# USAID GLOBAL ENVIRONMENTAL MANAGEMENT SUPPORT (GEMS)

## SECTOR ENVIRONMENTAL GUIDELINE: ARTISANAL AND SMALL-SCALE MINING

## Final

JUNE 30, 2017

BANRO MINING SITE IN THE DEMOCRATIC REPUBLIC OF THE CONGO. USAID

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# ABOUT THIS DOCUMENT AND THE SECTORAL ENVIRONMENTAL GUIDELINES

**This document presents one sector of the *Sector Environmental Guidelines (SEGs)*** prepared for United States Agency for International Development (USAID) under the Agency's Global Environmental Management Support (GEMS) program. All sectors are accessible at http://www.usaidgems.org/sectorGuidelines.htm.

**Purpose.** The purpose of this document is to support environmentally sound design and management (ESDM) of common USAID sectoral development activities by providing concise, plain-language information regarding:

- The typical, potential adverse impacts of activities in these sectors (e.g., mining, agriculture, construction, fisheries, health care), including climate change considerations;
- How to prevent or otherwise mitigate these impacts, both in the form of general activity design guidance and specific design, construction, and operating measures;
- How to minimize vulnerability of activities to climate change, as well as contributions of activities to climate change;
- More resources for further analysis of these issues; and
- How to develop environmental compliance applications.

**Environmental Compliance Applications.** USAID's mandatory life-of-project environmental compliance procedures require that the potential adverse impacts of USAID-funded and managed activities be assessed prior to implementation via the Environmental Impact Assessment (EIA) process defined by 22 CFR 216 (Reg. 216). They also require that the environmental management/mitigation measures ("conditions") identified by this process be written into award documents, implemented over the life of project, and monitored for compliance and sufficiency.

These procedures are USAID's principal mechanism to assure ESDM of USAID-funded activities—and thus to protect environmental resources, ecosystems, and the health and livelihoods of beneficiaries and other groups. They strengthen development outcomes and help safeguard the good name and reputation of USAID.

The SEGs directly support environmental compliance by providing information essential to assessing the potential impacts of activities and to identifying and designing appropriate mitigation and monitoring measures.

*However, the SEGs are **not** specific to USAID's environmental procedures. They are written for general application and are intended to support ESDM of these activities by all actors, regardless of the specific environmental requirements, regulations, or processes that apply, if any.*

**Region-Specific Guidelines Superseded.** This SEG replace the following guidance: *Small-Scale Mining: Cleaner Production Fact Sheet and Resource Guide* (2003) http://www.usaidgems.org/Documents/SectorGuidelines/ENCAP/mining.pdf.

This document serves as an introductory tool to Agency staff when initiating the design of projects related to artisanal and small-scale mining (ASM). This document is not intended to act as an exhaustive summary of all potential impacts, as-site specific context is critical to identify impacts. Further, the Guidelines are not a substitute for detailed sources of technical information or design manuals. Users are expected to refer to the accompanying list of references for additional information.

**Comments and corrections.** Each of these sector environmental guidelines is a work in progress. Comments, corrections, and suggested additions are welcome. Email: gems@cadmusgroup.com.

***Advisory:*** *The Guidelines are advisory only. They are not official USAID regulatory guidance or policy. Following the practices and approaches outlined in the Guidelines does not necessarily assure compliance with USAID environmental procedures or host country environmental requirements.*

# TABLE OF CONTENTS

# LIST OF ACRONYMS

| | |
|---|---|
| ASGM | Artisanal and small-scale gold mining |
| ASM | Artisanal and small-scale mining |
| BEO | Bureau Environmental Officer |
| DRC | Democratic Republic of the Congo |
| EIA | Environmental impact assessment |
| EMMP | Environmental mitigation and monitoring plan |
| ESDM | Environmentally sound design and management |
| FAA | Foreign Assistance Act |
| FAO | Food and Agriculture Organization of the United Nations |
| GEMS | Global Environmental Management Support Project |
| GIS | Geographical information system |
| GPS | Global positioning system |
| IEE | Initial environmental examination |
| ILO | International Labor Organization |
| IPCC | Intergovernmental Panel on Climate Change |
| LED | Light-emitting diode |
| LSM | Large-scale mining |
| MIDAS | Mining Investment and Development for Afghan Sustainability (project) |
| NAP | National Action Plan |
| OECD | Organisation for Economic Cooperation and Development |
| PPE | Personal protective equipment |
| PRADD | Property Rights and Artisanal Diamond Development (project) |
| SEA | Strategic Environmental Assessment |
| SEG | Sector Environmental Guideline |
| TB | Tuberculosis |
| USAID | United States Agency for International Development |
| UNEP | United Nations Environment Programme |
| US | United States |
| USEPA | U.S. Environmental Protection Agency |
| UNIDO | United Nations Industrial Development Organization |
| WHO | World Health Organization |

# INTRODUCTION AND PURPOSE OF THE GUIDELINE

An estimated 20-30 million people worldwide work in artisanal and small-scale mining (ASM), or *informal mining conducted by individuals, groups, families or cooperatives who use rudimentary processes to extract minerals or gems, often with no or very little mechanization*; an additional three to five times that number indirectly receive support from ASM activity (Buxton, 2013). While ASM is largely a poverty-driven activity (Tschakert and Singha, 2007), ASM and related activities contribute to poverty alleviation and economic development by providing jobs to millions of people around the world and offering diversification of livelihoods in developing nations. Communities and local economies throughout many developing nations often depend on the income raised through ASM-related jobs; in some areas, small-scale mines rival or outpace large-scale mining (LSM) in terms of local economic impact.

However, ASM can simultaneously create new or exacerbate existing environmental, health, and socio-economic challenges when not properly managed, potentially increasing risks for already marginalized populations and even perpetuating poverty. For example, ASM can involve the use of dangerous chemicals or practices for extraction and processing, resulting in unsustainable or unsafe conditions for the miners themselves, their families, and the surrounding community and ecosystem. In particular, mercury use in ASM (and artisanal and small-scale gold mining (ASGM)) is the largest source of mercury releases to the environment globally, and mercury emissions from the sector are transported through the environment on both a local and global scale. The occupational risks to miners from extraction and processing methods may require mitigation measures to reduce risk and improve overall health and well-being. Additionally, specific sub-populations (e.g., children and women) may face unique risks from ASM activity, both in terms of direct impacts to those engaged in mining and indirect impacts to those in surrounding communities. Human rights issues may arise in the sector, such as a lack of labor rights, especially among children or victims of human trafficking, and gender inequality in access to resources, working conditions, etc. In many nations where ASM occurs, rights to exploit the mineral resource can be a source of contention; for example, a lack of clarity on rights to surface versus sub-surface resources can lead to tensions and potential conflicts within ASM communities and between LSM and ASM stakeholders, especially in such cases when ASM occurs on LSM concessions. Finally, ASM practices can cause negative impacts to ecosystems via unsustainable use of natural resources, deforestation, degradation of land and/or waterways, or the alteration of valuable ecosystem services (food sources, soil nutrient cycles, etc.).

Despite the risks described above, project managers have a unique opportunity to positively impact ASM activities or communities through development interventions. USAID and other development funders or practitioners have a history of supporting ASM communities through miner formalization programs, reforestation projects, mercury-reduction activities, and other capacity-building efforts. Emphasizing best practices, contamination mitigation, and overall good governance in mining communities can translate into more effective development interventions and more sustainable communities and livelihoods. Toward that end, development specialists and USAID project managers working in the ASM sector can use this *Sector Environmental Guideline* (SEG) to understand the complexity of the ASM sector, including general risks and impacts, and apply this understanding to improve ASM practices for environmental, economical, social, and public health outcomes.

## DOCUMENT PURPOSE

This document is designed for project managers, project implementers, practitioners, or others working on development or environmental management projects that could impact ASM projects or communities that engage in ASM. This document addresses the following main components of ASM, after introducing the sector:

1. *The impact of development projects on ASM;*
2. *The impacts of ASM on the environment, health, and socio-political systems on multiple scales;*
3. *Best practices and mitigation measures for minimizing detrimental impacts of ASM;*
4. *The impact of climate change on ASM; and*
5. *The impact of ASM on climate change.*

This SEG for ASM introduces the range of possible impacts, particularly environmental, health, and socio-political, and explains how project managers and others can support prevention and/or mitigation through project design, environmental analyses for initial environmental examinations (IEEs), and during the development of site-specific environmental mitigation and monitoring plans (EMMPs). A focus on best practices and mitigation measures for ESDM of USAID projects will help missions comply with Section 117 of the Foreign Assistance Act (FAA) and Regulation 216, which require that EIAs be conducted and mitigations implemented for all USAID projects. This guideline is also intended to help USAID partners, staff, and other practitioners understand climate change impacts to and from ASM activities. Finally, the references section of the document lists cited documents as well as additional resources and references on this topic. The annexes address common ASM-related terminology in a glossary; the general ASM production phase, processing, and related technologies; and considerations for project design.

## HOW TO USE THIS DOCUMENT

This document is meant to be used as a tool to understand and respond to various challenges related to ASM. When referring to this document and working within their specific projects or interventions, project managers should recognize the complexity of the ASM sector and the diversity of influencing factors. ASM communities can be impacted by development projects, whether the projects focus on the mining sector specifically, or are focused on another sector but located in proximity to ASM communities. With an understanding of what defines ASM, managers should account for the specific local context, acknowledge issues to address, and identify means to prevent (if possible) or mitigate them, with an understanding that interests must be managed within the boundaries of project scope and administration ability.

Project managers should conduct a thorough assessment of local conditions before engaging in any work accounting for existing environmental, health, socio-political, and economic characteristics of an ASM community and the drivers of change. Underlying community health issues may be exacerbated by ASM activities or project activities in areas where ASM takes place. Thus, establishing a baseline understanding of the project context is critical prior to engaging in any activities.

Additionally, project managers should consider the lifecycle of the mine (discussed below and in **Figure 2**), from mine initiation to site closure. Ideally, new ASM-related projects will be designed to encourage implementation of best practices at each of the stages. Impacts to the environment, health, and surrounding socio-economic systems can occur throughout the lifecycle, and mitigation measures may also vary based on the lifecycle stage. USAID does not generally fund mining exploration or development; however, it can assist with formalizing existing mining activities or be involved in work during the mining closure or remediation phase. USAID may also be involved in purchasing equipment for use during production, especially as it relates to cleaner production, such as mercury capture technologies for gold shops, retorts, or alternative processing technologies such as centrifuges or shaker tables. Or, USAID may fund non-ASM-related projects in an area where mining site development is taking place. More on USAID's traditional role in ASM projects will be explored in the next section.

Regardless of the stage of the mining process during which the USAID project takes place, where possible, project managers and practitioners should focus on the implementation of sustainable practices (i.e., prevention) rather than remediation. Remediation is expensive – in some cases not financially feasible – and less effective overall. For example, instead of focusing on *removing* mercury from the surrounding environment, project managers should emphasize methods that avoid mercury use in the first place, and in particular, those actions called for in a country's ASGM National Action Plan (NAP), as discussed in the Contextual Considerations in ASM Communities section. Further, reforestation of a former mining site, a common activity that many might associate with reclaim of former mining lands, may actually increase risk as it opens potentially contaminated areas to farming, cattle grazing, or other public uses. When necessary, legacy mining issues should be referred to the appropriate bureau environmental officer (BEO) for further analysis.

Project managers should always understand that some impacts cannot be fully addressed by project activities; instead, they should pursue positive outcomes of engagement and intervention in communities. Improved practices should be drawn into project planning from the onset. Users of this guide are encouraged to consider how ASM practices can be made more sustainable throughout project activities.

Finally, project managers should note that projects are taking place within a value chain and existing landscape of relationships and networks built over time, both formally and informally. Projects may have impacts on those relationships in unintended ways, which project managers should try to anticipate during project design and implementation. These concepts will be introduced and explored in more detail in subsequent sections.

**KEY MESSAGE: PREVENTION VERSUS MITIGATION**

Avoiding impacts is more effective than remediating them, and prevention of contamination or unsustainable practices should be emphasized from the project start. Changing technologies or practices used during the development or production stage maximizes reduction of future impacts.

## ASM AND USAID

USAID has supported a variety of ASM-related projects; interventions in ASM typically occur in an existing community and involve improving existing processes. As described above, LSM activities are normally not supported by USAID. However, USAID's role in ASM may continue to change over time, as various global stressors (e.g., climate change, resource or food insecurity, conflict) influence migration and/or the adoption of alternative livelihoods and the positive and negative impacts of ASM on economic development are better understood.

USAID has pursued several activities in ASM-related work, including the following:

- Working in coordination with the local government and relevant agencies or ministries;
- Leveraging existing networks such as miner associations or indigenous groups;
- Addressing environmental impacts such as water contamination or forest cover change;
- Offering capacity building in coordination with technical assistance;
- Understanding complicating factors such as human trafficking in ASM communities; and
- Promoting formalization of miners, mining networks, or mining value chains.

These projects may impact existing ASM projects at various stages of a mine lifecycle or extraction process. Some interventions may seek to address mining itself and the use of mercury during production or refinement. Other interventions may seek to formalize the miners who are working within the extraction process in an effort to legitimize local value chains. Projects – and ASM-specific interventions in particular – should be carefully timed within the mine lifecycle, extraction process, or value chain so that project managers or implementers understand all the relevant forces.

