social surroundings in all phases of the mining cycle, including prospecting, exploration, exploitation and beneficiation/processing, and mine closure. Given that the region

[1] Information for this project was gathered through an extensive review of secondary sources of information (physical and digital documents) and key primary informants interviewed in the context of field missions to three selected countries. These missions took place in the second half of June 2013 in Bolivia, Guyana, and Peru (Guyana June 17th and 18th, Peru 20th and 21st as well as 26th till 29th and Bolivia 24th and 25th) and involved contacts with relevant public authorities as well as representatives from private and civil society.

hosts approximately 40% of the world's biological diversity, 30% of globally available freshwater, and almost 50% of the world's tropical forests (Bovarnick, Alpizar, and Schnell 2010), it is becoming increasingly critical that the industry invest in cleaner and more efficient technology and adopt more effective environmental management practices. Enhanced technology and practices can reduce negative externalities from mining and ensure that resource-based development is more environmentally friendly (WEF 2013). Although environmental and mining monitoring regulations in the LAC region have made notable strides over the past decades, government and civil society organizations agree that there is much room for improvement in terms of implementation. Experts stress that several practical challenges tend to hinder the implementation of the cleaner technology and production practices crucial to improving the performance of the mining sector (Ortega-Girones, Pugachevsky, and Walser 2009; Singh et al. 2013; Unger 2010; Hilson 2000). Cleaner technology includes cost-effective management instruments and technical tools to reduce the environmental impact of production in the extractive industries, such as the reclamation and re-habilitation of disturbed land, the treatment and stabilization of metal-bearing soils, improved water management systems, controlling gas emissions to the atmosphere, energy use, and waste management (Oblasser and Chaparro 2008).

This study assesses challenges related to the implementation of cleaner technology in the mining industry and explores the role of public institutions in incentivizing them. It emphasizes that operational realities, which are contingent on regulatory frameworks, economic incentives, and human capacity, determine the most appropriate public sector instruments for supporting or incentivizing the introduction of improved technology in the mining sector. Moreover, it underscores the need to distinguish between the technology employed in operations and the technology necessary to manage mine closure. This approach aligns with mainstream analyses of technology in the mining sector, which generally stress three types of barriers to the

implementation of cleaner technology and practices in the sector: legislative, technological, and economic (Hilson 2000; Pegg 2006).[2]

This paper describes the role of cleaner technology in mining and provides a detailed review of obstacles and opportunities related to adopting cleaner technology in three key countries of the LAC. The first section is devoted to a discussion of technology and practices in the mining industry, emphasizing the role of the public sector. The following section outlines the main features of the mining sectors in Bolivia, Guyana, and Peru and discusses the barriers to implementing cleaner technology. The next section of the paper discusses the changes necessary to eliminate these barriers and identifies key areas requiring further attention. The final section outlines recommendations applicable in Bolivia, Guyana, and Peru for introducing cleaner mining technology.

1. Cleaner Technologies in the Mining Industry

The use of cleaner technology and improved practices in mining are often conflated in discussions about "environmental management," which generally incorporate all the activities necessary to ensure that a mining project is designed, operated, and closed in an environmentally sound and socially acceptable manner.[3] Environmental management in mining encompasses several different actions, involving both the assessment of potentially significant socio-environmental impact that could result from mining and the implementation of appropriate mitigation actions. Such actions involve risk management, performance evaluation,

[2] The authors recognize that the absence of public sector initiatives for incentivizing the use of cleaner technology in mining is often due to a gap in knowledge and information in the private sector. In fact, many mining companies and governments in the LAC ignore that there is cleaner cost-competitive technology available on the market. For example, small and medium scale gold mining operations in the LAC using toxic mercury for amalgamation are unaware that cost-effective and more environmentally friendly alternative technologies, such as cyanidation setups, are also available (Veiga 1997). Limited knowledge of mining pollution issues and technological solutions reduces the capacity of decision-makers to promote change in the industry. However, the availability of such information and knowledge is no guarantee that these technologies will be introduced. Ultimately, the willingness and effectiveness of governments to promote technology that reduces environmental impact is contingent on several factors which include geological, mineralogical and hydrological features, the relative availability of infrastructure, service networks and a skilled workforce, as well as legal and regulatory frameworks and the enforcement capacity of the state.

[3] In the industry, Environmental Management Systems (EMS) integrate environmental responsibilities into everyday management practices through the adaptation of the organizational structure, responsibilities, procedures, processes, and resources.

and system auditing,[4] as well as activities that proactively create a positive environmental or social impact, such as measures that promote biodiversity or social investment. In this context, the regulatory framework of environmental management refers to the laws and normative systems that establish environmental performance standards in the mining industry and shape management and investment decisions. Normative frameworks prescribe specific 'required' actions, such as socio-environmental impact assessments and reporting practices. These environmental standards determine issues such as acceptable water usage, waste disposal, air emissions, and the control of hazardous substances in the industry. Overall, the emergence of these mining frameworks worldwide indicates that the mismanagement of unwanted mining by-products can severely affect environmental quality and human health.

In order to tackle the socio-environmental risks of mining and comply with increasingly stringent regulations and demands from civil society, the mining industry has implemented different technology and techniques that can improve waste management and pollution (Randall 1996; Thorpe 1999).[5] Technological improvements, for example, can help reduce natural capital losses (e.g., improving recovery rates within the industry) thus fostering the maximization of production for a certain area of disturbance, the minimization of indirect losses of renewable natural capital from mineral extraction, and improved compliance with environmental standards. A number of these cleaner technologies have emerged over the past century to address environmental problems in the mining industry. These technologies include "highly efficient environmental equipment, heavily retrofitted end-of-pipe designs, and improved control systems" which help address "the loss of natural capital and the sub-optimal capture of value from the sector" (Hilson 2000). For example, iron ore smelting facilities have progressively introduced desulphurization units (e.g. scrubbers) driven by the enforcement of more stringent air pollution regulations in most developed nations. While first-generation units were able to

[4] An Environmental Audit assesses the environmental and/or social performance of an existing operation. It is a method of ensuring compliance with regulatory requirements and of guaranteeing that the performance complies with stated policies and objectives.

[5] While upgraded environmental equipment is entirely responsible for reducing and minimizing pollution from industrial activity, improved management practices serve as valuable guidance and, more importantly, help an operation identify additional opportunities for waste minimization.

remove approximately 90% of SO_2 from flue gas (Bellas 1998; Hilson 2000), more recent technology can reach efficiencies of 98-99%. Similarly, the introduction of electrostatic precipitators and bagbouses for the treatment of flue gas has helped remove 99.9% of dust and 99% of toxic metal particles from smelting operations (ICME and United Nations Environment Programme 1996). Technology tackling water pollution from mining has proved efficient at treating the resource for chemicals, sediments, metals, and pH before its discharge. In addition to techniques fostering water reuse, the control of Acid Mine Drainage (AMD) through lime neutralization and bioremediation has helped reduce the overall impact of mining on surrounding watersheds and wildlife. Improved pond-dredging techniques have achieved the continuous rehabilitation of exploited areas, facilitating re-vegetation and reducing the overall impact of mining activities.[6] Moreover, not unlike innovation in clean technology, innovation in 'practices' can also significantly contribute to the reduction of negative externalities from mining. Cleaner mining practices, in the form of optimized industrial management actions, can help improve environmental performance as much as the latest technology (Randall 1996; Sousa et al. 2011; Hinton, Veiga, and Veiga 2003).