Current projects range in scope from worker or process formalization to land rehabilitation. Some of these projects are summarized in **Table 1**.

| TABLE 1. USAID PROJECTS IN THE ASM SECTOR. | | |
|---|---|---|
| PROJECT NAME | LOCATION | SUMMARY AND KEY ELEMENTS |
| Mining Investment and Development for Afghan Sustainability (MIDAS) | Afghanistan | • Legal and regulatory reform for mining-related laws and regulations<br>• Capacity building for the Ministry of Mines and Petroleum to improve knowledge related to mineral exploration, drilling, mapping, and investment promotion, for artisanal and other scale mines<br>• Enterprise development for businesses and job seekers throughout the mining value chain, with a focus on construction, transport, geosciences, and improving transparency and communication<br>• USAID's Office of Economic Growth will continue working to develop stronger policies governing the mining sector |
| Oro Legal Artisanal Gold Mining Program | Colombia | • Building governance capacity for gold mining activities by strengthening Colombian government enforcement capacity<br>• Enhancing miner formalization and participation of indigenous communities<br>• Providing training and technical assistance to artisanal miners<br>• Reforesting of degraded areas<br>• Generating alternative livelihoods<br>• Improving drinking water in mining areas |
| ENV/Mining Program | Colombia | • Legalization and formalization of gold mining<br>• Reduction of mercury<br>• Rehabilitation of areas impacted by informal gold mining<br>• Mitigation of impacts from unauthorized artisanal, small-scale, and informal gold mining |
| Property Rights and Artisanal Diamond Development (PRADD) II Program | Central African Republic, Cote d'Ivoire, Guinea | • Reinforce property rights through a system of control and access for diamonds from mine to export<br>• Bring a greater percentage of diamonds into the legal chain of custody<br>• Increase legal incomes |
| Assessment of Human Trafficking in Artisanal Mining Towns in Eastern DRC | DRC | • Assess human trafficking patterns in Eastern DRC and the underlying social conditions that contribute<br>• Understand the role of armed groups in labor issues in ASM communities |

# OVERVIEW OF ASM SECTOR

## DEFINING ASM

Defining ASM is important but complicated; definitions vary from country to country and according to various legal frameworks. In many cases, the country-level definitions or criteria for defining ASM are tied to national legislation and local business metrics. Some countries define "artisanal mining" as occurring on a very small scale with manual labor or utilizing rudimentary techniques, while "small-scale mining" may be conducted on a slightly larger scale with some mechanization (Mining, Minerals and Sustainable Development Project, 2002). Neither should be confused with large-scale or industrial mining activities, which USAID does not generally support. Other countries may utilize other criteria beyond scale to distinguish what constitutes artisanal or small-scale mining, as demonstrated in **Table 2.**

**TABLE 2. DEFINING CRITERIA FOR ASM IN VARIOUS COUNTRIES.**

| COUNTRY | ASM CRITERIA |
|---|---|
| Cambodia | Depth of working |
| Côte d'Ivoire | Level of mechanization |
| Ecuador | Tonnage |
| Ethiopia | Annual production, level of mechanization |
| Ghana | Capital investment, number of participants |
| Guinea | Type of minerals exploited |
| Peru | Illegal versus informal, ASM in protected areas |
| Senegal | Depth of working, crude production levels |
| South Africa | Capital investment |
| Tanzania | Investment, labor and technology requirements |
| United Nations | Annual production capacity |
| Zambia | Size of concession area |
| Zimbabwe | Size of concession area, capital investment |

Although numerous attempts have been made to come to agreement on a standard, internationally recognized definition, one has not yet fully been established. In a broad sense, ASM is defined as *informal mining conducted by individuals, groups, families or cooperatives who use rudimentary processes to extract minerals or gems, often with no or very little mechanization* (Mining, Minerals and Sustainable Development Project, 2002). In other words, ASM activities involve low per capita productivity, require (or can only access) low-capital investment, and utilize mostly manual labor. Historically, the International Labor Organization (ILO) described ASM as *"…labor-intensive, with mechanization being at a low level and basic"* (Jennings, 1999). The definition established by the Minamata Convention on Mercury, a globally recognized treaty designed to protect human health and the environment from mercury contamination, is generally accepted by experts in the ASM field, despite its focus on ASGM. The Minamata Convention on Mercury defines ASGM as *"mining conducted by individual miners or small enterprises with limited capital investment and production"* (United Nations Environment Programme, 2013).

Development planners and implementing practitioners should familiarize themselves with all definitions. The value of having a working definition of ASM at the country level that it allows integration of ASM (and effective interventions) into the development strategy. Because of the potential local or regional ties to legislation and economic market trends, project managers must take note of and heed local definitions whenever possible. Project managers should be aware that despite international engagement to address ASM, countries regulate ASM; internationally defined working definitions do not supersede country-specific specifications (see section below on International Frameworks).

**For purposes of this document, we adopt the definition of ASM established by the Minamata Convention, and apply it across all types of ASM, not just gold:**

*"Artisanal and small-scale … mining conducted by individual miners or small enterprises with limited capital investment and production"*

ASM may be further defined by the informal nature by which activities often occur. There is consensus across countries that ASM represents a spectrum of "informal" activities that are distinguished from "formal" mining by a relatively "*low degree of mechanization, high degree of labor intensity, poor qualifications and mining labor competence, poor occupational and environmental health standards, little capital and inefficient productivity, deposit exploitation, little consideration of environmental issues, limited access to land and markets, and chronic lack of capital"* (Hentschel, Hruschka and Priester, 2003; 2002). While many ASM miners operate informally, in the absence of appropriate frameworks, some ASM miners operate within a "legal" or "formalized" framework, with established land titles and government permits, payment of taxes or fees, and compliance with social and environmental regulations imposed by the government.

ASM activities themselves can be disorganized but often operate via cooperatives, community groups, or other means of organization. Participation in ASM often fluctuates with commodity prices; as world markets fluctuate, people may shift livelihoods to take advantage of higher prices. ASM activity often occurs on the fringes of LSM leases, either coexisting knowingly or scavenging on LSM concessions. In some instances, ASM may be further characterized as potentially illegal, but it is important to distinguish nuances in illegality. While some informal mining activities may be characterized this way because miners have not complied with administrative procedures governing formal licenses, permits, and rights to land and resources, other activities may be outright financing or otherwise supporting criminal activity (e.g., arms trade, drugs, and warlords). This spectrum of legality is discussed in further detail in the sections below on specific impacts (in particular, see the Impacts of ASM section). First and foremost, USAID does not condone or support any ASM activities that contribute to criminal activity. USAID may become involved in projects that support capacity building and interventions, assisting current ASM projects in overcoming administrative burdens so they can legally operate.

### ASM GEOGRAPHY

As shown in **Figure 1,** ASM is estimated to occur in more than 80 countries worldwide. While shifts in global market trends, among other factors, have altered the estimated number of operations or miners, ASM has become integral to the economies of many countries in the developing world, and it serves as a source of livelihood and income at the local and regional level. Additionally, ASM significantly impacts global markets, as ASM production equals or exceeds that of LSM in many countries.

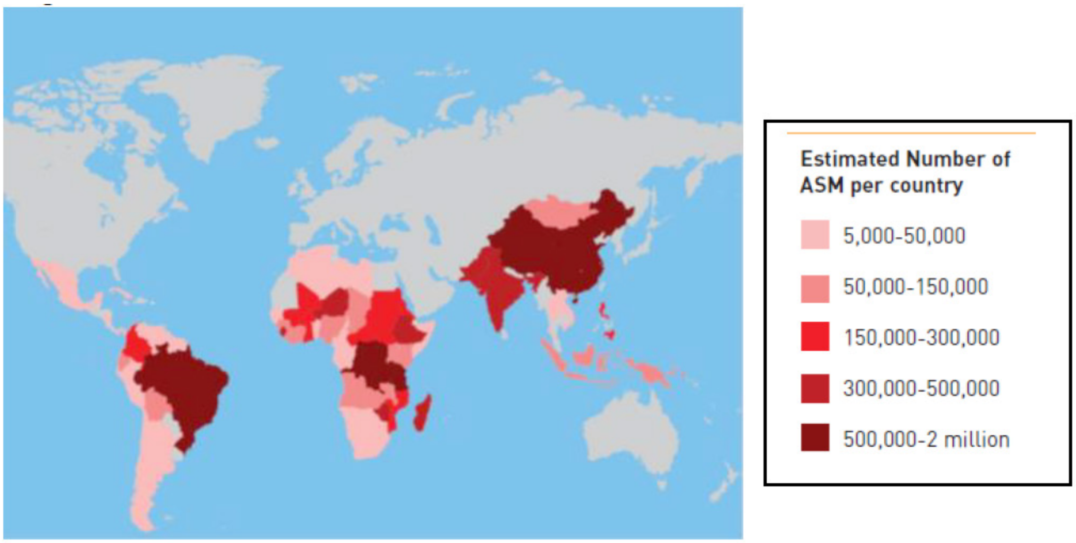


*Figure 1. Global representation of artisanal and small-scale miners. Source: World Bank's Communities and Small-Scale Mining Initiative.*

***ASM IN COLOMBIA***

Local ASM Activity: Colombia has a large ASM sector focused on gold and gemstones, such as emeralds. Gold, in particular, is gaining in popularity, and in the Department of Antioquia, there are 17 mining towns and 15,000 to 30,000 artisanal miners.

Challenges: Though mining is widespread in Colombia, ASM activities are largely unregulated. Additionally, guerrilla and paramilitary activities (as a result of a long-standing political conflict in Colombia) may force miners to process their gold in locations where it is not possible to handle mercury appropriately during the processing stage. However, legal miners may also use high amounts of mercury due to whole ore amalgamation. For these reasons, mercury release/emissions in Colombia are exceedingly high, as a result Colombia is the world's foremost mercury polluter per capita as a result of ASM activity.

Development Interventions: USAID currently funds the "Oro Legal" program in Colombia, which seeks to decrease environmental impacts and improve governance and address social conflict through the formalization of mining operations, recuperation of land, decrease in mercury use, and other activities. More on "Oro Legal" will be presented later in this document.

*See* http://www.sciencedirect.com/science/article/pii/S0048969711010059; https://www.usaid.gov/news-information/fact-sheets/artisanal-gold-mining.

***ASM IN THE DEMOCRATIC REPUBLIC OF CONGO (DRC)***

Local ASM Activity: ASM is a key source of revenue for hundreds of thousands of people in the DRC. In 2013, estimates of miners in eastern provinces of DRC measured more than 200,000, though some experts estimate that two to three million Congolese throughout the entire country work in ASM. Most mining in the DRC is for gold, as markets have shifted demand away from tin, tungsten, and tantalum.

Challenges: DRC mines face threats from state and non-state armed groups and public security forces; militarization is a key challenge in both gold mining and trade between provinces and entry into national and international supply chains. Violence in mining communities, fueled by this geopolitical conflict, has led to drastic impacts on social systems. The presence of militarized groups has also resulted in illegal taxation by non-state military agents and criminal networks interfering in local markets. Large migrations of miners following changes in security, production, local and world market prices, and the discovery of new deposits also have significant socio-economic impacts on local communities.

Development Interventions: Recent development interventions have encouraged the deployment of responsible supply chain initiatives for more sustainable sourcing practices, increased participation of local civil society, and improved governance by central and provincial governments.

*See:* http://mneguidelines.oecd.org/Mineral-Supply-Chains-DRC-Due-Diligence-Report.pdf; http://pdf.usaid.gov/pdf_docs/PA00K5R1.pdf.

***ASM IN MOZAMBIQUE***

Local ASM Activity: ASGM in Mozambique is the second largest sector in terms of employment after agriculture. It features little mechanization and heavy manual labor. Public health risks abound due to the lack of sustainable mining and processing techniques and low levels of environmental safety. In the Manica Province, where ASGM takes place, farming is common; however, many resources, such as water, soil, and forests, have been negatively impacted by mining.

Challenges: The Manica region has experienced substantial health and environmental impacts from ASGM, partly due to the general lack of formal processes and training among miners. Combined with political conflicts associated with the Manica Gold Mines, these issues have made enforcement and compliance activities difficult. A large number of informal miners work in concessional areas and older surveyed areas, as well as within fields, agricultural areas, and conservation areas. Families and communities often work together but are often unaccountable to the authorities.

Development Interventions: Efforts are ongoing to formalize mining groups and cooperatives in an attempt to provide training and protect natural resources and human health. The Development Mining Fund, for example, is a public institution, created to assist miners and promote sustainable mining practices and mitigation.

*See:* https://www.iucn.org/sites/dev/files/import/downloads/gold_mining_in_mozambique.pdf.

This document explores ASM on a global scale, despite the unique differences and contextual landscapes each ASM community may face. Therefore, while it is important to be aware of common practices among ASM communities, project managers should also gather and analyze site-specific information regarding underlying socio-economic and political systems, relevant extractives (e.g., targeted ores, gemstones, etc.), and physical environmental characteristics.

## ASM COMMODITIES

ASM can include extraction and processing of various types of minerals, gemstones (precious and semi-precious), and metals. A broad range of minerals, metals, or gems are mined within the sector, which continues to contribute significantly to global extraction. It is estimated that 15–20 percent of global minerals and metals are extracted through ASM. Of mined commodities worldwide, ASM accounts for an estimated 15-20 percent of gold, 15-20 percent of diamonds, approximately 20-25 percent of tin and tantalum, and 80 percent of colored gemstones, most notably sapphires. In many countries in Africa, activities center on the production of gold and diamonds. Beyond Africa, in Ecuador, the Philippines, and Peru, gold constitutes a majority of mineral production.

As global market trends shift, (e.g., significant changes occur in global prices for specific commodities, or demand for rare earth minerals for electronics increases), the scope and spatial and temporal distribution of ASM mining for specific commodities may follow. Arsenic, gallium, indium, and the rare earth elements cerium, europium, gadolinium, lanthanum, terbium, and yttrium are important mineral materials used in light-emitting diodes (LED), smart phone, and semiconductor technologies. Additionally, cobalt for use in lithium ion batteries is in high demand. Many of these metals are toxic or carcinogenic, and exposure increases chronic health risks to miners and their families. Globally, the ASM sector also exploits large amounts of tantalite, iron ore, and industrial minerals such as bauxite, marble, and limestone for aggregate and agricultural purposes. The ASM sector additionally includes mining and sale of coal, construction grade rock, depleted tailings, and sands in villages and along the roads.

Given the range of commodities that can be mined via ASM, **this document focuses largely on gold and diamonds**, due to the particular impacts that they have on local environments, human health, and socio-political systems, as well as the international governance attention that they have received. Foreign aid or intervention has also historically focused on activities related to gold and diamond mining.

## ASM LIFECYCLE AND EXTRACTION PROCESS

The lifecycle and extraction processes associated with artisanal or small-scale mines varies depending on the commodity or location but generally follow similar patterns. The lifecycle of a specific mine begins with site prospecting and exploration, which includes site development. Earth may be moved using rudimentary hand tools and manual labor, or in some cases may involve larger equipment. Though mining and processing can often happen at the same time, they are separated, as shown in **Figure 2,** because the activities associated with each step may differ. Site closure typically occurs when the commodities in that mine are spent, however, in ASM this typically does not occur if miners simply abandon the site. Ideally, remediation – or actions associated with reversing any environmental damage that occurred as a result of ASM activity – would take place upon mine closure; however, this often does not occur in ASM sites.