Options to minimize the environmental impact of mining can thus be categorized as: i) operational optimization initiatives, ii) end-of-pipe technology investments, and iii) the integration of technology in optimized mining operations. Operational optimization strategies do not include the introduction of new technology. Rather, they promote improvements by changing the conduct of mining organizations. These measures tend to have only limited impact on environmental performance but are often the least expensive for mining companies. Comparatively, investments in end-of-pipe technology are more costly; the introduction of this

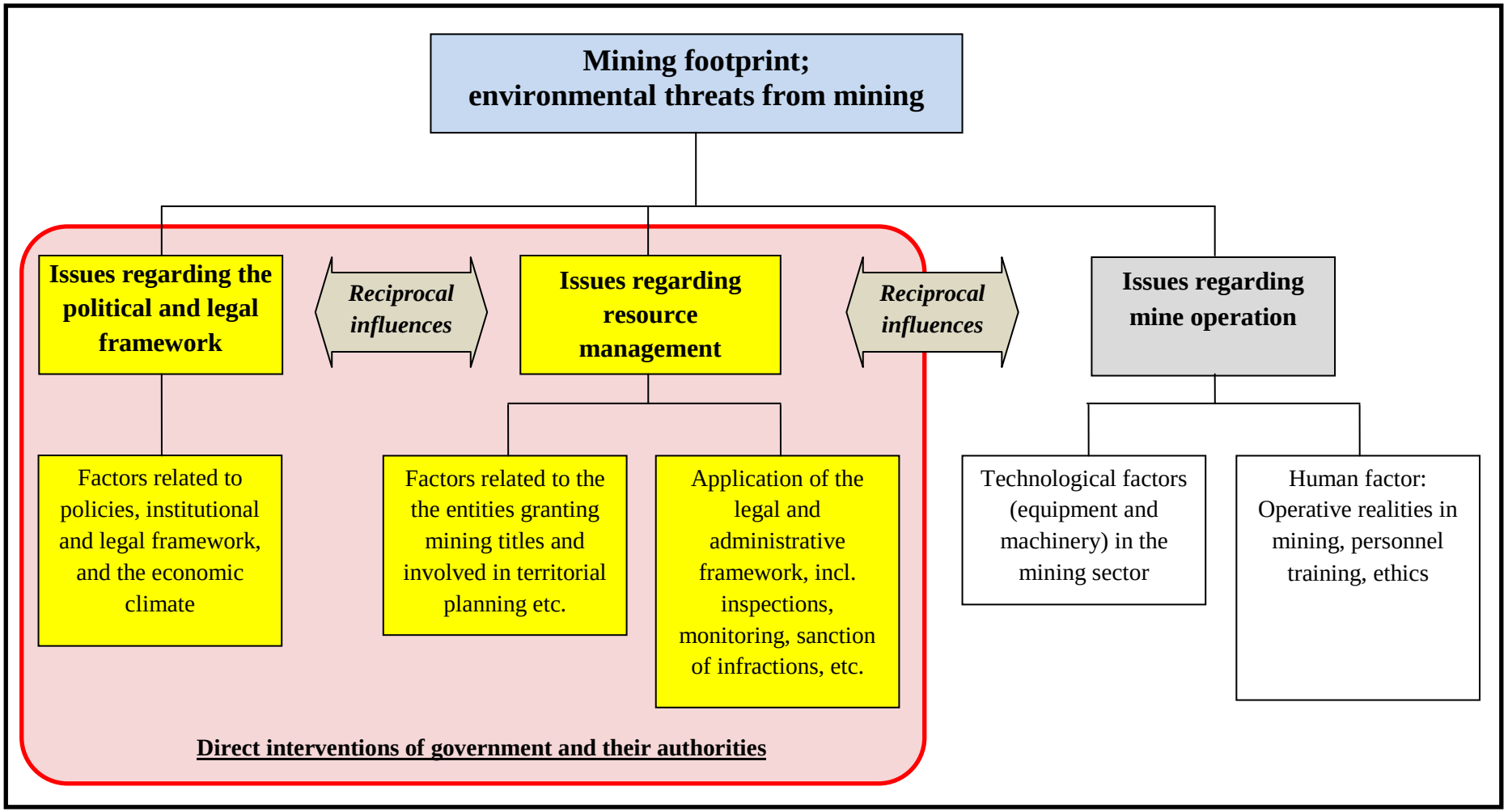
[6] Cleaner production measures in the mining sector encompass a number of different and complementing approaches, such as: i) Energy auditing and raising the energy efficiency of the process (i.e. reduction of over milling, staged sorting, change from truck transport to belt conveyor transport, etc.), ii) Recycling of process water and reduction of water consumption and discharge (reduction of losses, closed process water cycle etc.), iii) Optimization of chemical use (flotation reagents, mercury etc.), iv) Upgrading of recovery of ore in the exploitation stage (reduction of ore losses due to the mining method, reduction of transport losses etc.), v) Upgrading of ore concentration for the milling and concentration stages (reduction of ore dilution in exploitation, loading, hauling etc., selective exploitation, and separation of product streams, etc.), vi) Upgrading of recovery of valuable minerals in the concentration stage (with constant control of tailings etc.), vii) Optimization of the material flow in the concentration process (use of gravity, reduction of loading and unloading cycles etc.), viii) Marketing of by-products, and ix) Reduction of dust production in the mining and concentration stages.

technology, which focuses on treating the by-products of mining operations, may contribute to reducing the environmental impact but only to a limited extent. Significant reduction of environmental impact from mining requires the integration of new technology in mining processes, which is the third and most expensive option. It involves the introduction of cleaner technology to increase the operational effectiveness needed to achieve environmental performance objectives.

The conceptual distinction among the different strategies available to operators emphasizes that the environmental impact of mining operations depends on both the availability of adequate technology and the operational effectiveness of the industry. Moreover, it stresses that incentivizing the use of cleaner technology in mining is not the only strategy available to public officials seeking to reduce the environmental footprint of mining operations.[7] The diversity of environmental management options for mining companies reflects the various 'push' and 'pull' factors employed to incentivize investment in clean technology. Investment in such technology results from a combination of regulatory pressure and self-motivated reforms made by operators. Environmental threats from mining have public and private repercussions that are related to the reciprocal influences of political, legal, and regulatory frameworks and mine operation practices (See Table 1 below)

[7] The environmental impact of mining is often inseparable from the incentive structure in the mining sector. From the perspective of operators, for example, the relative cost of new technology is a key factor determining strategic choices. For small and medium scale operators, the relative cost of introducing environmentally-friendlier technology and practices tends to be higher than for large scale companies. Thus, the preferred strategy for compliance with environmental standards may vary accordingly depending on the number of smaller scale miners.

Figure 1: Environmental threats from mining and the role of the public sector



Source: Elaboration by Michael Priester, Projekt-Consult GmbH for the present study

2. Public Sector Instruments

Identifying opportunities to effectively incentivize the use of cleaner technology requires an understanding of the specific challenges faced by industry players. One must take into account their decision-making rationale, as well as the effect of mining activities on key socio-environmental variables. Despite these challenges, governments have a host of tools at their disposition to promote improved environmental stewardship in the sector. In general, governments resort to both regulatory and non-regulatory instruments, which are described in the following section.

Regulatory instruments (laws, regulations, and standards)

Many of the mining countries in the LAC have fairly stringent legal frameworks for the mining sector. These frameworks generally encompass both mining laws and a number of other important regulations that are summarized in the table below:

Table 1: Regulatory Instruments for the Promotion of Clean Technology

Area	Laws, regulations and standards
Mining	Mining Law (Act, Code etc.) incl. Small Scale Mining Law Mining Regulations
Institutional	Laws mandating specific mining authorities (mostly part of Mining Law)
Health and Safety	Labor Law Regulations on Occupational Safety and Health
Environmental	Environmental Laws (Protection Act, etc.) Environmental Regulations Laws related to Protected Areas and Cultural Heritage Sites Legal stipulations on rehabilitation funds
Explosives	Laws on explosives use
Water	Water Act Water regulations
Local native communities	Amerindian Act or similar laws
Fiscal	Company Act Taxation laws and regulations Export laws and regulations

Area	Laws, regulations and standards
	Windfall tax laws
International Conventions	ILO conventions on child labor International treaties on mercury

Source: Michael Priester, Projekt-Consult GmbH for the present study

Agencies with supervisory functions in the mining sector are responsible for ensuring mining company compliance with these contractual, legal, and moral duties.[8] These duties generally comprise the respect of social (i.e., for human rights and labor laws compliance relates to surrounding communities, gender issues, access to social security, education, healthcare, drinking water, etc.) and environmental standards (i.e,. emissions, water treatment, waste management, etc.), and guidelines for local regional development (i.e,. benefit sharing agreements, private-public partnerships). Compliance with these standards is often only possible using modern mining methods and technology. As such, inspection duties tend to require comprehensive technical qualification from government officials and/or contractors. Moreover, in order to adequately control and/or supervise compliance with the legal and fiscal framework, government agencies must be capable of adequately coordinating their actions.[9]

Non-regulatory instruments

In addition to regulatory instruments and compliance supervision systems, governments can also resort to several non-regulatory instruments to promote the use of cleaner technology and practices in mining. In using non-regulatory instruments, governments may employ both direct and indirect incentives. Financial

[8] With respect to mining governance, the organization of the institutional framework is particularly important. Although initiatives to streamline administrative procedures have led to one-stop-shop approaches to sector governance–meaning that mining governance systems are under the authority of a single government entity– such an approach has often subordinated environmental priorities to economic productivity. The configuration of the governance system responsible for the mining sector often shapes the inclusion and enforcement of the aforementioned environmental regulatory provisions.