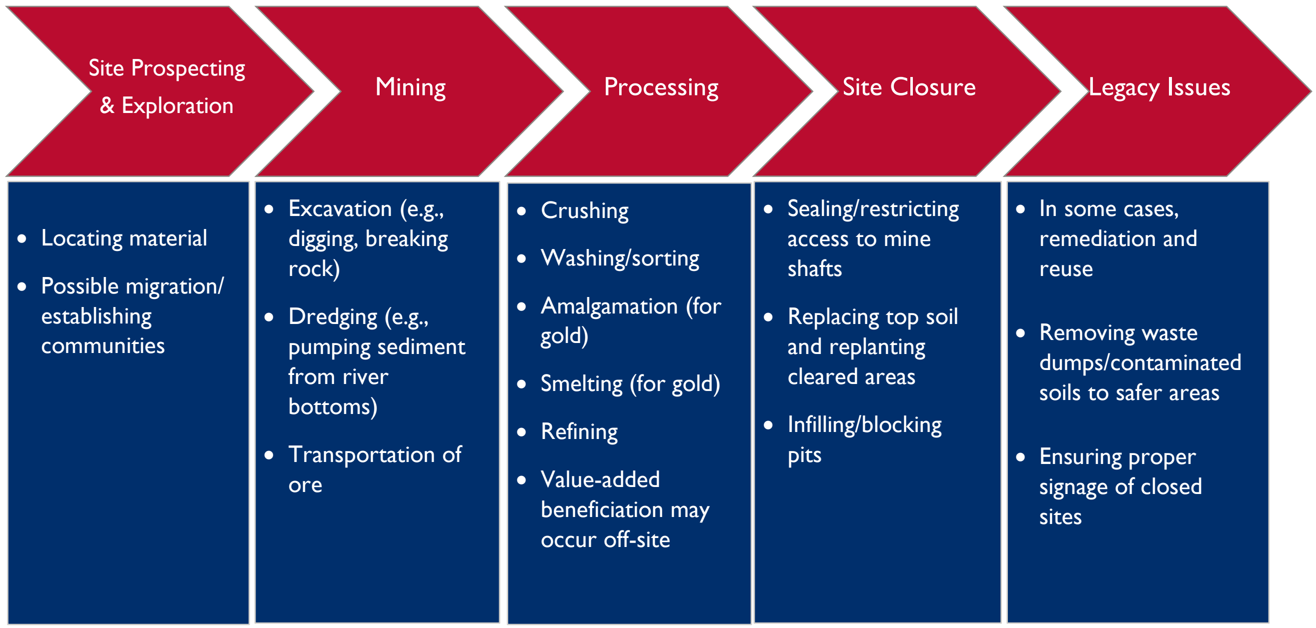


*Figure 2. Lifecycle of an artisanal mine and typical activities.*

Within the mining lifecycle, each phase may involve a separate series of steps. For example, processing may take place locally, or the commodity may be shipped elsewhere. Beneficiation, or value-adding, marketing, sales, final processing into jewelry or other goods, and transfer to buyers also occur outside of the mine and mining community. The value chain, which incorporates the economic or market stages of commodity production and sale, will be discussed later.

The mining and processing steps in **Figure 2** are highly complex and variable. ASGM extraction, described in **Figure 3** below, is just one example of how the mining and processing step in **Figure 2** is practiced; however, it can involve additional steps depending upon the commodity and region. In ASGM, additional possible extraction steps, such as crushing and milling, are outlined in red. Amalgamation, smelting, and other possible refining processes (outlined in blue) occur as part of processing. For further details on the process for ASM, see Annex 2: ASM Production, Processing, and Technologies.

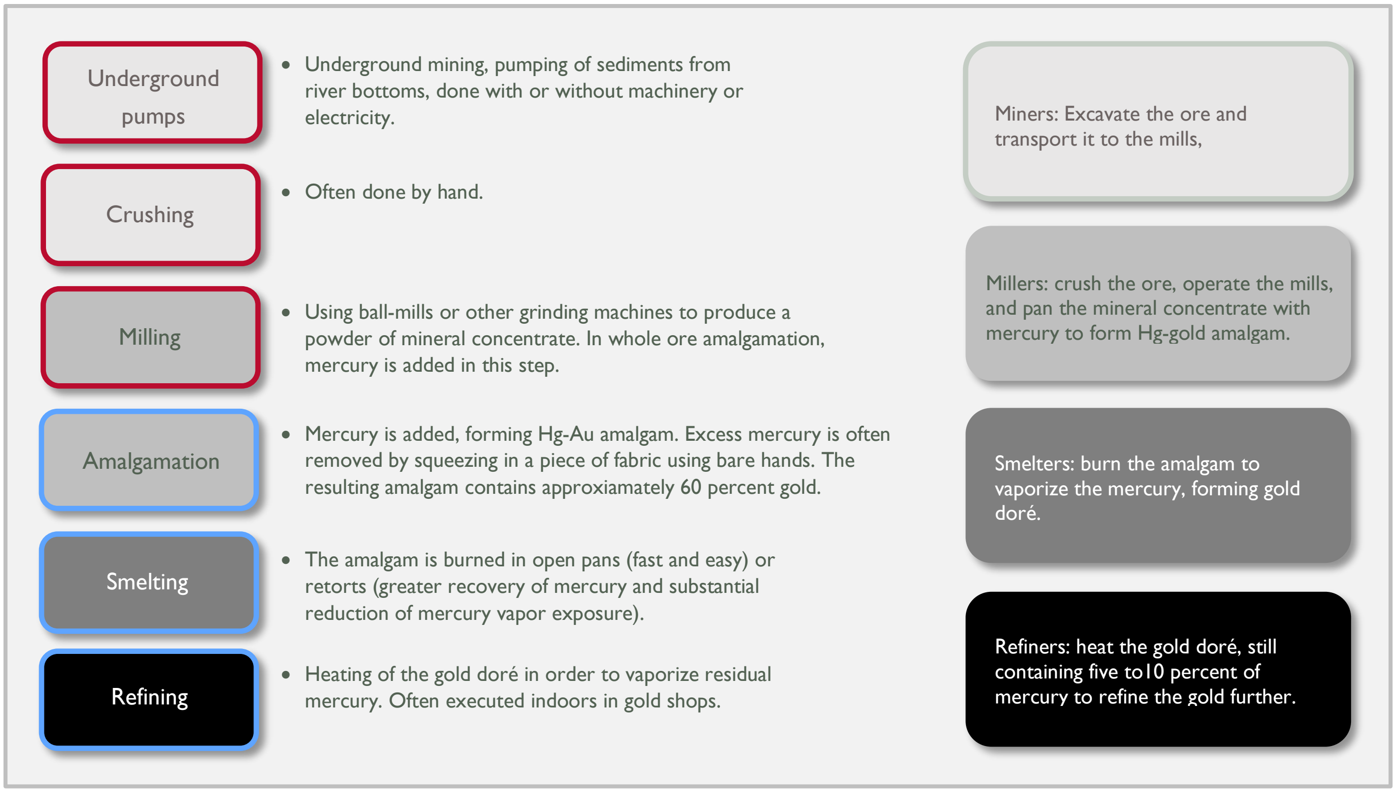


*Figure 3. Example extraction processes for ASGM. Source: Kasper et al., 2014*

Project interventions or development activity can take place at many stages along this lifecycle. Each stage in both the life cycle and extraction process can generate various impacts. For example, site exploration and mine development can result in deforestation. The extraction process itself can result in erosion due to activity along river beds, or health impacts due to the use of contaminants in processing. Site closure, especially if conducted incorrectly or not conducted at all, can also result in persistent long-term contamination, flooding or other safety hazards.

## CONTEXTUAL CONSIDERATIONS IN ASM COMMUNITIES

ASM activity often occurs in complicated social, political, economic, and environmental landscapes. Not only do ASM activities have impacts on these areas, but ASM activity is subject to direct and indirect drivers, as seen in **Figure 4.** ASM can impact, and is impacted by, human well-being and poverty, ecosystem services, and other direct and indirect drivers of change. ASM varies across contexts and is impacted by local or global forces differently in different places. ASM occurring in West Africa will impact the surrounding environment or social systems differently than it might in Asia. Therefore, it is important for project managers to recognize that there may be underlying community factors that will impact projects directly, as well as surrounding mining communities.

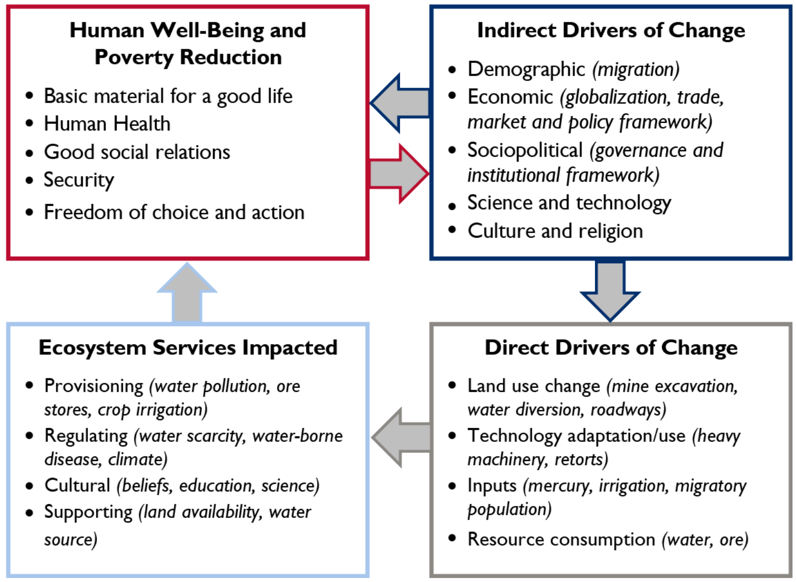


*Figure 4. Cycle of ASM drivers with examples. Source: Basu et al., 2015*

In the case of human health, underlying community health factors, such as existing prevalence of communicable disease or access to healthcare, can have broad impact on community members at mining sites. Even if the mining processes themselves are similar, a community with little healthcare infrastructure may not be able to address injuries associated with unsafe ASM practices, nor outbreaks of waterborne disease or sexually transmitted infections, for example. Another community facing a weak local economy may respond differently to the job prospects that ASM may provide. Regarding economic considerations, mining activity responds to the rise and fall of commodity prices, market trends, or other adverse events affecting the workforce. The perception of a greater income entices hopeful miners to leave their traditional livelihoods for risky and physically demanding jobs in ASM. Marginal financial savings may be offset by having the entire family engage in work throughout the mining process, which expands new Irisks. More on family involvement and other labor issues is presented in the Impacts of ASM section.

Project managers should recognize that the contextual considerations introduced above occur at various scales. ASM communities are impacted by micro- (or local) and macro- (or global) level forces. Micro-scale considerations may include local economic or market forces, pressure from regional or state regulations, community or cultural pressures, local health trends, geopolitical or security-related issues, and environmental or ecosystem-specific trends depending on the soil, weather, geology, etc. On the other hand, macro-level or global forces might include global economic forces (like commodity prices) or wider environmental forces such as climate change.

### MICRO-LEVEL CONSIDERATIONS

At the micro-level, local and regional markets, social and political trends, and the environment influence communities and their decisions to engage in ASM.

ASM is a critical element of the local economy, where it often provides a significant source of employment for local residents**.** It is important to recognize that the ASM supply chain may contribute more to the local economy than LSM. This is because the producer country, or country where the physical mine is located, relies on a wider range of on-site buyers, regional buyers, and exporters with ASM, whereas LSM firms may only use a local smelter, or may even directly export concentrate and not engage in local processing or purchase of infrastructure at all. ASM can serve as a source of rural development, as miners acquire wealth and are able to transition into more sustainable livelihoods.

There may also be pre-existing environmental, health, or other trends occurring in ASM communities, but they may also be impacted (even exacerbated or worsened) by ASM activities. It is critical to recognize and address these trends in program or intervention planning. They are discussed in more detail in later sections of this document, but may include some of the following:

- **Environmental trends**: ASM may cause or further contribute to erosion, deforestation, and alteration of natural waterways (natural flows, morphology, or riverine ecosystems) in local areas. Climatic trends such as rainfall or drought vary from region to region, and therefore, impacts will depend on geographic siting.

- **Health trends:** Some communities may already be facing pre-existing health threats or disease burdens, such as ongoing battles with cholera, HIV/AIDS, tuberculosis (TB), malaria, or other communicable diseases that could increase with influx of people to mining sites.

- **Gender roles:** Women and men may have very different roles in the household and community, driven by cultural or religious values. These roles may dictate whether and how women and men work together in mines or in other components of the mining cycle and value chain.

- **Education:** Surveys show that in some places, the percentage of women with no education is higher than that of men and increases with higher age well above national rates (Long et al., 2015). Additionally, the high reliance on children as a labor source for ASM, depending on the context, results in decreased opportunity for education for those engaged in ASM.

- **Water security**: A challenging aspect of mining is the strong history and continuing tradition of herding and farming adjacent to ASMs and the reliance on traditional water sources that are also used by the ASM sector. The quantity and quality of arable land and water sources is diminishing, underscoring the need for integrated management and investment in water infrastructure for miners, farmers, and herders. The barriers are broad, ranging from the lack of baseline data, feasible engineering, and reclamation solutions, to governance (McIntyre et al., 2016).

- **Temporality of ASM:** Individuals, groups, or families may partake in ASM activity on a seasonal basis, shifting between agricultural, fishing, or other livelihoods. One peer-reviewed study (Gyan-Baffour, 2003) described four different informal ASM activities that could impact the social structure, local economy, and/or political dynamics of mining communities:

  - *Seasonal ASM* provides a source of employment in agricultural off-seasons.
  - *Permanent ASM* relies on established mineral resources that are often located where previous large-scale industrial or formal mining occurred. Seasonal miners become permanent if the compensation is a reliable source of income. Permanent mining activity may be a traditional practice in some ASM communities, where mining may have been ongoing for hundreds of years.
  - *Shock-push ASM* refers to rapidly established mining sites to which workers relocate due to severe drought, social disruptions, conflicts, or the hope of more productive and lucrative livelihoods.
  - *Rush ASM* typifies many diamond and gold mines where the news of a major strike can create a stream of skilled and unskilled miners to an area over a short period of time. With poor infrastructure and potentially crowded conditions, socio-environmental and health problems may be easily exacerbated.

- **Inadequate physical infrastructure:** The absence of infrastructure, both for operations, transportation, and worker housing, is common for seasonal, shock-push, and rush ASM mines, and infrastructure is often marginal at permanent ASM mines. Surveys indicate limited cement flooring, potable water, and higher use of charcoal and wood in cooking, posing a risk in children for smoke inhalation. Rates of electricity, television, and refrigerator ownership are much lower, and access to electricity is often prioritized for mining operations (Long et al., 2015; Basu et al., 2015).

- **International governance frameworks:** Variations from one country to the next, in addition to a lack of monitoring and enforcement, impose numerous challenges in the regarding enforcement of ASM regulations directly, and well as indirect consequences of ASM activities (e.g., child labor, gender rights, health and safety, environmental management, etc.).

- **National enforcement:** Each country has its own mechanisms and regulatory frameworks for governing mining activity, including enforcement and compliance. Despite the existence of such frameworks, the ability of each country to enforce those frameworks and implement related activities will vary depending on the capacity of the government to employ enforcement staff or implement efficient processes.

- **Security:** Due to the remoteness of some ASM activities and the inability of enforcement agencies to reach these areas, mining may also fund illicit activities or contribute to corruption, money laundering, guerilla activities, the drug trade, arms trade, etc., while undercutting the viability of legal mining. Some areas have a geopolitical history of violence, though the factors involved – and how they impact ASM projects or local communities – will vary based on the area.

- **Political systems:** Certain countries may have a strong regulatory framework and political support. However, in some countries or parts of countries, ASM operations may take place in a governance and/or political vacuum if government agencies have weak regulatory or enforcement capacity or the country is involved in conflict, for example. The informal nature of some mining operations may prevent monitoring and enforcement of environmental regulations and tariffs, as enforcement agencies are unaware of these operations and are unable to conduct enforcement due to the remoteness of some ASM locations and a lack of resources. The inability of the government to collect taxes or royalties for services or regulation may result in fewer social services.

- **Land tenure:** ASM may take place on land subject to a variety of rights; lands may range from informal undocumented holdings to customary land, privately owned land, or public lands. Conflicting claims to and perceptions of land and resource rights may exist. For example, statutory law may recognize the land as public, but in reality, the land is subject to longstanding customary or informal rights. Questions of land tenure and property rights raise issues of legality and access, with implications on employment, livelihoods, and sustainable management. Informality associated with land tenure and mining site locations, as mentioned above, can indirectly result in a lack of associated services. Some ASM activity may also take place on the edges or outskirts of larger mining concessions, with or without formal agreements, which can lead to conflict (Tschakert and Singha 2007).

## MACRO-LEVEL CONSIDERATIONS


*Figure 5. ASM value chain*

A number of cross-cutting or global issues of concern are relevant at the *macro-level*. These issues may include underlying poverty, poor infrastructure, labor and gender rights, land tenure, governance, and global change (discussed further below). Regarding global economic forces, the ASM economic value chain, as depicted in **Figure 5** for the gold industry**,** connects communities and local mining activities to other stakeholders, including banks, buyers, and others in the private sector, before minerals ultimately end up in the hands of consumers. As outlined previously, extraction may occur locally if smelters are located nearby, though processing can also take place elsewhere. Therefore, global market forces can have cumulative impacts on stakeholders throughout the chain. Global costs can also have dramatic impact on local activities as demand changes or shifts. It is also important to note that individual miners may sell their product for a very low price, ultimately receiving only a fraction of the final selling price. Each additional step or player within the value chain adds additional profit, whether adding value or not. Some miners do not have knowledge of the market values of their minerals and therefore do not receive fair value for their goods.

Besides economic forces, macro-level environmental and socio-political issues may impact not only ASM activities in general, but the miners themselves, environments where they mine, and communities where they live. Global change may include demographic shifts and migration of populations due to regional or international/global environmental or socio-political stressors such as climate change, conflict, and security concerns. These forces may result in additional growth in the ASM sector as a viable employment option due to low barriers to entry. Alternatively, ASM may contribute to additional global change as natural resources may be depleted or ecosystem services altered due to poorly managed and enforced mining practices (e.g., deforestation or land clearing, unsustainable use of natural resources, contamination of ecosystems). Potential impacts may be addressed by introducing environmental monitoring and risk mapping. These impacts and possible mitigation measures are discussed later in the impacts section.

### ROOT DRIVERS OF ASM-RELATED IMPACTS

It is important to note that negative or destructive impacts can occur as a result of any variety of root causes or drivers which may be present in the community. Each of these are cross-cutting and can relate to micro- and macro-level phenomena, as well as local, national, and international drivers.

- **Government-level policies that fail to consider the local conditions** or contradicting national strategies.
- **Government-level policies that emphasize production** over sustainability.
- **Underfunded and understaffed government ministries** that are unable to manage mining activities, especially those taking place informally or in remote areas, in terms of enforcement and compliance (if related regulations exist).
- **Corruption** in government leading or contributing to inadequate management of the ASM sector.
- **Poverty or limited job prospects** leading individuals to take on dangerous jobs with little oversight.
- **Inadequate knowledge of best practices for protecting the environment at the local level**.
- **Lack of training or equipment** to successfully implement cleaner or safer production techniques.
- **Geopolitical unrest or conflict** preventing formalization and, therefore, safer, more sustainable practices.
- **Conflict between ASM and LSM concessions** leading to dispossession of land, relocation of communities, and other forms of instability for miners engaged in ASM.
- **Lack of understanding and valuation of ecosystem services** and natural resources impacted by ASM.
- **Presence of organized crime networks** with quick-profit objectives.

## INTERNATIONAL ASM FRAMEWORKS

The exploration for and extraction of gold and diamonds have increasingly become an international concern due to potential consequences related to child labor, environmental destruction, and connections to rebel movements. Particularly, gold mining involves introduction of mercury into the environment during processing, which is detrimental to human health and the environment. A series of international frameworks have been established in recent years to govern aspects of the mining process and avoid unintended consequences. There is variation in the legality of ASM across the world, and these frameworks seek to place political, social, and market pressure on those responsible for the governance of ASM. The Minamata Convention on Mercury seeks to address the adverse effects of mercury and to ultimately ban new mercury mines and phase out and down mercury use. In the case of diamonds, "conflict diamonds" have historically been mined and used to support war activities against legitimate governments. The Kimberly Process, a joint government, industry, and civil society initiative, seeks to stem the flow of conflict diamonds and raise awareness of consumers. The Minamata Convention, the Kimberly Process, and other international frameworks governing the legality of ASM are discussed below.

***Project managers should consider how their ASM activity aligns (or does not align) with all of these frameworks, keeping in mind that local regulations and laws supercede international frameworks.***

### THE MINAMATA CONVENTION

Mercury used in ASGM causes significant adverse neurological and other health impacts, particularly in unborn children and infants. The Minamata Convention on Mercury is a global treaty implemented by the United Nations Environment Programme (UNEP) to protect human health and the environment from the adverse effects of mercury. It was adopted in 2013 at the United Nations Diplomatic Conference in Kumamoto, Japan. The Minamata Convention includes a ban on new mercury mines, the phasing out of existing ones, the reduction and phasing out of mercury use in products and processes, control measures on emissions to air and on release to land and water, and the reduction of mercury use in the informal sector of ASM. It also addresses storage of mercury and its disposal as waste (including long-term storage), as well as site contamination by mercury. Countries that join the Minamata Convention are under legally binding obligation to implement the responsibilities outlined in the Convention.

To reduce mercury use in ASGM, participating countries who declare that they have "more than insignificant ASGM" must develop and implement a NAP. The NAP must outline the following:

- National objectives and reduction targets;
- Actions for eliminating worst practices with respect to mining and processing using mercury;
- Actions for mitigating mercury emissions;
- Steps for facilitating the formalization or regulation of ASM;
- Baseline information on mercury use;
- Strategies for promoting the reduction of mercury and managing trade;
- Methods for involving stakeholders, building capacity in training healthcare workers, and preventing exposure of vulnerable populations; and
- Strategies for sharing information.

Article 7 of the Minamata Convention focuses on ASGM in particular.

Many destructive impacts of ASM are also due to worst practices, or specific techniques that result in negative consequences. Country-specific obligations under Annex C of Article 7 of the Minamata Convention include elimination of these worst practices as part of their ASGM NAPs. For definitions of these practices, see Annexes I and 2. These practices may include *whole ore amalgamation, open burning of amalgam or processed amalgam, burning of amalgam in residential areas,* and *cyanide leaching in sediment, ore, or tailings to which mercury has been added without first removing the mercury.* Focusing on worst practices allows countries to set priorities to deal with the most dangerous and widespread uses of mercury first.

## ADDITIONAL RESOURCES

- *Minamata Convention*
  http://www.mercuryconvention.org/
- *The Minamata Convention: A Beginner's Guide*
  http://www.artisanalgold.org/publications/articles/the-minamata-convention-on-mercury-a-beginner-s-guide/
- *Considerations for ASGM:* https://www.nrdc.org/experts/susan-egan-keane/minamata-convention-what-it-means-artisanal-and-small-scale-gold-mining
- *Key operational articles of the Minamata Convention:*
  http://www.mercuryconvention.org/Portals/11/documents/Awareness%20raising/UNEP%20PPT/Presentation%20by%20the%20Interim%20Secretariat_Implementation%20of%20the%20Minamata%20Convention.pdf

**MINAMATA CONVENTION NATIONAL ACTION PLANS**

The UNEP report, *Developing a National Action Plan to Reduce, and Where Feasible, Eliminate Mercury Use in Artisanal and Small Scale Gold Mining,* provides guidance to countries that are formulating their NAPs, including technical, legal, and policy information in line with the requirements of the Minamata Convention. Each NAP must include the following elements:

- National overview
  - Review of legal and regulatory status of ASGM
  - National baseline analysis, including: demographic, environmental, health, and economic information about mining communities and the mining sector in that country, including mercury usage, environmental contamination, health impacts, etc.
  - Relevant stakeholders such as local leaders and organizations working in ASGM at the national and local level
  - Innovations in addressing AGSM
- National objectives and reduction targets
- Implementation strategy
  - Actions for eliminating worst practices
  - Steps planned to facilitate formalization activities
  - Strategies for reducing emissions and exposure risk
  - Strategies for managing trade of mercury
  - Strategies for involving stakeholders and sharing information with miners
- Evaluation mechanisms

The breadth of information in a country's NAP can provide a helpful resource to program or project managers as they work on related activities in areas where ASM occurs. USAID-sponsored or funded activities can be more effective if they support and leverage the national objectives and targets of the countries in which they operate.

*See:* https://wedocs.unep.org/bitstream/handle/20.500.11822/11371/National_Action_Plan_draft_guidance_v12.pdf?sequence=1&isAllowed=y.

For examples of NAPs, *see:*

- *Ghana:* https://www.thegef.org/project/national-action-plan-mercury-artisanal-and-small-scale-gold-mining-sector-ghana
- *Kyrgyzstan:* http://ipen.org/project-reports/national-action-plan-khaidarkan-mercury-mining-strengthening-environmental-policy
- *Phillipines:* https://wedocs.unep.org/bitstream/handle/20.500.11822/12897/Annex5_PHL_NationalActionPlanonMercury&Mercury-Contai.pdf?sequence=1&isAllowed=y

### THE KIMBERLY PROCESS

The Kimberly Process was established in 2000 in response to the trade of "conflict diamonds" or "blood diamonds" throughout sub-Saharan Africa, with the goal of preventing or reducing violence by rebel groups seeking to undermine legitimate governments. In the case of conflict diamonds, diamonds would be seized or mined by rebel groups and sold to finance their activities. The Kimberly Process was adopted by the United Nations General Assembly and created an international certification scheme for rough diamonds, which requires controlling rough diamond production and trade in participating countries. Requirements include certifying rough diamonds as "conflict-free" and preventing conflict diamonds from entering the legitimate trade. Participating states must enact national legislation and institutions must monitor export, import, and internal controls, as well as commit to transparency and the exchange of statistical data. Participating states may trade with each other if they meet minimum requirements, providing market benefits to participation. Currently, Kimberly Process members account for 99.8 percent of the global production of rough diamonds. Participating countries include South Africa, Canada, Russia, Botswana, the European Union, India, Namibia, Israel, the DRC, the U.S., Angola, and the Republic of China.

**ADDITIONAL RESOURCES**

- *Information on the Kimberly Process:* https://www.kimberleyprocess.com/
- *Report by the Working Group on Artisanal and Alluvial Production (WGAAP) of the Kimberly Process Certification Scheme:* https://www.land-links.org/wp-content/uploads/2016/09/Washington_Declaration_Kimberley_Process_Implementation.pdf

### ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT DUE DILIGENCE GUIDANCE FOR RESPONSIBLE SUPPLY CHAINS OF MINERALS FROM CONFLICT-AFFECTED AND HIGH-RISK AREAS

The Organisation for Economic Cooperation and Development (OECD) Due Diligence Guidance provides recommendations to help companies avoid contributing to conflict through their mineral purchasing decisions and practices. The guidance emphasizes responsible mineral supply chains, especially for purchases from areas associated with armed conflict, terrorism financing, human rights violations, and poor economic or social development. With the guidance, companies are better equipped to manage risks along the entire supply chain, from miners, local exporters, and mineral processors to manufacturing. Adopted in 2011, the guidance is a leading industry standard for mineral supply chain transparency and integrity. It is cited and used in binding regulations in the United States (U.S.) (Section 1502 of the Securities and Exchange Act of 1934: *Disclosing the Use of Conflict Minerals*) and is part of legal frameworks in the DRC, Burundi, and Rwanda. Implementation of the guidance provides market

**ADDITIONAL RESOURCES**

- *OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas:* http://www.oecd.org/corporate/mne/mining.htm
- *A Global Standard Towards Responsible Mineral Supply Chains:* http://mneguidelines.oecd.org/Brochure_OECD-Responsible-Mineral-Supply-Chains.pdf
- *Section 1502:* https://www.sec.gov/opa/Article/2012-2012-163htm---related-materials.html

pressure to support legal or formalized ASM endeavors versus those that support conflict.