[9] The assessment of mining operations involves the examination of three major issue-areas: i) administration, ii) environmental compliance, iii) technical issues. The administrative component requires the revision of documentation related to the inspected operation, as well as the assessment of compliance with pertinent laws and regulations (mining title, operational license, EIA, environmental, water and surface license, enrolment of staff in social security system, etc.). The evaluation of the environmental impact of mining requires inspection of and compliance with environmental regulations (for air, water, soil pollution, etc.) and environmental impact reports. Finally, the assessment of technical issues necessitates the analysis of operational processes, risk management and mine site rehabilitation plans, environmental management measures (i.e. prevention and environmental control, contingency preparedness), and license monitoring. Equally critical is the fact that verifying compliance with environmental standards, government agencies may determine corrective measures related to the environmental and operational obligations of operators. They can establish a series of sanctions for non-compliance, a list of which is included in section 2 of the Annex.

and material direct incentives that encourage the use of cleaner technology include subsidies for technology purchases, eased credit, and financing opportunities. Governments may indirectly encourage changes in conduct in the sector through infrastructure development, adjusted taxation[10] and administrative requirements, and the provision of key technical support to operators. These instruments allow governments to significantly lower the cost of introducing new technology in mining operations. These mechanisms promote better mining practices by influencing the economic rationale of the operators and removing barriers for the implementation of new and improved technology.

Several non-regulatory initiatives illustrate the critical role of such initiatives in the promotion of cleaner technology.[11] Funding mechanisms to support the greening of the industry demonstrate the increasing importance of non-regulatory instruments in addressing a host of environmental governance challenges ranging from climate change to energy efficiency to the use of clean technology. They have been linked to other international management initiatives such as Carbon Trade Mechanisms (re-funding climate change related investments by CO_2-certificates) and national innovation systems. The improvement of practices in the sector has also been fostered through the development of local clusters and value chains. The African Mining Vision,[12] for example, has outlined a strategy for cluster development along development corridors and for the creation of upstream, side-stream, and downstream linkages in order to add value in the country.[13] The development of these linkages has provided the leverage necessary to address environmental priorities at the sector level.

The development of vocational training in the sector can also contribute significantly to improved practices in the mining sector. Local experts and improved technical skills in the workforce can help foster better practices and cleaner technology in the mining sector. For example, technical assistance at a

[10] On taxation incentives see, Otto, J. et al, Global Mining Taxation Comparative Study (2nd edition), Colorado School of Mines, Golden: 2000.

[11] See a list of non-regulatory instruments in the Annex.

[12] See more details at http://www.africaminingvision.org/

[13] Activities may include: i) Aligning the timber and mining industry (using the clearing of timber for mining purposes), ii) Providing environmental studies (EIA, EMP etc.), iii) providing re-cultivation services, iv) Developing sustainable SME projects on rehabilitated mined out lands.

mine site can help promote the use of new technology and improve operational performance. Finally, cooperation with academic institutions can enhance both educational opportunities and the environmental performance of mining operations. Addressing technical issues related to the implementation of cleaner technology is often beyond the financial or training capacity of the operators. Thus, coordination and cooperation with public agencies, civil society, and academia can provide critical support.

3. Mining and Environmental Initiatives in Bolivia, Guyana, and Peru

Despite the number of legal instruments available and the crucial role that mining often plays in the economy, the promotion of cleaner technology often faces significant hurdles. The situations in Bolivia, Guyana, and Peru illustrate some of the key sectoral, environmental, and operational challenges, as well as the initiatives pursued by the public sector to address them.

Bolivia

Bolivia is a country rich in minerals, natural gas, forests, and other natural resources. It possesses an estimated half of world's lithium reserves and is home to the second-largest proven gas reserves in South America. Mining has long been a key sector of the Bolivian economy, and it is expected to continue playing a central role in its development. According to the latest figures available from the Ministry of Mining and Metallurgy, mining composed 6.2% of the GDP and 37.3% of total exports in 2011. The country was once home to the Spanish colony's richest silver and gold mine (Potosí), and it currently boasts one of the world's richest tin mines (Siglo XX), two of the world's largest silver mines (San Cristóbal and San Bartolomé), and has planned the construction of the largest iron ore mine (Mutún).

Like many other natural resource-rich countries, Bolivia has historically struggled to translate natural resource extraction into sustained and inclusive economic development (Farthing 2009). Its mining sector has been characterized by boom and bust cycles. Today, despite proven mineral reserves, Bolivia faces difficulties attracting investments in the mining sector. Few prospecting and exploration projects have been successfully developed in the country, and the production of most minerals (e.g., tin, tungsten, lead,

and silver) has dropped significantly. Moreover, the few promising mining projects that are in the pipeline have faced hurdles and not yet come to fruition. The most important projects for the diversification and industrialization of the Bolivian mining sector have been delayed. For example, the Mutún project has been hindered by transport infrastructure gaps and energy shortages. Similarly, the large lithium mining project in the Salar de Uyuni region has faced unexpected weather challenges, unexpectedly low quality ores, and political disputes that have hindered its progress. In addition, the operation of the Karachipampa poly-metallic smelter is equally unlikely to open on its projected date.

Stakeholders in the field argue that limited investments in the sector, which are key for the introduction of cleaner technology, are largely due to institutional and infrastructure barriers. Investors emphasize that uncertainties related to mineral tenure and unattractive fiscal conditions, as well as difficulties enforcing legal and regulatory frameworks as strong deterrents for investment. They note that uncertainties regarding tenure present major challenges for investment because they prevent any long-term planning. These issues are compounded by unstable fiscal conditions and the dysfunctional enforcement of mining regulations, which foster both further uncertainties for investment plans and uneven compliance with environmental regulations. These observations are consistent the 2012 World Economic Form *Global Competitiveness Report* findings which rank Bolivia 104th out of 144 countries, and the 2012 World Bank and International Finance Corporation *Doing Business Report* which ranks the country 153rd out of 183 countries. These reports emphasize that investment challenges are critical hurdles to achieving technological modernization and improving mining practices in Bolivia.

Another major challenge is limited technical capacity at the regional level, which hinders the ability of the public sector to supervise and monitor the increased environmental risks associated with mining. Moreover, technical skills development is at a critical low. Although at least three universities (e.g., “Universidad Técnica de Oruro”, UTO, “Universidad Autónoma Tomas Frias”, UTF and “Universidad Mayor de San Andrés”, UMSA) are offering courses related to the geo-sciences, mining, and metallurgy, there are few capacity-building opportunities at the technical and vocational level. Limited technical skills

and leadership in the private sector,–especially in small and medium mining sector dominated by mining cooperatives ,has proved a barrier to the adoption of improved technology and the dissemination of information about responsible mining practices in the traditional base metal sector.

Paradoxically, the limited expansion of mining activities has not led to a reduction in environmental impact. On the contrary, mining legacies and cumulative impact still account for the vast majority of environmental challenges in the country. In the altiplano region, for example, where the majority of base metals from sulfidic and mixed sulfidic/oxidic deposits are mined, old mine tailings continue to threaten ground and surface water quality. Similarly, abandoned unregulated mining operations have left a legacy of cumulative environmental impact. During the colonial era, the amalgamation of silver with mercury led to the discharge of more than 40,000 tons of mercury into Bolivia's ecosystem. Mining has led to water pollution, the accumulation of hazardous solid waste, air contamination, and major trophic disruptions.

In order to tackle economic and environmental challenges in the sector, the Government of Bolivia has developed a series of policy initiatives. It has, for example, created a specific line of credit for cooperative mining producers, the Mining Financial Fund ("Fondo Financiero Minero", FOFIN), which is endowed with approximately US$13 million. However, there has been little demand for financial support from miners; instead, the majority of mining cooperatives, which account for the majority of medium and small scale operations, receive equipment donations under the "Evo Delivers" Program. In addition, in order to tackle environmental legacies from mining in the altiplano region, where mismanaged mine tailings have led to significant acid drainage, the Geological Service (Servicio Nacional de Geología y Técnico de Minas, SERGEOTECMIN) and the National Mining Corporation (Corporación Minera de Bolivia, COMIBOL) have mapped and classified the environmental impact of these activities. They also identified business opportunities related to the exploitation of mine by-products. In addition, the government has developed several vocational and technical training programs. Although most of them have been abandoned, they highlight the official recognition that technical and vocational training, including the empowerment of sector authorities, are prerequisites for implementing better practices and technology in

the mining sector. Training and education have been identified as key conditions for the implementation of economically competitive measures that improve efficiency and environmental performance, especially related to government management of environmental mining legacies.

Guyana

As is the case in Bolivia, mining and quarrying contribute significantly to Guyana's economy: the sector accounted for 10% of the country's 2012 GDP. That year, the value of exports from mining and quarrying jumped to US$ 795 million (61.6% of the totalUS$1,291.1 million), from US$ 662.3 million (58.7% of the total US$ 1,128.8 million) reported in 2011. The increase in the overall value of mineral production was due to continued outstanding performance and high prices in the gold and bauxite sub-sectors, as well as increases in sand and loam output. In 2012, the mining industry directly employed approximately 16,500 people. If indirect and induced jobs are added in, a total of approximately 20,000 people were employed in the sector.[14] In Guyana extraction of alluvial gold is the main mining activity. In 2012, gold production accounted for approximately 78% of the industry's contribution to the GDP (equivalent to 8% of GDP), all of which was contributed by small and medium scale gold miners.[15] The expansion of the sector has had severe environmental consequences such as deforestation, habitat loss, water contamination by mercury, and river siltation.

Guyana has implemented policy instruments for environmental governance in its innovative Low Carbon Development Strategy (LCDS) (Office of the President 2013). Launched in 2008, this strategy outlines Guyana's vision for promoting economic development while simultaneously combating climate change. The strategy provides a roadmap for sustainable environmental and economic development in Guyana; it

[14] This section reflects information presented in: Low Carbon Development - Strategy Update: Transforming Guyana's Economy While Combating Climate Change March 2013, Office of the President, Republic of Guyana.

[15] Diamond, bauxite, and quarry products were budgeted to account for the remaining 22% of the Mineral Industry's contribution to the GDP. In the coming years, projected investments in the sector include two major gold exploration projects, Guyana Goldfields Inc. and ETK Inc/Sandspring Resources Ltd, both of which are at the resource assessment stage. Guyana Goldfields Inc. announced positive feasibility study results for its Aurora Gold Project in Guyana with the total investment expected to amount to US$600 million create 250 jobs during the development phase and 200 during mine operation. In the case of the Toroparu mine being developed by ETK Inc/Sandspring Resources Ltd., the total investment is projected at US$400 million, and 300 jobs will be created during development while another 200 jobs will be created during mining.

was set up to preserve Guyana's forests, which are often referred to as "the lungs of the world." The LCDS, however, does not specifically address mining issues. Despite this fact, recognition of the impact of mining on forests has recently led to initiatives that coordinate ongoing environmental and mining policies.

Due to mining's contribution to employment and socio-economic development, the cessation of these activities is not required under the LCDS. Instead, a balanced approach to land use is being pursued in which mining, forestry, and interim REDD+ payments collectively provide a set of economic incentives that optimize job and economic value in each sector while minimizing environmental impact and safeguarding the rights and livelihoods of workers and Guyanese citizens who live near mining activity.

Although Guyana's Mining Act and its environmental regulations for mining predate the LCDS, since the LCDS was launched the government has redoubled efforts to ensure that mining practices are continually improved and aligned with international best practices. The existing mining regulations were developed by a multi-stakeholder committee that included representatives from the Guyana Geology and Mines Commission (GGMC), the Environmental Protection Agency (EPA), and the Guyana Gold and Diamond Miners Association (GGDMA). After they were enacted, education and awareness programs were carried out in the mining districts for small and medium scale gold and diamond miners. Throughout the LCDS process, the mining sector and small and medium scale miners have been directly involved so as to provide a better understanding of the LCDS and its implications for the sector. The government has prioritized stronger enforcement and sustainability standards to prevent mining from causing environmental degradation and excessive forest loss.[16]

[16] A Special Land Use Committee was established in January 2012 to coordinate cross-sectoral planning on sustainable land use, and to give guidance for harmonizing mining and forestry in the context of the LCDS. One of the Special Land Use Committee's recommendations was that prospecting before mining be employed by small and medium scale gold and diamond miners. The SLUC is also progressing on five specific projects: 1. Strengthening Land Use Planning and Coordination among natural resource agencies; 2. Sustainable Land Management in the mining and forestry sectors; 3. Enhanced Land Reclamation; 4. Improved Infrastructure in Mining Districts, and 5. Amendments to Mining Act and Regulations.

In this context, the GGMC and other related agencies are making sustained efforts aimed at addressing forest degradation and advancing several codes of practice. The GGMC has increased its monitoring and enforcement in the field, improved technical assistance and guidance to miners, and established miners' committees to facilitate this process. It has also employed additional field staff to focus on enforcing regulations. The GGMC is starting to include newly developed codes of practice for mine operators, and work has commenced on the creation of a new mining school and training center, which will be accredited by Guyana's Ministry of Education.[17]

The Guyana Environmental Monitoring and Conservation Organization (GEM-CO) conducted a study that found environmental challenges in the mining sector resulted not from a lack of rules or regulations but rather from a lack of compliance and enforcement. In line with this general observation, the 2013-2018 Strategic Framework of the Ministry of Natural Resources and the Environment (MoNRE) identifies three priority areas for the improvement of Guyana's environmental governance (Strategic Environmental Advice 2013). It suggests targeting the efficiency of institutional frameworks and legislation, strategic planning coordination mechanisms, and sustainable resource use and monitoring. In line with Guyana's strategy for the GGMC for 2013 to 2017 (Guyana Geology and Mines Commission 2012) and expert assessments (Corbin 2010; Singh et al. 2013), possible areas of intervention include regulatory improvement and capacity-building, enhanced revenue management and transparency, improved interagency cooperation, and technological innovation for greener mining operations.

Despite the quality of the regulatory framework and sustained efforts to improve environmental performance, the GoG has not yet managed to fully enforce existing regulations. The recent development of the mining industry, triggered by surging gold prices and an influx of mining knowledge from Brazil, has resulted in increased mechanization and productivity improvements, which have had a negative impact on the environment. Inadequate mining operations, which include mine closure and the

[17] In March 2013, the Ministry of Natural Resources and the Environment launched an initial draft of its strategic plan setting out how it intends to sustain high standards of environmental stewardship, and the strategy is currently undergoing stakeholder consultation.

rehabilitation of degraded land, have affected more than 50,000 hectares. In addition, gaps in technical and financial capacity have hindered the necessary systematic inspection of mines and the application of sanctions for infractions against environmental regulations. Although capacity-building mechanisms for the extractive sector have been developing in the past years – i.e., the government has established successful mining schools in Linden and Bartica – adequate technical and vocational training is still lacking, and highly qualified experts from the mining sector have been emigrating. Knowledge on best mining practices is limited, and the GoG so far has been unable to implement pragmatic approaches for an economic after-use of rehabilitated or re-vegetated mine sites.