## IMPACTS OF ASM

In this section, impacts of ASM are categorized by environmental, human health and safety, and socio-political factors. As emphasized previously, project managers should recognize that many issues are cross-cutting. Case studies throughout this section will outline examples of cross-cutting impacts.

### ENVIRONMENTAL

ASM generally involves moving large volumes of earth to access the valuable ores or gems; frequently uses large volumes of water to help wash away dirt and rocks of no value; and can cause deforestation or pollute the air with dust, sediment, chemicals, and other contaminants. This section will describe in more detail how ASM affects land, water, and air resources and why these effects are significant. Mitigation measures and best practices are presented later. **Table 3** lists some of the possible environmental problems associated with typical ASM practices, their causes, and their significance, divided between land, water, and air resources.

**TABLE 3. ENVIRONMENTAL IMPACTS OF ASM AND THEIR CAUSES AND SIGNIFICANCE.**

| PROBLEM/ISSUE | | CAUSE | SIGNIFICANCE |
|---|---|---|---|
| Land Resources | Deforestation | -Land clearing for mine construction, expansion, etc. | Clearing land for the construction of mines can cause small-scale clearing or larger scale deforestation. Regardless of the scale, deforestation or forest clearing has impacts on biodiversity, ecosystem services, and climate change mitigation (e.g., carbon sinks). |
| | Landslides | -Improper mine pit construction<br>-Deforestation (which destabilizes the soil surface)) | Landslides in an active mine pit can cause loss of human lives. Landslides into streams will reduce water quality and alter the stream flow, causing additional erosion and possibly flooding. |
| | Chemical Contamination of Soil | -Dumping of chemicals or excavated materials on the ground | Chemicals in soil can make it difficult to grow crops, and the crops can accumulate heavy metals and other compounds that are transferred to humans when eaten. |
| | Topsoil Loss and Erosion | -Deforestation<br>-Improper erosion controls<br>-Mixing of topsoil with other excavated materials | Loss of topsoil can make land infertile such that agriculture cannot occur and/or create a persistent erosion problem due to lack of revegetation. |

| | | | |
|---|---|---|---|
| | | -Release of contaminants in the soil or natural pollutants, rendering soil unusable | |
| | Contamination of Food Supply | -Bioaccumulation of chemical contaminants<br>-Chemical contamination of soil and water | Mercury and other contaminants can collect in edible plants and animals, transferring to humans upon ingestion in both the local and global food supply chains. |
| | Biodiversity Loss | -Deforestation<br>-Chemical and/or physical contamination<br>-Ecosystem services alteration | Plants and animals that the community typically utilizes may not be available. Natural processes that sustain food sources and fertile soils downstream are negatively impacted. |
| Water Resources | Chemical Contamination of Water | -Dumping of mining chemicals such as mercury or cyanide<br>-Weathering of excavated ores (acid rock drainage)<br>-Washing of ores in surface water<br>-Methylation of mercury from ASGM | Heavy metals in drinking water can cause developmental and other health problems in humans. Heavy metals and other contaminants will also impact aquatic species that the local community uses for food. Contamination of water supplies can also impact the global food supply chain for fish or other resources. |
| | Physical Contamination of Water | -Erosion, especially when stream channels are disrupted<br>-Dumping of debris, overburden, and trash<br>-Dredging of river sediments for mineral processing | Muddy water from erosion can kill aquatic species used for food and make the water unfit for drinking. |
| | Stagnant Water | -Unfilled mine pits<br>-Localized flooding due to stream channel disruption | Stagnant water breeds mosquitoes and is more likely to harbor pathogens if it is drunk by people or animals. Larger pits filled with water can be a drowning hazard to people and animals. |
| Air Resources | Air pollution or contamination | -Emissions or toxic fumes from fuels used in vehicles or machinery around ASM sites | Carbon dioxide and other emissions contribute to climate change. |

### CLIMATE CHANGE AND ENVIRONMENTAL IMPACTS

While climate change will be explored in further detail in the section on climate change implications and ASM, it is important to note that the environmental impacts of ASM listed in the table above can be exacerbated by climate change indirectly and directly over the short, medium, and long term. These impacts will also vary by region, each of which experiences climate change impacts, such as sea level rise, storm surge, or temperature or rainfall changes, differently. For example, landslides may occur because of improper mine construction; however, extreme rainfall can worsen landslides or make them more likely to occur. In the same way, topsoil loss due to improper erosion controls during ASM may be worsened by climate change-related flooding. Some regions are expected to experience drought, which may exacerbate water availability already affected by ASM-related water contamination. Longer-term changes in temperature and rainfall can also impact environmental conditions and the provision of ecosystem services.

### EFFECTS ON LAND RESOURCES

When vegetation is removed from large areas of land, the roots, stems, and trunks of the plants are no longer present to retain soil as water or wind flows over the ground. This can result in erosion of the topsoil into streams, which makes the cleared land less fertile for crops and more difficult to revegetate with native flora and fauna. The topsoil can also be lost if it is not removed separately when the mine is excavated, since mixing topsoil with rocky and less fertile dirt from the excavation will lead to poor soil quality. It is good practice when clearing land for a mine to minimize the cleared area, to use the removed vegetation as an erosion barrier, and to try to leave native trees and plants to hold soil in place where feasible. Additionally, it is good practice to separate and store the topsoil separate from underlying layers while digging a mine so that the topsoil can be reapplied when the mine is remediated. Materials that were excavated from the mine should be stored away from water bodies since they can erode or leach and potentially degrade the water quality.

**CROSS CUTTING ISSUES: SOIL AND WATER CONTAMINATION FROM ASGM IN LUKU, NIGERIA**

In 2013, soil sampling near ASGM sites in Luku, Nigeria, found elevated concentrations of lead, arsenic, cadmium, and mercury (Ako et al., 2014). These contaminants can bioaccumulate in ecosystems; plants can take up chemicals, and animals can absorb these chemicals in their fat tissues when they ingest contaminated plants or drink contaminated water. Some animals can experience malformations due to chemical exposure, with impacts to the ecosystem food web. Plants can also experience slowed growth rates.

When people ingest edible, contaminated plants or animals, the contaminants can be transferred to those people, with impacts on human health. International food supplies, such as global fish supplies, can also be impacted. In Luku, chemicals in the soil were found to be accumulating in plants, animals, and surface and ground water, making the water unsuitable for human consumption. Some residents were found to have respiratory problems as well as liver and kidney damage as a result of ingesting contaminated food and water.

Landslides are another concern when it comes to clearing land and digging mines. When the land is cleared of vegetation, there are no roots to retain the soil in heavy rains. This can cause a landslide which can fill the mine site with mud, flow into and block rivers and streams, or harm people and livestock. It is also important to angle the sides of the mine to reduce the likelihood of collapse in wet weather, for the safety of mine workers and economy of the mine.

Chemical contamination of soil can occur in ASM both from chemicals brought in to help with resource recovery, such as mercury or cyanide, or from the materials that are removed from the mine. Mercury and cyanide are used in gold mining to help separate gold from rocks and gravel, and both have significant health effects that are described in more detail in the human health and safety section of this document. Mercury is combined with gold to extract it from its matrix, after which excess mercury is removed by heating over a flame, causing the mercury to evaporate into the air. It can be deposited onto the soil or in waterways, where it affects crop growth, accumulates in fish or other animals that can then be eaten by humans, or ends up in drinking water for communities downstream of the mine. Methylation of mercury also presents particular human health and aquatic risks, as discussed below in the section on human health and safety. Cyanide can be used to dissolve gold, and while it also has negative health impacts, it will naturally break down in the environment.

*Figure 6. Forest degradation from illegal mining in Peru. Source: http://sps.columbia.edu/certificates/environment-peace-and-security-certificate/stories/peru.*

Chemical contamination of soil can also come directly from the rocks that are excavated from the mine. Some rocks, when exposed to air and water, will weather away, causing the soil they contact to become acidic. In some cases, as water travels through the mined materials, it becomes acidic and causes heavy metals to leach out of the rocks into the soil, contaminating it and crops that may be grown there in the future. This weathering is called acid rock drainage. Even if a mine is closed and forest cover or plant life returns, that land may still be contaminated and any crops grown or livestock kept could be contaminated as well. Legacy issues require coordination with USAID BEOs.

ASM can also contribute to biodiversity loss in the lands where it is practiced. Clearing forest and other natural land cover destroys habitats for native species, and if the soil is not fertile enough or the land did not retain other structural properties needed to support timely reforestation, then these ecosystems and species may be locally lost. Deforestation and land cover change can impact entire ecosystems of high biodiversity value. Chemical contamination of the soil and water may harm native species of plants, animals, and insects, reducing biodiversity. Finally, an influx of mine workers to the area may cause unsustainable biological resources extraction (over-hunting, over-fishing, over-harvesting of timber and non-timber forest products, etc.) around the mining community.

When a mine pit is abandoned, it becomes a hazard to wildlife and humans as falling into a mine pit can lead to injuries or death. If the pit fills partially with water, then it becomes a drowning hazard and a stagnant water source that can breed mosquitoes and contribute to the spread of diseases. Abandoned mine tunnels can also fill with water, become more susceptible to collapse over time, and can harbor dangerous gases that can asphyxiate or poison people or animals that enter the shaft. The water in abandoned mining structures can also become acidic or contaminated with mercury, depending on the location, presenting a hazard for cattle or wildlife if they use it as a source of drinking water.

## EFFECTS ON WATER RESOURCES

Water is a major consideration in ASM since it is frequently used for separation of grains of valuable material from gravel and soil in pans or sluices. This practice can have several impacts on water resources near mine sites, including degradation of water quality to erosion and chemical contamination.

*Figure 7. Erosion of a stream bank near artisanal gold mining activities in Luku, Nigeria. Source: Ako et al., 2014*

Several water-based mining practices can result in contamination of water sources or other environmental impacts (see Annex 2 for more details on these practices). Pans and sluices function by allowing water to carry away less dense soil and gravel, leaving heavier valuable gold or minerals, and require a water source to function. Often, the soil and gravel washed away from the target material is left in the streambed, and with many miners in a small area, this accumulated material can destroy natural riverbed ecosystems, causing damming of the stream and a change in the course of the water flow. When the stream course changes, it can cause erosion of stream banks, further impairing the water with mud and silt. This mud and silt can settle on aquatic plants, killing them and the animals that depend on them. It will also impair drinking water quality downstream. Furthermore, the eroded bank can make the stream shallower, decreasing its capacity and making the area susceptible to flooding in heavy rain situations. Riverine mining can destroy rare, delicate and valuable habitats that depend on the water body's specific physical, chemical, and biological properties and processes. The impacts of riverine mining can also be felt by downstream ecosystems and communities when natural sediment, nutrient, and species migration cycles are altered. These floods, aside from primary damage from the rising water, can lead to standing water, which may breed mosquitoes carrying diseases.

Washing of ores in waterways can also lead to chemical contamination of the water. It is common for metal ore deposits, such as gold and cobalt, to also contain other heavy metals and contaminants like lead, arsenic, copper, and radioactive elements. These contaminants are dangerous to humans and aquatic life, and can be washed out of the ores and into the waterway. They are especially dangerous in small streams or periods of low water flow, since there is no extra water to dilute the concentration of hazardous compounds.

Direct dredging of river sediment is also an important source of water contamination. This is a very common practice where sediment is directly pumped from the river bed. The materials dredged (known as slurry) are put through a sluice to capture the gold. The turbid, muddy water is then discharged directly back into the river. The discharged water can harm the aquatic ecosystem by blocking oxygen for fish and plant life living in the river, among other impacts.

### EFFECTS ON AIR RESOURCES

ASM can impact air resources in several ways. If mechanized equipment or vehicles are used in ASM sites, fossil fuel (e.g. carbon dioxide) emissions can contribute to climate change. Additional impacts to ambient air quality will be discussed in the next section on health.

## HUMAN HEALTH AND SAFETY

This section summarizes ASM-related human health and safety hazards. ASM miners extract commodities in largely low-resource field settings in remote areas, sometimes characterized as boom towns that are unconnected to services. Supportive infrastructure is usually weak and lacking basic housing, sanitation, municipal electricity, potable water, medical services, and good roads.

These conditions exacerbate occupational health hazards that cover a broad range of health effects from extraction, grinding, sifting, washing, amalgamating, to burning hazards. **Table 4** categorizes health and safety hazards with a brief review of significant health effects in each category. The most pronounced risks are biomechanical risks and physical injury, and working in confined spaces followed by chemical, biological, and psychosocial effects compounded by poverty. Attention is also paid to differential occupational risks associated with more vulnerable children and women.