Guyana has not yet been able to implement effective integrated land management mechanisms, a problem rooted in effective inter-agency coordination and regulatory instruments. Licensing and titling issues pertaining to land use reduce the effectiveness and competitiveness of the sector, but also lead to a disproportionate distribution of the impact of mining on already-marginalized regions and members of civil society, in particular Amerindian groups. Limited information collection and management systems hinder the overall governance of the sector. Particularly, there is limited knowledge of issues related to the different stages of the mining cycle, as well as limited knowledge and implementation of low-cost rehabilitation techniques appropriate to the difficult climatic and geological environment of Guyana. In addition, a pragmatic approach for the economic after-use of rehabilitated or re-vegetated mine sites is still lacking. Finally, local financial institutions are disinclined to work with mining sector actors as clients. A green funding line (e.g., refinancing the equipment suppliers, which currently lend equipment on a leasing basis) and other financial mechanisms could help improve private performance in the sector and facilitate the introduction of environmentally friendlier technology.

Peru

Peru is entering the second decade of sustained growth in the mining sector. The process has been driven by sound governance standards[18] and heavy investment by international mining companies. Currently, the country is one of the world's largest producers of silver, copper, tin, and zinc; and as of 2012, the main source of gold in Latin America. Mining is a key sector of the economy; approximately 65% of the country's exports correspond to metallic and non-metallic mineral products. In fact, the value of mining exports more than doubled between 1993 to 2000, to US$3.2 billion, and had risen sevenfold to US$ 21.7 billion by 2010 to amount to approximately 14 percent of the country's GDP. In line with this growth, mining investment increased by 5.8% in 2013 (respective to 2012), reaching approximately US$ 10 billion. It is estimated that the country will perceive approximately US$ 57 billion in FDI for the sector over the next decade (SNMPE 2013). In 2012, approximately 209,000 people were employed in the formal mining sector and, for each one of these jobs, private companies estimate that the economy added approximately nine non-mining jobs, pushing total employment driven by the sector to approximately 1.9 million jobs. Peru's mining sector encompasses small, medium, and large-scale operations. The majority of metals are produced by large and medium scales miners, but small scale mining operators produce approximately half of all non-metallic minerals and are major producers of industrial minerals and coal (MINEM 2013; Wetzenstein 2005). In addition to formal actors, informal and illegal miners produce a significant amount of metallic and non-metallic minerals in the country. It is estimated that informal and illegal miners account for approximately 12% of Peru's annual 161 tons of gold output (2012).

Peru's Mining Law was approved in 1992 with the aim of attracting foreign investment in the sector. Since 2000, a number of countervailing laws have been enacted that focus on sustainable development. Currently, the Ministry of Energy and Mines (MINEM) has the authority to regulate mining activities within Peruvian territory. MINEM grants mining concessions to local or foreign individuals or legal entities through a specialized body called The Institute of Geology, Mining and Metallurgy (INGEMMET). In addition to permission from MINEM, mining companies must receive the approval of

[18] At the federal level, governance legal provisions are exemplary, i.e. the e-governance of mining titles, licenses and reporting.

environmental impact studies (reviewed by the Ministry of the Environment, MINAM), including an assessment of their social relations plan, certification that there are no archaeological sites in the area, and a draft of a mine closure plan. In addition, the mining company must obtain water rights from the National Water Authority and surface lands rights from individual landowners.[19]

Given the importance of the sector, environmental performance has long been pivotal issue on the political agenda. Discussions about environmental governance in the mining sector have been driven by the recognition that environmental issues can affect the competitiveness of the sector, as well as the well-being of the population. In 2001, for example, the Ministry of Energy and Mines developed a project for the environmental rehabilitation of abandoned mine sites.[20] Under the initiative, Peru conducted studies to identify areas affected by mining, as well as the type of environmental problem, which included areas affected by acid drainage, mining tailings, and water pollution. The "Inventory of Inactive Mines" helped assess approximately 85% of environmental liabilities in the country and establish priority areas for mitigation activities.[21] The project showcased 20 sites requiring immediate attention and at least four watersheds in critical condition (e.g. Santa, Rimac, Mantaro and Llaucano). In 2012, further studies supported by the Governments of Germany and Japan and the European Union assessed and geo-referred mining environmental legacies, identifying 7,576 sites requiring urgent government intervention.[22] Identified hotspots included areas such the La Oroya smelter, often described as one of the most polluted places on earth, Pasco, Hualgayoc, and Huancavelica.

The government and private operators have been under increasing pressure to respond to civil society organization demands for improved environmental stewardship. The Cajamarca region, for example, was slated to receive US$ 20 billion in projects, including US$ 4.8 billion for the 'Minas Conga' gold-copper

[19] http://www.kpmg.com/Ca/en/industry/Mining/Documents/Peru.pdf
[20] Law No. 28271 defines 'environmental liabilities' to include "all installations, discharges, emissions, waste leftover, and disposals from mining operations which have been abandoned or are inactive that constitute a permanent and potential threat to human health, the surrounding ecosystem, or property".
[21] Priorities were established on the basis of the assessment of key variables which included: risk of catastrophic failure, size of the population and infrastructure affected or at risk of water contamination level, soil, flora and fauna, impact on the quality of life of the population and the socioeconomic impact.
[22] The information on "Pasivos Ambientales Mineros" was updated on 03/09/2012.

project. However, it had to suspend the project in 2011 due to major environmental protests. In 2012, as a response to these protests, the governments created an independent National Service for the Certification of Sustainable Development (SENACE, chaired by MINAM) to approve environmental permits. The Ministry of Environment was charged with its implementation through an independent entity, the "Oficina de Evaluación y Fiscalización Ambiental" (OEFA). In addition, it was charged with oversight of mining Environmental Impact Assessments (EIAs), a mandate that was transferred from the Ministry of Energy and Mines.[23] If anything, recent social conflicts have stressed legal regulations and lack of adequate enforcement. EIAs are not sufficient to ensure sustainable development and a conflict free mining sector.

Administrative reforms in the mining sector, however, have not prevented the emergence of new environmental problems. For example, in the 'Madre de Dios' region, where 97% of mining is informal alluvial gold extraction, experts estimate that approximately 42,000 kilos of mercury per year are being discharged into the ecosystem and that approximately 50,000 hectares of forest have already been affected by mining (Asner et al. 2013; Mosquera 2009). In order to foster the introduction of cleaner technology in the region, the government of Peru has recommended the use of gravimetrical methodologies and other practices that do not rely on the use of mercury and toxic substances (DL N° 1100, art. 9°). It has also recommended the evaluation of environmental compensation mechanisms for select projects (EIA category III). The GoP has supported an extensive program for the legalization of artisanal and small-scale informal gold miners (i.e. in the Costa and Sierra regions), which are often used as an example in the global mining community. Some 70,000 mining companies have enrolled in the ongoing campaign to formalize the ASM. Moreover, as part of the National Environmental Action Plan ("Plan Nacional de Acción Ambiental / Diagnóstico Situacional 2011-2021") Peru passed Decree N° 012-2010-MINAM targeting the reduction of illegal activities and environmental deterioration in the area; it recommended the creation of a judicial unit specifically dedicated to prosecuting environmental crimes in

[23] The Conga project was the last project approved under the old MINEM-operated system.

the Madre de Dios region. Along with government-approved norms to regulate the process of participatory environmental monitoring and surveillance, a growing number of environmental participatory committees are being created to ensure community oversight during all stages of the mining process. Assessing the level of participation of these local communities is essential to evaluate and improve these initiatives. At the next stage, the GoP needs to monitor and register the level of local participation in environmental issues related to the mining process. Despite the success of these legislative initiatives, challenges related to alluvial mining persist. This is mainly because the GoP has delegated mining management and environmental oversight responsibilities to regional authorities, which are often unable to deliver effectively on their mandates. In fact, although recognition of the impact of mining has been reflected in policy and law, inadequate mining practices continue to threaten the environment. The effective implementation and enforcement of legislative provisions and environmental governance directives requires further empowerment of regional authorities.