**TABLE 4. HUMAN HEALTH AND SAFETY-RELATED IMPACTS OF ASM AND THEIR CAUSES AND SIGNIFICANCE.**

| PROBLEM/ISSUE | | CAUSE | SIGNIFICANCE |
|---|---|---|---|
| Biomechanical | Lifting and physical exertion | -Accidents from manual material handling<br>-Physiological strain<br>-Work-related musculoskeletal disorders<br>-Tendinitis and nerve impingement<br>-Chronic injury | Injuries can result in severe impacts in the ability to work, affecting local economies and poverty. Females often experience excessive physiological strain from physical labor, resulting in impacts to family structures. The severity of these cases is often unknown due to lack of surveillance. |
| | Physical trauma, falls | -Contusion, fractures, spinal injuries from working in unsafe conditions and rock falls or explosions<br>-Chemical or electric burns and eye injuries due to inappropriate use of equipment | Physical trauma can also impact individuals' ability to work or lead to death. Fatality rates are estimated to be 90 times higher than in large-scale mines in industrial countries. |

| TABLE 4. HUMAN HEALTH AND SAFETY-RELATED IMPACTS OF ASM AND THEIR CAUSES AND SIGNIFICANCE. | | | |
|---|---|---|---|
| PROBLEM/ISSUE | | CAUSE | SIGNIFICANCE |
| Physical Exposure | Heat | -Heat stress, stroke, faintness, dizziness due to extended work underground or intense sun exposure<br>-Breathing difficulties<br>-Palpitations due to lack of rest schedules<br>-Excessive thirst due to lack of potable water access | Health impacts should be avoided for their own sake, however poor health can also alter one's ability to work. |
| | Noise | -Hearing impairment or loss due to noisy tools, blasting, drilling, crushing, ore processing | Undetected hearing loss can impact one's role in society and ability to maintain work. |
| | Vibration | -Ulnar nerve damage, numbness in hands and arms from explosions, noise, vibrating drills, or hand tools | Ergonomic stress or burdens can result in lower mobility, higher healthcare costs, and lower probability of finding work. |
| | Dust | -Dust from roads, excavation, or mine blasting | Dust can cause breathing problems for people and carry heavy metals into the body. |
| Mine Structural Hazards | Structural failures, mine tunnel or pit flooding, mud slides, confined spaces and other health or safety impacts as a result of structural hazards | -Falls or even death/drowning can occur if tunnels collapse due to inadequate trenching and shoring or if rain fills shafts and trenches<br>-Pit walls, tailings piles, or tunnels can collapse | These structural failures cause not only miner death or injury, but can impact local communities depending on their extent. Local infrastructure such as roads, bridges, or buildings can also be impacted. |

| TABLE 4. HUMAN HEALTH AND SAFETY-RELATED IMPACTS OF ASM AND THEIR CAUSES AND SIGNIFICANCE. | | | |
|---|---|---|---|
| PROBLEM/ISSUE | | CAUSE | SIGNIFICANCE |
| Chemical Exposure | Mercury (elemental and methyl mercury) | -Neurologic symptoms such as poor short term memory or concentration, affected vigor, tension, confusion, or anger; kidney disease or developmental problems in children and fetuses | Mercury can be inhaled as airborne vapor when used in gold processing, or absorbed and bioaccumulated from the consumption of fish, shellfish, and other animals that live in contaminated water. There are long-lasting impacts on children with far-reaching effects on health, education, etc. |
| | Lead | -Deficits in neurocognitive development<br>-Prenatal fetal neurotoxin | Exposure via ingestion and inhalation of lead-contaminated soils and dust also has far-reaching impacts on children's health. |
| | Arsenic | -Dermal impacts, cancers | Exposure via ingestion and inhalation of arsenic-contaminated soils and dust also has far-reaching impacts on children's health. |
| | Silica dust | -Silicosis, chronic obstructive pulmonary disease, tuberculosis (TB), lung cancer | Inhalation during drilling, mineral extraction, ore crushing, blasting, and explosions can occur due to a lack of worker protection programs. |
| | Sodium cyanide/hydrogen cyanide | -Asphyxiation affecting body's ability to use oxygen<br>-Cancers, visual impairment | Inhalation and skin exposure resulting in long term health impacts. |
| | Toxic gases (methane, sulfur dioxide, nitrous oxide, etc.) | -Respiratory tract irritation.<br>-Asphyxiation from lowered oxygen levels during mining | Due to a lack of ventilation training, deaths or long-term health impacts can occur. |
| | Carbon monoxide | -Headache, nausea, vomiting, confusion, leading to coma and death | Incomplete combustion in poorly ventilated spaces where petrol or diesel fuels are used can lead to deaths. |
| Biological Hazards | TB, HIV/AIDS, cholera, other waterborne or vector-borne, sexually transmitted infections | -Disease transmission within ASM communities | Contaminated and stagnant water in mines and homes can lead to vector-borne diseases. Higher risk sex practices and unsafe health behaviors can also lead to the spread of disease. |

| TABLE 4. HUMAN HEALTH AND SAFETY-RELATED IMPACTS OF ASM AND THEIR CAUSES AND SIGNIFICANCE. | | | |
|---|---|---|---|
| PROBLEM/ISSUE | | CAUSE | SIGNIFICANCE |
| Social Hazards | Drugs or violence<br>Armed groups or organized crime | -Health impacts.<br>-Violence. | Informal work settings and transient lifestyles (e.g., seasonal or migratory) can lead to the spread of disease, as described for biological hazards above. A lack of community health workers can contribute. |

### CLIMATE CHANGE AND HUMAN HEALTH AND SAFETY

Climate change can amplify a number of the human health and safety-related impacts described in the table above, though the actual effects will vary by time scale and region. Increasing temperatures can worsen the physical heat exposure that miners may already feel while working in poorly ventilated mines. Excessive rainfall can exacerbate potential structural hazards in mines by weakening tunnel walls or filling pits with floodwaters. Drought conditions can also worsen dusty conditions from road construction, mine excavation, or mine blasting, with implications for respiratory health. Over the long term, changing climatic conditions may also lead to water or food insecurity or famine, resulting in demographic shifts as individuals and families seek out alternative livelihoods or move to new regions entirely.

### PHYSICAL AND BIOCHEMICAL EXPOSURE

Heat, noise, and vibration are common exposures attributable to working in small-scale mining in hotter climates and underground, with machinery and vibrating hand tools, and with explosives that can result in excessive dust, unstable soils, and elevated risk of injury. Even simple mechanized industrial processes produce a mix of continuous sound and complex peak noises from extraction, crushing, and milling processes.

ASM activities generate dust through use of mining tools in the pit or shaft, blasting, truck traffic on unpaved roads, dumping or moving rocks and dirt, grinding ores, or wind erosion in areas where vegetation has been cleared. Any dust can irritate the lungs and throat, and silica dust that is released when breaking down rocks can cause silicosis, which decreases lung capacity and can be fatal. Additionally, dust from ores commonly contains heavy metals that are transferred to the body as the dust is breathed. This is especially problematic when dust gathers in homes from indoor ore grinding, as children receive heavier doses simply by being smaller and closer to the ground when the contaminated dust is stirred up.

### MINE STRUCTURAL HAZARDS

Mines can take the form of tunnels, pits, or other confined spaces. Failures due to poor trenching and shoring practices, uncontrolled flooding, and mudslides are an inherent risk in ASM operations, particularly those operations that are unregistered or illegal. These hazards can result in severe injuries and fatalities. In the absence of formal surveillance in this sector, an exploratory study collated

*Figure 8. A Ghanaian miner at the opening of a 15-m mine shaft reinforced with wood. Source: https://www.iied.org/ghana-our-way-participatory-reform-artisanal-small-scale-mining-asm-sector.*

newspaper articles reporting small-scale accidents between 2007 and 2012 in Ghana and found 31percent of events were attributable to entrapment, 17 percent to drowning, 13 percent each to crushes and falls, nine percent each to burning and shootings, and four percent to suffocation (Kyeremateng-Amoah and Clarke, 2015). The high percentages for entrapment and drowning underscore the importance of introducing safer tunneling and confined space practices with occupational safety and health training.

## CHEMICAL HAZARDS

*Chemical hazards* from several different contaminants are common due to the unregulated use of chemicals for mineral processing. These chemicals make their way into the environment and individuals' bodies. In the case of mercury, 37 percent of global air emissions are produced by ASGM processes (USEPA, 2017). Mercury amalgamation is one of the most common ways to extract gold from raw ore; ore is crushed and then mixed with metallic mercury, which binds to the gold, creating an amalgam. In another process, ore is combined with water and channeled through a sluice box that captures gold. The gold-rich silt is further refined by panning with mercury or applied to copper plates lined with mercury. Finally, the amalgam is dried and heated to drive off the mercury and concentrate the gold (Telmer and Stapper, 2012). At that point, the product is subject to sale or further refinement at a shop, typically located in densely populated commercial centers.

**HEAVY METAL EXPOSURE FROM COBALT MINING IN THE KATANGA REGION, DRC**

Urine samples from 311 subjects living near the cobalt mining activity had four-, 43-, five-, and four-fold higher concentrations of the heavy metals cadmium, cobalt, lead, and uranium, respectively, than the general U.S. population. These levels were due to contaminated land, water, and air resources in the region (Banza et al., 2009).

Elemental mercury exposure can also occur throughout the extraction process. Mercury is usually directly handled by workers and their families without personal protective equipment (PPE) such as gloves and respirators. During the sluicing process in whole ore amalgamation, mercury can be spilled on the ground, wiped on clothing, or lost to the environment as mercury flour which readily contaminates soil and waterways near processing centers. **Figure 9** depicts the wide geographical scope of mercury contamination, though it is likely still not reflective of undocumented or unofficial mercury usage and subsequent contamination.

### HEALTH EFFECTS FROM MERCURY EXPOSURE

ASM communities face substantial mercury exposure, with profound health effects. Lower occupational exposures in adults adversely affect mood (tension, anger, confusion, fatigue, depression), increase self-reported symptoms (poor short term memory and concentration), and can result in performance deficits linked to neurobehavioral domains for visual memory, hand-eye coordination, and manual dexterity. Adverse health effects may intensify and/or become irreversible as exposure duration and concentration increase. Very high exposures are more common in small-scale mining operations and this can increase the severity of neurotoxicity. Mercury has no physiological benefits and even small exposures can cause negative health effects in children in particular; mercury's impacts are particularly severe for the developing fetus in women who are exposed while pregnant.

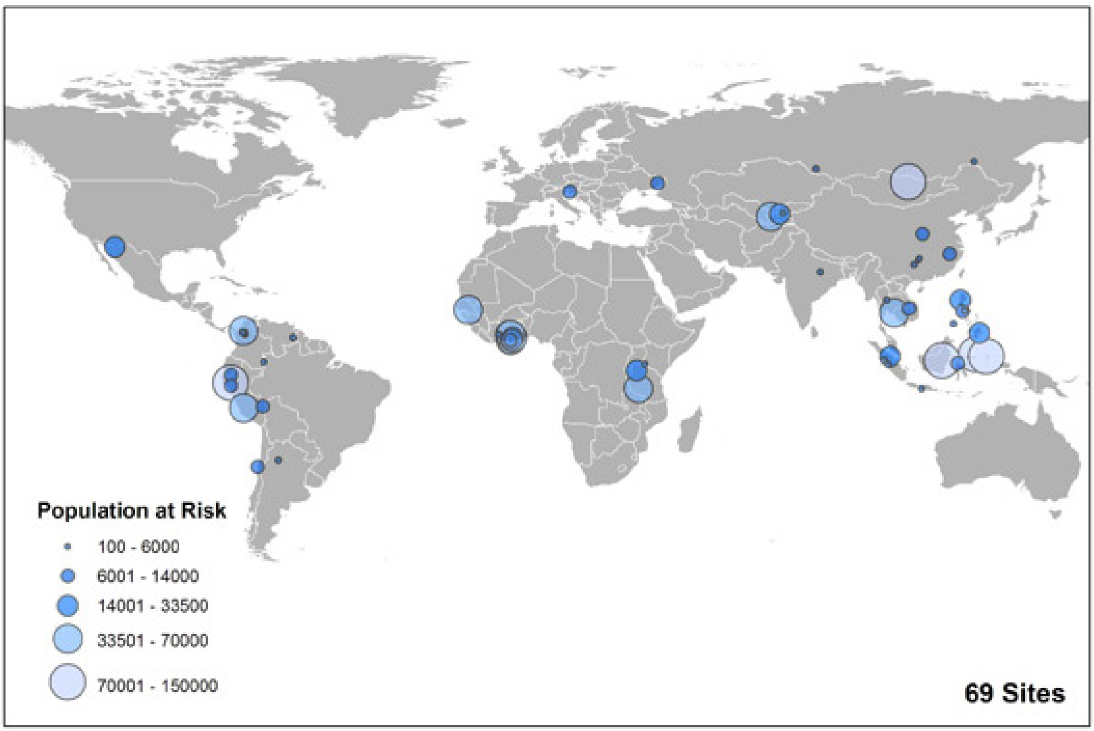


*Figure 9. Mercury contamination from ASGM mining and processing around the globe. Source: http://www.worstpolluted.org/projects_reports/display/87.*

Exposure to *methyl mercury,* an organic compound of mercury that is generated by microorganisms present in water, primarily occurs when contaminated fish or other animals are consumed. Methyl mercury can bioaccumulate in fish, shellfish, or other wildlife in contaminated waterways near mining sites. Impacts are more severe depending on the dose, ranging from hair loss to delayed brain development in children. A large study of 1,000 children from the Faroe Islands concluded that methyl mercury exposure during intrauterine development was associated with deficits in motor skills, language, and memory in school-age children (Pearson, 2004). The levels of methyl mercury in ASM populations are equally high or higher. In 43 subpopulations of women and infants living near small-scale gold mining sites in Bolivia, Brazil, Colombia, French Guiana, Indonesia and Surinam, the pooled central distribution median hair levels were 5.4 µg/g (ranging up to 125 µg/g at the 95$^{th}$ percentile) which is four times the joint Food and Agriculture Organization of the United Nations/World Health Organization (FAO/WHO) provisional tolerable weekly intake reference level of 2.2 µg/g and two orders of magnitude higher than the 0.04 µg/g recorded levels in the U.S. and other inland populations. As part of the study, observed levels in the ASM communities were modeled to estimate significant losses in IQ for gold mining women and children. In general, lead exposure with mercury, arsenic, and other contaminants is also a significant risk factor.

**LEAD POISONING FROM ASGM ACTIVITY IN ZAMFARA STATE, NIGERIA**

In March 2010, global alarm was raised by a series of unexplained deaths among young children in more than 50 villages in Zamfara State, Nigeria. More than 400 children died, and at least 3,000 were poisoned. Investigators identified lead poisoning as the likely cause; the lead originated from the nearby gold deposits, and gold mining activities spread the lead as dust, in particular from dry crushing and milling of ore. Unfortunately, the processing was conducted in the villages, in close proximity to family compounds. High levels of lead were measured in housing dusts and community water sources. This dust was inhaled or ingested from the hands of people living in the community, causing lead poisoning. Lead poisoning can cause irreversible damage to brain development and lead to seizures and death (Medecins Sans Frontieres, 2012).

The Government of Nigeria, with the assistance of Médecins Sans Frontières, provided health education, and environmental remediation is underway. These efforts reduced mortality, but many exposed families remain unremediated. Wet milling of the ore and other dust control practices can also help mitigate the impacts of dust-borne contamination. Other ASM communities have never been tested for potential exposure to lead and likely remain at risk.