Regardless of policy implementation challenges, technical skill development opportunities are adequate[24] in Peru, and a considerable number of Green Funds are available for the promotion of clean technologies in the sector. For the formal mining sector, the challenge lies in adequately handling the administrative requirements needed to apply for financing opportunities rather than in their availability. An example is the recently approved US$ 120 million fund for CONCYTEC, which co-funds industrial technical innovation, including mining. These funds support international PPP projects in which the cost is shared equally among international partners, national academic institutions, Peruvian private companies, and CONCYTEC.

Findings

In general, reducing the environmental footprint of mining operations requires initiatives on several fronts, including:

[24] At the technical level, the main service providers are the National Service for Industrial Work Training ("Servicio Nacional de Adiestramiento en Trabajo Industrial", Senati) and Tecsup.

- The establishment of a **technical and process-oriented environmental monitoring system** capable of supporting inspection needs. Traditional surveillance of environmental performance based on measuring critical indicators (e.g. regarding water, air, soil qualitative status) that encompass mineral-economic aspects only partially. From the perspective of mineral governance, the optimization of a deposit's outcome, including the eventual selling of by-products, is increasingly important to the overall performance of the mining sector. In addition to conventional indicators, sectoral performance now requires the monitoring of other factors, such as the state's income or the re-cultivation capacity of previously mined areas. These considerations often require the development of new technical indicators to monitor the environmental effects of mining operations and define benchmarks for different applicable techniques and processes. These assessments must be accompanied by evaluations of the mandated institutions and the personnel to perform inspections evaluating the effectiveness and adequacy of sector-related performance indicators in decision-making.
- The **improvement of occupational training in mining** on all levels. Appropriate academic training (e.g. Universities) as well as opportunities for technical and vocational capacity-building (e.g. mining schools and training centers) are a crucial aspect for the introduction of cleaner technology. In order to ensure the sustained reinforcement of training programs, the sector could benefit from the development of regional cooperation networks. These initiatives would also facilitate issues such as the mutual recognition of certificates, professional training, and the development of a regional market for experts in the sector.
- The **systematical after-use and rehabilitation of tailings and mining legacies.** Innovations in mining technology offer great potential to re-process tailings, sludge ponds, and other mining legacies, which until now have only been partially exploited. Promoting private engagement for the recovery of valuables in these mining legacies, and a simultaneous remediation would be of high economic and political value. This component often requires the development of standards and regulations for process-parallel rehabilitation and mine closure, as well as means to secure

funding (e.g. closure bonds, accrued liabilities, etc.) for mine closure.

- The **formalization of small-scale mining.** Small-scale mining operations account for a significant part of mineral production in Latin America and the Caribbean, and they present unique challenges for monitoring and regulatory agencies. The formalization of small-scale miners facilitates the identification of challenges and the development of appropriate responses to reduce the environmental footprint of these operations. Initiatives for the formalizations of small-scale miners are currently developing in several LAC countries, and they present significant opportunities for regional exchanges and the development of new strategies.
- Promoting dialogue related to experiences in the area of **fiscal and non-fiscal incentives as political and economic steering instruments**. There are opportunities for the development of incentive systems geared at promoting investment and safer operational practices. Regional experiences demonstrate the potential for stimulating prospection and exploration through regulatory mechanisms, which could be fostered through regional dialogues geared at the identification of appropriate incentive policies.
- A **fair distribution of rights to have a say in the approval of operations, costs, and benefits of mining** at all levels (e.g. national, regional, local). Reducing the environmental and social footprint of mining requires improved participation and better distribution of the financial benefits derived from mining to the communities and regions of origin. Perceived unfairness in the allocation of sector costs and benefits can trigger political and social instability, and thus foster the use of shortcuts and more environmentally risky practices geared at maximizing benefits in the short term. Instead, the development of safe conditions for investment, rooted in reliable social licenses to operate, promotes the development of safer operational practices.

Recommendations

The implementation of such initiatives cannot be recommended without paying particular attention to the context in which they are promoted. Indeed, although they share common features, the institutional,

political, geological, and social framework conditions in Bolivia, Guyana, and Peru are quite different. On the basis of an analysis of the mining sector in the each country, the following section outlines opportunities to promote cleaner technology in each specific context.

Bolivia

In Bolivia, the establishment of adequate national mining qualification services and capacity building opportunities would require, in the first place, the assessment of the specific human resources and skills needed for the mining sector. The design and development of curricula aligned with sectoral priorities could be achieved through the implementation of mobile training brigades capable of delivering training and qualification at problem sites. In addition to operator training, capacity building activities should target key mining sector institutions. They should train government officials and other stakeholders about responsible mining on issues such as environmental management, OSH, social issues, and mine closure, all of which are crucial for the implementation of cleaner mining practices. These programs should provide a strategy for retaining competent staff and a plan for acquiring the necessary technology and equipment to allow them to perform their job effectively. Moreover, qualification services will have to meet the requirements of the national educational system.

In this regard, Bolivia should consider the establishment of a Cleaner Production Center to be responsible for technology benchmarking, to support to the local manufacture of cleaner technology and the implementation of new methodology, to promote the development of more efficient indicators to monitor energy, resource, and environmental aspects of mining production. In addition, such a center could support the development of pilot interventions in hotspots and promote responsible mining practices through capacity building and information dissemination activities that build upon exiting initiatives (i.e. MEDMIN program, CPTS, Danida).

Finally, the government could incentivize the use of cleaner technology in mining by providing support for the economic re-use and rehabilitation of mining liabilities. Such policies could build upon existing

initiatives for the management of environmental legacies (i.e. SERGEOTECMIN's mapping and mining tailings management program; COMIBOL's tailings and dumps reuse; and the "Cuenca Poopo" project funded by the EU). Moreover, the GoB should support the identification of investment opportunities in former mining rehabilitation sites. It should also support tender investment through the identification of potential sub-products and increased added value through productive linkages in the sector, as well as assisting with mine tailings management.

Guyana

In Guyana, actions to promote the use of cleaner technology in mining should, in the first place, target the creationof economic development policies that function within the legal frameworks of the mining sector. Such objectives may be achieved by mainstreaming the principles of LCDS into national mining policies, laws, and regulations. The GoG may then consider reviewing mineral revenue and mineral rent management, particularly as a tool to foster growth in key sectors of the low-carbon economy, to improve tools supporting decision-making for land use design, and to enable systemic technical inter-agency integration. Further, the development of adequate natural resource management tools and the establishment of an environment that promotes investment will require the commissioning of a Sector Environmental and Social Impact Assessment (SESIA) capable of addressing, among other elements, the cumulative impacts of small and medium scale operations. In addition, the government should consider the development of new environmental performance indicators and the establishment of more stringent monitoring practices via the formulation of governmental environmental targets that meet international mining industry standards (i.e. GRI, ICMM). Finally, it could pursue the implementation of an integrated approach to land use planning before releasing new areas for mining purposes, the review of existing mining incentives frameworks with respect to environmental efficiency (for the design of adequate incentive frameworks to promote the greening of the industry), and the optimization of existing reclamation funds and environmental bond schemes.

In the second place, in order to promote skill development, Guyana should consider upgrading its training programs and facilities at the Linden mining school and other academic, technical, and vocational service providers, while ensuring that its training meets national education guidelines (certification etc.). Such activities would also contribute to necessary institutional strengthening. For example, the GoG could consider supporting the GGMC on the e-governance of mining operations and the delivery of technical advice for the sector. In addition, these initiatives would help coordinate mining and forestry activities, and the institutional mandates for environmental monitoring, enforcement of legal framework, and inspection.

The GoG should also ensure the alignment of funding mechanisms for mining investment in clean technology with regional and infrastructural planning strategies. The promotion of investment in non-traditional mining resources (diversification of production) with a low impact (underground gold, non-metallics, etc.) would particularly help alleviate the impact of alluvial gold and diamond production. Improved prospection and extraction practices would reduce the impact of tailings, foster the early recuperation of land, reduce energy consumption, and help screen oversize gravel. In line with these policies, the GoG could establish a fund to re-finance leasing and loan schemes for mining investment in green technologies, and promote the development of public-private partnership frameworks to enable private sector participation in infrastructure projects. Finally, strengthening mining environmental governance could be achieved through the establishment of a dedicated task force to recover/rehabilitate land degraded by mining operations. Such groups could travel to neighboring countries and help establish a more effective monitoring system and appropriate rehabilitation practices. They could also implement practical measures in Amerindian communities and promote alternative income generation on land recovered from mining.

Peru

The government should consider supporting business development services for technological innovation in the mid strata of medium scale operations in Peru. Specialized support for these companies should take into account pre-finance support to businesses, including matchmaking services, and business development (e.g. support for operational effectiveness) via corporate agent capacity building. In addition, financial support should specifically target the SME tranche of mining sector companies. By compiling and sharing business strategies and plans the government could help assess best practices in financial planning, repayment capability evaluation, and in the preparation of supporting documentation for financial assistance. Support services provided by the South African company GO-HI to the Swiss-South African Vertical Shaft Brick Kiln project provides us with a successful example of initiatives that support the greening of the brick industry. Under these schemes the service provider acts as a qualified facilitator for manufacturers and finance institutions. The development of a platform for investment in clean technologies facilitates access to green funds and tailored technical advice for operators. It also supports targeted investments in the mining sector. Overall, such mechanisms support the development of cleaner production facilities and promote the use of non-regulatory incentives for improved operations. In essence, the government of Peru should promote the development of effective partnerships with the private sector and directly focus on the promotion of recognized best practices.

In addition, the GoP should develop technical training programs to improve education at the regional-level. Such initiatives would contribute to the mining formalization initiative and the development of improved natural resource governance in subnational governance systems. Supporting these systems could result in improved land-use and mining management mechanisms (e.g. economic and ecological planning systems), streamlined administrative procedures and guidelines for local authorities (e.g. strengthening e-governance schemes); and increased integrated industrial development along resource corridors. Finally, in order raise the level of OEFA member training, the GoP should consider developing an environmental assessment database. Such a database would assess and rate the known best practices and clean technology available to producers and offer guidelines for monitoring operations.

References

Asner, Gregory P., William Llactayo, Raul Tupayachi, and Ernesto Ráez Luna. 2013. "Elevated Rates of Gold Mining in the Amazon Revealed through High-Resolution Monitoring." *Proceedings of the National Academy of Sciences of the United States of America* (October 28)

Bellas, AS. 1998. "Empirical Evidence of Advances in Scrubber Technology." *Resource and Energy Economics*. 20 (4). 327-343

Bovarnick, A, F Alpizar, and C Schnell. 2010. "The Importance of Biodiversity and Ecosystems in Economic Growth and Equity in Latin America and the Caribbean: An Economic Valuation of Ecosystems." *New York: United Nations Development*. UNDP.

Corbin, Hisakhana. 2010. "A Case Study of the Socioeconomic and Environmental Impacts of Brazilian Migration to Guyana". Washington D.C.: IADB.

ECLAC, Economic Development Division. 2013. "Updated Economic Overview of Latin America and the Caribbean 2012". Santiago de Chile: ECLAC.

Farthing, Linda. 2009. "Bolivia's Dilemma: Development Confronts the Legacy of Extraction." *NACLA Report on the Americas.* 42 (5). 25.

Gunningham, Neil, R.A. Kagan, and D Thornton. 2003. *Shades of Green: Business, Regulation, and Environment*. Stanford: Stanford University Press

Guyana Geology and Mines Commission. 2012. "Guyana Geology and Mines Commission - Review 2012". Georgetown: GGMC, Government of Guyana.

Hilson, G. 2000. "Barriers to Implementing Cleaner Technologies and Cleaner Production (CP) Practices in the Mining Industry: a Case Study of the Americas." *Minerals Engineering*. 13 (7): 699-717.

Hinton, Jennifer J., Marcello M. Veiga, and A.Tadeu C. Veiga. 2003. "Clean Artisanal Gold Mining: a Utopian Approach?" *Journal of Cleaner Production* 11 (2): 99–115.

ICME, International Council on Metals and the Environment, and United Nations Environment Programme. 1996. *Case Studies Illustrating Environmental Practices in Mining and Metallurgical Processes*. Paris: UN.

MEG, Metals Economics Group. 2012. "World Exploration Trends". Nova Scotia: MEG.

Mosquera, César. 2009. *Estudio Diagnóstico de La Actividad Minera Artesanal En Madre de Dios*. Lima: Fundación Conservación Internacional.

Oblasser, Angela, and Eduardo Chaparro. 2008. *Estudio Comparativo de La Gestión de Los Pasivos Ambientales Mineros En Bolivia, Chile, Perú y Estados Unidos*. Santiago, Chile: CEPAL.

Office of the President, Republic of Guyana. 2013. "Low Carbon Development - Strategy Update: Transforming Guyana' s Economy While Combating Climate Change". Georgetown: Government of Guyana.

Ortega-Girones, Enrique, Alexandra Pugachevsky, and Gotthard Walser. 2009. "Mineral Rights Cadastre". Washington D.C.: World Bank.

Otto, James, Maria Luisa Batarseh, and John Cordes. 2000. "Global Mining Taxation Comparative Study." Institute for Global Resources Policy and Management, Colorado School of Mines, Pennsylvania State University.

Oxfam America. 2010. "Metals, Mining and Sustainable Development in Central America". Washington D.C.: Oxfam America.

Pegg, Scott. 2006. "Mining and Poverty Reduction : Transforming Rhetoric into Reality." *Journal of Cleaner Production* (14): 376–387. doi:10.1016/j.jclepro.2004.06.006.

Randall, PM. 1996. *Engineers' Guide to Cleaner Production Technologies*. USA: Technomic Publishing Company Inc.

Singh, David, Michael Priester, Thomas Hentschel, Cynthia L. Watson, Williams Aiesha, and Patrick Williams. 2013. "Guyana's Extractive Industry Sector (EIS)". Washington D.C.: Conservation International, WWF, and Projekt Consult.

Soares, Paulo Sergio Moreira, Osvaldo G. C. Cunha, and Lidia Yokohama. 2004. “Environmental Performance Indicators in the Mineral Industry.” In *VI International Conference on Clean Technologies for the Mining Industry*, 11. Rio de Janeiro: CETEM.

Sousa, Rodolfo, Marcello Veiga, Dirk Van Zyl, Kevin Telmer, Sam Spiegel, and Jeff Selder. 2011. “Policies and Regulations for Brazil’s Artisanal Gold Mining Sector: Analysis and Recommendations.” *Journal of Cleaner Production* 19 (6): 742–750.

Strategic Environmental Advice. 2013. “Draft Costed Strategic Framework for the Ministry of Natural Resources and the Environment 2013-2018”. Georgetown: Strategic Environmental Advice.

Thorpe, Beverley. 1999. *Citizen’s Guide to Clean Production*. Lowell: University of Massachusetts, Lowelll Center for Sustainable Production.

Unger, Jelena. 2010. “Cadastre Involvement in Sustainable Development as an Essential Component.” In *FIG Congress 2010,* Facing the Challenges – Building the Capacity (11-16 April).

USDI, US Department of the Interior, and US Geological Survey USGS. 2013. “Mineral Commodity Summaries 2013”. Washington D.C.: USGS.

Veiga, Marcello. 1997. *Introducing New Technologies for Abatement of Global Mercury Pollution in Latin America*. Vancouver: UNIDO, UBC, CETEM.

WEF, World Economic Forum on Latin America. 2013. “Responsible Mineral Development Initiative”. Geneva: World Economic Forum.

Wetzenstein, W. 2005. *Wirkungen Des Bergbaus in Entwicklungs- Und Schwellenländern*. Hannover: Bundesanstalt für Geowissenschaften und Rohstoffe (BGR).

ANNEX

Non-regulatory Instruments

Governments may employ regulatory and non-regulatory instruments to promote the use of cleaner technology in mining. A list of exhaustive direct and indirect incentives is detailed below.