*Silica* in drilling and extraction dusts is a mineral that is also found in gold and diamond-bearing ores. Depending on the size of silica particles, silica can be retained in the lung, causing lung cancer, and can increase susceptibility to TB. The absence of personal protection and respirators contributes to the health risks. Exposure to silica dust is also associated with development of silicosis, a lung disease that leads to fluid buildup and scar tissue in the lungs, impacting respiration.

*Sodium cyanide* is often dissolved in water to make a solution for leaching gold out of an ore. However, it can emit *hydrogen cyanide*, a gas, that can emit interferes with the body's ability to use oxygen. Inhalation of dust or fumes that it generates can cause severe and acute effects including rapid breathing, tremors, asphyxiation, and death. Chronic effects include neuropathologic lesions, difficulty breathing, chest pain, nausea, headaches, and enlarged thyroid gland. Despite these health impacts, cyanide is increasing in wide use because the gold recovery rate is high and the cost is low. In Zimbabwe, most small-scale regional mills first amalgamate with mercury and then use open pools of cyanide on the tailings to increase yield. The gold is further refined in a sealed cascade impactor where cyanide is poured into a closed system to increase purity. The process actually increases the bio-availability of mercury in the environment. For this reason, the use of cyanide after the use of mercury is an "action to eliminate" in Annex C of the Minamata Convention on Mercury, and included as a "worst practice" in the Minamata Convention.

*Toxic gases*, such as methane, sulfur dioxide, nitrous oxide, and carbon monoxide exposures are also common in ASM activities. Many mines in the informal sector do not add additional ventilation ducts or forced air in confined spaces or deep trenches. This elevates the risk of carbon monoxide exposure when using petrol- or diesel-operated machinery in these areas, which can be lethal. It also increases the risk of asphyxiation by methane and nitrous oxide. Blasting fumes and vapors also contain sulfur dioxide and nitrogen oxides which are strong respiratory tract irritants. The absence of safety personnel contributes to the health risks.

### BIOLOGICAL HAZARDS

HIV/AIDS, other sexually transmitted infections, TB, cholera and other waterborne diseases, and vector-borne diseases can be found in mining communities or exacerbated by mining activities. Mining locations are often far from a home village, so miners may seek out concurrent sex partners and engage in unprotected practices. These factors increase the spread of sexually transmitted infections, HIV, and AIDS. Male miners and families are also more prone to living in crowded substandard housing which increase contact with airborne TB. Studies have shown increased susceptibility to TB in miners due to co-exposure to silica dust. The inhalation of silica dust decreases immunity and increases scarring of lung tissue permitting TB infection to advance.

*Figure 10. A gold mine with standing water in the Amazon. Source: Fraser, 2010*

The absence of infrastructure for sanitation and potable water is another a pressing problem across informal ASM communities, increasing the risk of cholera. The presence of stagnant pools (such as that shown in **Figure 10**) of water at most mine sites permits reproduction of mosquitos that can become carriers of and transmit malaria, dengue, and emerging infections. Finally, small-scale mining communities often live near the tailings of larger mines located along water ways used for drinking, cooking, and bathing. The probability of mine waste and discharges into communal water, with and without flooding, is high.

## SOCIO-POLITICAL

ASM activities can cause or exacerbate a variety of socio-political complexities, ranging from labor to gender to political conflicts.

| TABLE 5. SOCIO-POLITICAL IMPACTS OF ASM AND THEIR CAUSES AND SIGNIFICANCE. | | |
|---|---|---|
| PROBLEM/ISSUE | CAUSE | SIGNIFICANCE |
| Child Labor | -Poverty-stricken communities where children are forced to work, either in family-run operations or otherwise, versus attend school<br>-A source of cheap (and exploitable) labor<br>-Cultural traditions<br>-Lack of legislation and enforcement<br>-Lack of education on risks or impacts | Child labor puts minors in very dangerous positions and causes a loss of educational opportunities, impacting future generations. Children are also at greater risk for health impacts as well as potential sexual harassment or exploitation. |
| Gender Issues | -Disruption of traditional gender roles and cultural traditions<br>-A source of cheap (and exploitable) labor<br>-Particular impacts on pregnant women<br>-Lack of education on risks or impacts<br>-Human trafficking | The exploitation of women in mining operations has far-reaching impacts due to the important role that women play in the home. Women often do not receive equal compensation or benefits and their contributions go unrecognized. Women's profits are typically spent on family and household needs, compared to some men who may spend on alcohol, gambling, and prostitution. Women also experience particular impacts when pregnant, and are at greater risk for sexual harassment and exploitation. |
| Migration and Demographic Shifts | -Underlying poverty trends<br>-Stresses on alternative livelihoods or lands (e.g., agriculture, conflict, climate change)<br>-Rush mining as a result of strikes and rushes on potential commodities (e.g., gold, diamonds) | The migration of people to work in mines may result in conflict or security concerns. Fluctuation in unstable communities can also lead to social deterioration (e.g., prostitution, gambling, substance abuse), though demographic shifts can also provide an opportunity for economic gain for those families or individuals. |
| Land Tenure Conflicts | -Informal miners often don't have formal titles to land or rights to the sub-surface resources that are being mined, creating conflict around land stewardship, financial arrangements between workers and titleholders, and worker rights | Questionable land tenure rights can cause tension and conflict between miners, both within ASM as well as between ASM and LSM. A lack of clarity on access and rights to land complicates financial arrangements between titleholders and those leasing land (or those on land without rights or formal agreement). Clarification of land tenure can improve legitimacy of |

| TABLE 5. SOCIO-POLITICAL IMPACTS OF ASM AND THEIR CAUSES AND SIGNIFICANCE. | | |
|---|---|---|
| PROBLEM/ISSUE | CAUSE | SIGNIFICANCE |
| | | artisanal efforts, increasing likelihood of investment in and ultimate profits for the community. Clarification of land tenure can also be linked to continued use of lands, encouraging rehabilitation of mined lands or conversion to alternative uses.<br>Finally, clarification of land tenure rights moves miners from the realm of "illegal" status, shielding them from criminal prosecution. |
| Social Issues (e.g., Prostitution, Gambling, Substance Abuse) | -Unstable mining communities due to strikes or rushes and large influxes of miners<br>-Unequal compensation and distribution of income to favor men, who are more likely to use the income for activities such as prostitution, gambling, substance abuse | A wide range of social issues can bring increased risk of community health issues (e.g., sexually transmitted diseases), with far-reaching impacts to community development and the local economy. |
| Development Challenges and Opportunities | -ASM as a permanent, seasonal, or temporary source of livelihood for poor and marginalized populations in remote settings<br>-ASM impacts other economic opportunities | ASM is a potential strategy for livelihood diversification, including economic production and stimulation, but can also impact other economic opportunities. Development opportunities also provide the potential for alignment with sustainable development goals and additional co-benefits with improved health, more sustainable environmental practices, and improved infrastructure. |

## CLIMATE CHANGE AND SOCIO-POLITICAL IMPACTS

As in environmental and health-related impacts, climate change can have particular impacts on socio-political systems of ASM communities. Many of these impacts to socio-political systems can be considered longer-term, indirect impacts. For example, changing climatic conditions over time may cause migration shifts as climate refugees move from areas where their livelihoods or homes are threatened by extreme weather, storm surge, changing agricultural conditions, etc. Land tenure conflicts, which can happen as a result of transient population movement (among other things), could arise from climate-related demographic shifts as well. In general, instability brought on by climate change can worsen any underlying socio-political issues, and vice versa.

## LABOR, DEMOGRAPHIC, AND GENDER CHARACTERISTICS OF ASM COMMUNITIES

ASM serves as a significant, but generally poorly compensated and potentially dangerous source of livelihood in many developing countries. Additionally, the demographics of the ASM sector vary considerably across nations and include all age groups. ASM is sometimes conducted as a family business and, as such, women and children play significant roles in the sector. Men primarily work in the mines, while women and children work both in the mines and the surrounding communities, as well as in the household, requiring a balancing of mining and household responsibilities. However, when spouses or family members are ill or their capacity to work is otherwise diminished, a "healthy" family member must work harder to pay for normal living expenses in addition to health costs. Available low-cost labor and poor health are thus components of the ASM poverty cycle. These factors expand the number of women and children engaged in the ASM sector. The World Bank estimates that between one and 1.5 million children, defined as boys and girls under the age of 18, are involved in ASM worldwide. Additionally, an estimated 30 percent of the 20 million ASM miners worldwide are women (GIZ, n.d.). In the world's 12 poorest countries, 650,000 women are engaged in ASM (World Bank, 2008).

***Male Miners.*** Men are more prevalent in the mining work force, though this varies by region (Eftimie et al., 2012), and have more control over land, units of gold and diamonds, the mine site, and its revenues and its resources. Men are also more directly involved in the physical excavating and breaking down of ores. There are usually two groups – those who have been long-term members of a mining community and those who are younger, lack experience, and are more prone to risk-taking work and personal behaviors.

***Female Miners.*** The degree to which women participate in mining activities varies by region; in general, less than 10 percent of miners in Asia, 10-20 percent in Latin America, up to 50 percent in Africa (GIZ, n.d.), and even higher in some regions, are women. However, the actual number of women involved in ASM may be underestimated. Women are more active in ASM versus LSM. Typically, women's responsibilities in the mines are more likely to be in processing or transporting materials, while more mechanized work is reserved for men. Women may also be involved in the trading of gold, gemstones, or extractives. Women not only incur the same excessive occupational risks as that of men but also incur pregnancy and reproductive risks from working with toxicants. There are perceived trends (e.g., see Javia and Siop, (2010)) suggesting women are more likely to:

- Transport ore and water, conduct manual crushing and grinding, washing or panning, amalgamation, and amalgam decomposition (the process of removing mercury by heating or adding acid). At many ASM sites, women work with young babies tied to their backs and toddlers at their side, increasing children's exposure to contaminants;
- Participate in decisions for low unit-value commodities, such as industrial minerals, but not gold or diamonds;
- Be less prevalent in larger and more mechanized ASM operations; women are most prevalent in small family operations where mining takes place to supplement subsistence agriculture; and
- Remain primary caregivers, prepare food, care for children, clean, etc. In some locations, women also supply food and drink, tools and equipment, and sexual services.

When women are compensated for their work, they oftentimes earn much less than men. For example, in Guinea, men mine the soil and women wash gold from the soil. However, for every five containers of ore that women wash, they only receive profits on one, while the remaining profits go to male buyers or other intermediaries (USAID, 2000).

Traditional gender roles also impact the sector. Women are typically responsible for maintaining households, sometimes resulting in workdays that can be between four and eight hours longer than those of men. This added contribution is largely unrecognized and undervalued. Despite this, men may ultimately retain control over the household, reserving decision-making authority for the family. In addition, although women's contributions to ASM are significant, oftentimes ownership and control of land, incomes, tools, households, etc., belong to men, as do the rights and any benefits that come out of them. Due to this difference in influence, women may be differentially affected by project plans or the sector and reform more broadly. However, properly designed projects may provide an opportunity to improve economic outcomes for women in developing countries.

### ASSESSING GENDER DIMENSIONS OF ASM

The World Bank released a Rapid Assessment Toolkit in 2012 that outlines how practitioners should assess gender dynamics and promote gender equality in ASM communities. The toolkit provides a framework for understanding the factors that determine an individual or group's capacity to assess, control, accumulate, and benefit from ASM-related assets. With this understanding, a practitioner can ensure that the project's interventions are cognizant and supportive of human rights and the equal rights of women in particular, providing means of engagement and participation in policy and interventions.

While this toolkit provides a thorough and in-depth methodology for collecting data and analyzing related local dynamics, project managers and implementers can consider the overarching goals of increasing both women and men's voices in influencing policies and programs, increasing commitment of local government or key organizations to general equality, and recommending means of increasing opportunities for women and men to drive their own social and economic development.

*See:*
https://siteresources.worldbank.org/INTEXTINDWOM/Resources/Gender_and_ASM_Toolkit.pdf.

***Child Labor.*** The ILO describes child labor as work that deprives children of their childhood, their potential, and their dignity; that is harmful to physical and mental development; is mentally, physically, socially, or morally dangerous and harmful to children; and interferes with schooling. ILO Convention No. 182 prohibits the "worst forms of child labor" for anyone under the age of 18 – work that is likely to harm the health, safety or morals of children, either by its nature or the circumstances in which it is carried out. The worst forms of child labor include hazardous work, such as mining activities including underground work, work with dangerous tools or machinery, transportation of heavy loads, and work that exposes children to hazardous substances.

Child labor is a serious problem in local, small-scale gemstone and mineral mining operations worldwide. Human Rights Watch studies conducted in Ghana found that most children working in ASM are aged 15 to 17, but younger children work in mining, too, with the youngest child interviewed just nine years old (Human Rights Watch, 2015). In other regions, children as young as three may be engaged in ASM. Many of the children who work in mining attend school, however, most attend school irregularly, as they may be required to work variable schedules, sometimes up to 14 hours a day. Some children drop out of school altogether, while others work in ASM specifically to cover school-related costs.

Children may be involved in virtually all stages of ASM. Depending on the country, child labor in ASM may be equally divided between boys and girls, or dominated by boys. There are few tasks performed by children in ASM that are not hazardous; often, children conduct work similar to that performed by adults. Most work characteristics fit the definition of a "worst form of child labor" under ILO Convention No. 182 (ILO, 2005). In underground mines, for example, children may be involved with ore extraction, assist with drilling, push carts, clean galleries, and remove water from the mines. In river mines, they may dig and dive for sediment. Children may also crush stones, haul minerals, pick gemstones, and wash gold in mineral concentration processing. Boys perform a range of functions, from helping to dig and haul to washing sediment, burning amalgam, and performing support tasks such as brick-making and hauling water. Within industrial material mines (e.g., clay, coal, and sand), young girls may be required to carry huge loads on their heads and backs, sometimes in extreme temperatures. Some children are also required to run errands or deliver food and water to miners working deep within the mines. Girls may also be expected to perform other jobs on mining sites, such as preparing or selling food or other items, and may face the additional risk of sexual harassment, sexual exploitation, and rape. These children incur developmental as well as excessive occupational and environmental risks from working with heavy loads and toxicants.