A. Direct Incentives

Nature of incentives	Different potential incentives	Options for environmental conditionality
Financial	Subsidized buying price	For gold from small producers this system has been established with certification and labelling schemes under ARM and Fair Trade. The compliant producers receive a market established bonus payment of 10 to 15% on the sales price, which is bound to social and environmental investments. It seems that the effect of subsidized buying prices is not effective in stimulating investment in new clean and better performing mining technology[25].
	Credits and banking services	Special "green credit lines" with commercial banks or development banks (and eventually re-financed by international donors) can establish access to finance for operators willing to invest in cleaner technologies.
	Support of an affiliation to carbon-trade scheme as an individual project or under the umbrella of a plan of action	Projects that focus on reducing the carbon footprint, i.e. reducing transport mining operation costs by replacing diesel truck transport with conveyor belts may qualify for the generation of CO_2-certificates. The high administrative burden, the high cost of preparing a contract (around US$ 300,000 per contract) and funding scheme as well as the currently very low prices for the certificates suggest that this is not a good option.
	Revolving funds	Revolving funds can be established for investments in green mining technology. It is a specific investment in the mining sector given that the periods of amortization are quite long and could lead to slow pay back and turnover of a revolving fund.
	Operating subsidies	Operating subsidies are only justified in cases where the additional environmental work done exceeds the normal responsibilities of the operator, i.e. in the case of mine site rehabilitation from legacies of the past. These kinds of subsidies tend to create a subsidy economy and lead to market distortions.

[25] Most of the cases where mines have affiliated to the certification scheme these mines were already adhering to higher moral, environmental, human rights and social standards.

	Equity participation of the Government	This may be seen by Governments as a means to impose stronger rules and gain more transparency with respect to the operation. Given the difficult track record of public institutions as operators, the private sector is looking at this option more as a threat than as an incentive.
Material	Free or subsidised equipment	Would be justified for innovative technology, which has only been introduced to the country as showcase technology. In the case of public funds involved in subsidies, the operator shall grant access to interested parties such as academics, industry, government, and civil society for further dissemination of the technology.
	Provision of infrastructure	In many of the alluvial mining operations the lack of infrastructure hinders the mechanization of heavy tools, ie. in Guyana and the Peruvian Amazon region, miners have faced technical challenges dredging, monitoring impacts, and introducing more efficient mining equipment
Diverse	Mixed-bag of direct financial and material incentives	• See above

Source: Elaboration by Michael Priester, Projekt-Consult GmbH for the present study

B. Indirect Incentives

Nature of incentives	**Different potential incentives**	**Options for environmental conditionality**
Taxation	Tax waivers	Tax holidays or tax stabilization may be agreed upon in concession agreements. They can be linked to the application of environmental best practice.
	Special tax deduction schemes	Deduction of twice the prospecting and exploration costs from the taxable income has led to accelerated mining development in Chile. This system may be adopted to incentivize investment in cleaner technology. In addition, a scheme of accelerated depreciation allowances for expenditure on machinery and equipment, as well as on shaft sinking and exploration of mineral resources for underground exploitation would be beneficial and would only slightly distort the market.

Nature of incentives	Different potential incentives	Options for environmental conditionality
	Exemption from import taxes for "green" mining and equipment processing	Tax-free import of acknowledged clean mining, processing, and exploration equipment should be foreseen. According to James Otto,[26] to encourage investors to run a more environmentally friendly mine, a tax credit may be granted by the government for the installation of pollution control devices, or a high tax may be imposed on the discharge of harmful effluents. See more details on tax incentives below.
Legal & admin.	Relief from administrative procedures for small mines (e.g. concession applications, EIA)	Type approval for tested standardized concentration plants with optimized environmental performance. This option is repeatedly discussed as a mean to promote the formalization of small-scale mining and ease application procedures. Legal recognition of collective EIA systems for mines with similar technology that operate in the same environmental conditions (same drainage area, same ecosystem) can avoid unnecessary costs for studies and focus on the practical issues of environmental management plans, which remain individualized (system ECO+, as approved for the Ecuadorian ASM sector)
	Benchmarking	Benchmarking allows authorities to easier evaluate the performance of techniques and processes and their compliance with national environmental and social standards. It thereby contributes to easing administrative processes.
	Legalization of the mine	Supporting the negotiations between operators and titleholders is recommended in cases of conflict. This had been performed by the GAMA project and supported by the national and regional Governments in Peru in the case of La Rinconada, which was successfully concluded and led to a take-over of the mine by the operators. The process led to law and order at the mine side and enhanced adherence to national standards Lowering the barriers for legalization and providing means for overcoming informal status (as the IGAC system in Peru currently) further help to enact environmental laws in the

[26] Mining Taxation in Developing Countries; Professor James M. Otto; study prepared for UNCTAD; 11/2000

Nature of incentives	Different potential incentives	Options for environmental conditionality
		sector.
	Provide status of “landed immigrant“ to investors and specialists/experts	In countries with restricted immigration rules it can be of importance to ease these rules for innovative and responsible mining companies, allowing easier access to skilled international staff (generally more problematic in African and some Asian countries).
Professional support	Supporting the access to finance services	Supporting the access to funding arrangements will overcome the existing bottleneck, where mining operators are not sufficiently prepared to meet the pre-requisites of funding agencies and are not internally prepared for third party funding.
	Machine leasing pools	Leasing arrangements are quite frequent between equipment providers and mining operators and have minimized upfront cash requirements for mining operators. Governments may support these systems, if environmentally sound technology is supplied under these schemes The Peruvian Government is assessing the options to initiate PPP projects to establish local custom milling plants for ASM communities, replacing their rudimentary and polluting concentration processes by modern and environmentally better performing processes. This is in addition seen as a further element of formalization.
	Technical advice	Technical support and advice is a major driver of change towards environmentally sound working practices and responsible mining processes, as underlined by experiences from projects. On-site advice and successful pilot projects demonstrate the advantages of technological change.
	Support of local service providers and contractors	Especially the small and medium mining sector is generally not prepared to hire consultants and contractors. Consequently a local consulting and contractor sector is not developed. It is recommended that international cooperation support the development of these markets, thereby enhancing not only the added value for the local economy but also contributing to the upgrading of operational performances (i.e. by accreditation processes).

Nature of incentives	Different potential incentives	Options for environmental conditionality
	Training and further training	Training, qualification and vocational education is a key for establishing sound national industry in general and mining sector in particular. It should be aligned with the national educational system and targeting at the academic (university), the technical (college) and the vocational level (mining school or in house/on the job training). Clean technology and responsible mining practice has to be built into the curricula.
	The support of institutional and organization framework	The lack of advocacy and umbrella organisations of certain mining subsectors can hinder the dialogue between the Government and the private sector actors. A support of the sector organisation helps to overcome this thread, as positive examples i.e. from Peru underline
	Engineering support	Engineering support would rather be an aspect to be provided by international cooperation projects than by Governments itself, which generally lack the technical expertise required. Examples as the Global Mercury Project, as well the Swiss funded projects in Ecuador, Peru and Bolivia[27] show, how important these supports are in obtaining environmental goals.
	Supporting innovation in the equipment supply and manufacturing sector	The supply of high quality locally manufactures equipment and machinery is a highly supportive issue within the sector innovation and modernization process and greening of the industry. Successful examples as the one in Senegal (see text box below) underline this statement. This even more, as in many countries the equipment providers act as financing and/or buying agent and have an important role for the selection of technology (i.e. in Guyana).
	CPC	Cleaner Production Centers and databases on proven technical and operational solutions for responsible mining and process optimization with regards to environmental and social performance are seen as an effective mean to overcome the existing lack of knowledge of local mining operators (i.e. CPTS in Bolivia).
	Support with academic studies	Cooperation between academic institutions and mining operations can greatly enhance the quality of the academic education as well as the performance and knowledge of mining

[27] Proyecto Minería sin Contaminación (PMSC) in Ecuador, Gestión Ambiental en la Minería Artesanal (GAMA) in Peru and Medio Ambiente y Minería (MEDMIN) in Bolivia

Nature of incentives	Different potential incentives	Options for environmental conditionality
		operations, and increase willingness to study options for the upgrading of processes (since costs are shared with the academic institutions). A link with the National Innovation System would further enhance impact and dissemination (i.e. via CONCYTEC in Peru).

Source: Elaboration by Michael Priester, Projekt-Consult GmbH for the present study