Given the level of family engagement in ASM, it is very difficult to eliminate the participation of children. There are several underlying challenges that make the elimination or limiting of child labor in ASM difficult. Often, the mines are in poverty-stricken areas and are family-oriented, with children working alongside family members. Additionally, the informality and transient nature of many ASM mines mean it is difficult to ensure that mines or traders purchasing from unlicensed sources do not benefit from child labor.

***Forced Labor or Slavery.*** The exploitation – as forced laborers, indentured servants, or slaves – of men, women, and children occurs at mining sites around the world. In forced labor, fraud or deception are often used to obtain consent initially, or individuals may offer their services and then become exploited regardless of consent. In areas of extreme poverty, resources such as food or housing may be offered in exchange for employment; however, then coercive means are used to prevent those individuals from leaving. Forms of coercion include threats and violence, restriction of workers' freedom of movement, debt bondage or debt manipulation, withholding of wages, retention of identification documents, or abuse of vulnerability (Hidron and Koepke, 2014). Debt bondage refers to forced labor specifically for the repayment of debt or other obligations when the service's duration is undefined.

***Off-Site Milling and Shop Workers.*** Impure gold at around 85-90 percent purity is generally taken from a mill to a centralized gold shop where the sponge-like gold doré is further refined through smelting to remove residual mercury and other impurities. The work is largely performed by better educated men who are also able to work with the miner to buy and sell products. Efforts to improve fume hoods through the installation of mercury capture technologies are reducing ambient and indoor exposure of these workers to mercury remaining in the gold.

**HUMAN TRAFFICKING IN ARTISANAL MINING TOWNS IN EASTERN DRC**

Artisanal mining towns in eastern Congo have gained international attention due to the role that they have played in fueling conflict with rebel groups. Aided by poor governance, poor regulatory oversight, and corruption, labor and sexual trafficking have become commonplace due to the lack of job prospects. The 2014 State Department *Trafficking in Persons Report* specifically mentions trafficking associated with ASM, but human trafficking in general includes sex trafficking as well as forced labor ( involuntary servitude), debt bondage, and slavery.

Based on a USAID-funded survey published in 2014, 6.7 percent of surveyed respondents were at the time or had been victims of trafficking. 3.7 percent of those surveyed experienced labor trafficking and 2.6 percent experienced debt bondage. Though sex trafficking was lower than expected (0.9 percent), 31.1 percent of female respondents reported exchange of sex for money. Child labor was found to affect 22.4 percent of surveyed minors. However, underlying social systems were such that non-armed group actors – such as family members, mining bosses, or government officials – were actually found to be behind many of the coercive labor practices.

The USAID effort emphasizes the need to address socio-cultural norms, peace-time power structures and attitudes, and the need to promote civic engagement rather than solely armed group abuses.

*See:* http://pdf.usaid.gov/pdf_docs/PA00K5R1.pdf.

*For more on human trafficking, see:* https://www.state.gov/j/tip/rls/tiprpt/2014/.

## MIGRATION AND DEMOGRAPHIC SHIFTS

ASM typically occurs in remote, rural areas and is often poverty-driven. The most typical forms of ASM occur in stable communities and are year-round or seasonal in nature, varying with agricultural cycles as an alternative livelihood. Other forms of ASM in stable communities may include traditional activities that are practiced in countries such as Bolivia, Colombia, Chile, Philippines, Indonesia, and Zimbabwe. Alternatively, rush mining, or ASM activities that result from gold or diamond rushes, or temporary ASM activities that begin during economic recessions, occur in unstable communities that may have significant fluctuations in population and potential conflict or security concerns. Such fluctuations may be a result of migrants from within country, or from neighboring countries.

Various types of ASM operations may occur depending on market values and local conditions. Informal ASM activities often involve seasonal, permanent, shock-push, or rush workers as introduced above. Due to the transient nature of some mines and surrounding communities, a lack of population data on mining settlements is a challenge for tracking populations in and out of ASM sites. However, the World Bank estimates that the total number of people entering the ASM sector will continue to grow as social and economic stressors increase, especially in regions that are already vulnerable to conflict (Hund et al., 2013). As the number of miners increase, the risk for conflict among miners – whether between individuals, individuals and formalized ASM operations or between ASM and LSM operations – increases. Alternatively, with many migrants having to separate from their homes or existing social networks for extended periods of time, there is a need to re-establish social networks in the destination locale, which may eventually result in new migrant-based social networks. Such networks may result from commonalities, such as homeland or region of origin, religious beliefs, tribal or ethnic linkages, language, culture, etc., and alleviate the loneliness and social isolation that may present from migrating to a new location.

Additionally, ASM will continue to provide a viable alternative livelihood as other sectors face challenges due to environmental or social stressors (e.g., climate change, lack of education, and labor skills). For example, women are increasingly entering the ASM sector as an alternative to subsistence agriculture. However, governments face numerous challenges designing policies that are effective in controlling informal labor sectors, such as ASM.

### LAND TENURE CONCERNS

While the majority of ASM is "informal," operating in the absence of appropriate frameworks, some ASM miners are operating within a "legal" or "formalized" framework, with established land titles and government permits, payment of taxes or fees, and compliance with social and environmental regulations imposed by the government.

Local property rights may determine the extent to which extractives may cause conflict. For example, if mining communities possess statutory or customary rights to land, the presence and extraction of mineral resources may not lead to social conflict and may in fact allow indigenous communities to lease or receive other compensation for use of the land. Alternatively, in instances where land rights are unclear, artisanal mining may create conflict over boundaries and access, as well as land use, which may result in deterioration of relationships and social networks, possibly leading to violence.

The extractive industry has a contentious history regarding access to and control of mineral resources worldwide. In several developing countries, customary tenure often extends to only the surface land and resources; communities and other surface landholders acknowledge that sub-surface sources are owned by the state. "Statutory tenure" is a system based on laws and regulations, which authorize state-established institutions to oversee access, use, or transfer of rights to both surface and sub-surface resources. "Customary tenure," also referred to as "informal," "indigenous," or "traditional" law, is based on indigenous populations' customs and coexists with statutory tenure. It may allocate seasonal access to resources and provide nuanced agreements to address competing users of natural resources, such as hunters, gatherers, cultivators, and herders. However, while customary tenure arrangements may be clear regarding surface resources, they may not be for sub-surface mineral resources, resulting in potential conflict between land holders and miners. In the case of fragile states, "customary tenure" typically rules, unless neither government nor traditional authority enforces access, in which case armed groups may move in.

While allocation of rights to sub-surface minerals in many countries is the responsibility of government, the resulting tension between distribution of mining rights between large-scale and artisanal and small-scale miners can be rampant and sometimes result in violence. Typically, the government will allocate rights to individuals or corporations that are equipped with the capability to extract the resource, while taxing the miners to financially support infrastructure and social services, which often do not make it equitably back to the local community.

**LAND TENURE ISSUES IN COTE D'IVOIRE**

The West African nation of Cote d'Ivoire has experienced forest cover loss and unsustainable resource depletion, including via ASM, in part due to land tenure customary law. Historic land tenure practices based on customary law have traditionally dictated that land is held and transferred according to the lineage of the original inhabitants of the area; however, these laws are not well defined and not consistently applied. Further, population growth, immigration, and commercialization of agriculture have led to increases in competition for land, resulting in conflict, confusion, and ultimately unsustainable farming techniques and land uses. While in the past agricultural livelihoods were most common (and had more predictable incomes), diamond mining has become more widespread due to the perceived potential for greater income.

In 1998, the World Bank assisted Cote d'Ivoire in transforming to a land tenure system defined by the Rural Land Law, utilizing private property rights regulated by the state. While private property regimes can potentially remove the confusion and competition for land, potentially resulting in the enforcement of more sustainable practices, little has been done to implement the Rural Land Law. The USAID PRADD project seeks to define and strengthen the appropriate laws, assess the formalization of existing tenure agreements, build capacity among stakeholders within ASM communities to manage and resolve conflict, and establish a collaborative framework of stakeholders to improve land tenure laws based on the appropriate local political and social context. Overall, the project aims to clarify and formalize land tenure regimes in order to reduce conflicts and contribute to increased investments in sustainable livelihoods by local communities.

*See:* https://www.land-links.org/country-profile/cote-divoire/; https://www.land-links.org/document/pradd-ii-diagnostic-land-conflict-artisanal-diamond-mining-communities-french/.

## UNDERLYING SOCIAL ISSUES IN MINING COMMUNITIES

ASM communities with unstable or unsafe mining operations, a transient mining workforce, or shifting market forces may be more vulnerable to underlying social issues. The instability brought on by poor ASM working conditions can serve as a catalyst for the worsening of other social issues such as human rights violations, substance abuse, violence and crime, prostitution, and increased risk for sexually transmitted diseases, as discussed in the previous section on health impacts. Additionally, due to poverty, crowded living situations (where large influxes of migrant miners occur), and lack of sanitation infrastructure, increased exposure to other communicable diseases may result.

Men, who receive higher compensation than women, may be more likely to spend their income on prostitution, gambling, or substance abuse, rather than improvement of households or local community investment (Hentschel, Hruschka, and Priester, 2002).

Drugs and violence especially can be present in ASM communities due to the influx of variable cash flow into the local economy, combined with scarce economic alternatives and a transient workforce. Studies have shown that escalation of violence occurs under stressful working conditions where workers are subject to extortion, theft, and intimidation (World Health Organization, 2016). The effect is pronounced when mining is perceived as illegal, escalating into violence between the miner, gangs, authorities, and even local land users. The absence of a structured established community limits availability of normal social services even in low-resource countries. Thus, health and social issues are often compounded.

Political disputes or geopolitical conflicts may also be ongoing in ASM communities, in some cases resulting in the seizure of mineral resources or mines themselves to fund their activity. The text box below outlines the case of Colombia; however, this has also been identified in Afghanistan, DRC, and other countries.

### CROSS-CUTTING ISSUES: VIOLENCE IN ASM COMMUNITIES IN COLOMBIA

Violence taking place around mines often fuels illegal activity of armed rebel groups, with cross-cutting implications for both social systems and community and individual health. In Colombia, mining-related violence takes place via a complicated web of players. Illegal mining is worth approximately $7 billion per year, funding the activity of leftist guerillas, paramilitary groups, and drug traffickers. Each of these elements have established a presence in various regions throughout Colombia in an effort to control mining operations, and informal miners – often of Afro-Colombian descent – face murders and kidnappings. For example, in 1988, 43 civilians were killed when armed men opened fire and threw grenades into crowds. Community members say that paramilitary and armed groups both threaten miners and extort money from them, which has become another source of funding for mining activity in the Segovia region. Informal miners are threatened and required to pay in order to continue mining, even if on their own land.

The government, in an attempt to cut off funding for armed groups and lower mercury levels in rivers, is cracking down on informal mining activity, and though they are prioritizing legalization and formalization programs, a number of informal miners have lost their livelihoods and see the government's efforts as a means of regaining control of resource-rich land for the sake of business ties to multi-national corporations. President Juan Manual Santos' administration has prioritized the drug trafficking and the licensing of mining as inter-related and core safety-related problems in Colombia. Nonetheless, as gold prices have risen in global markets, more miners are employing semi-mechanized mining techniques versus the lower-impact gold panning processes that had a smaller environmental footprint, and more are entering the (formal and informal) ASM/ASGM sector.

*See:* http://america.aljazeera.com/articles/2015/11/18/blood-gold-colombia.html; http://www.aljazeera.com/indepth/inpictures/2016/10/illegal-gold-mining-fuels-violence-colombia-161005063014208.html.

*Read about similar conflicts involving the Taliban's profit and funding from Afghanistan's lapos mines:* https://www.globalwitness.org/en/reports/war-treasury-people-afghanistan-lapis-lazuli-and-battle-mineral-wealth/.

## DEVELOPMENT CHALLENGES AND OPPORTUNITIES

The exploitation of a non-renewable resource, such as that which occurs with ASM, may be challenging to tie to sustainable development. However, the ASM sector can provide an accessible source of livelihood for poor, unskilled, and marginalized populations, with limited financial and administrative barriers and start-up time to enter the sector, thereby offering high potential for beneficial contribution to development efforts. Additionally, in times when livelihood diversification is increasingly important, ASM can play a critical role in development strategies and overall adaptive capacity and resilience. ASM can play a role in stimulating additional business development around mining communities and sites as well as trade opportunities. For example, initial wealth created through ASM activities can be invested in longer-term, more sustainable activities or livelihoods.

Nonetheless, ASM can present development challenges, such as impacts to other economic opportunities or the local economy. ASM activity can impact river geomorphology, impacting the ability of non-miners to rely on the river for transportation or bringing goods to markets. Contamination and violence associated with some mining communities can also bring bad publicity, of additional concern when communities or regions have depended traditionally on ecotourism. Finally, contamination associated with ASM can impact other sectors that communities and local economies may rely on, such as fisheries, timber and non-timber products, agriculture, etc.

## BEST PRACTICE GUIDANCE AND MITIGATION STRATEGIES

USAID-funded projects and related interventions or activities should always strive for maintaining or improving environmental, health, or socio-political systems, minimizing negative or detrimental impacts. Projects should be designed to meet best practices and sustainability goals. As discussed previously, mitigation measures can be used to prevent the need for remediation and rehabilitation later by encouraging the implementation of best practices early in a project lifecycle, but best practices can be incorporated throughout a project, including during project design, IEEs, and during the development of EMMPs. Whatever the point in the project, such practices should be considered in light of economic viability and practicality or utility for the project manager and implementers. For example, to minimize greenhouse gas emissions, renewable fuels could be mandated for use in project vehicles. However, if renewable energy sources are not available at the project site, this option is not realistic. At a minimum, project design and ongoing program and project efforts should emphasize improvement of existing conditions. This section will provide a summary of best practices, mitigation strategies, and indicators for measurement and monitoring.

### UNDERSTANDING CONTEXT AND CONDITIONS FOR PROJECT DESIGN AND IMPLEMENTATION

As discussed in this SEG, there are a variety of potential environmental, health, and socio-economic impacts of ASM. Preventing, mitigating, or otherwise addressing environmental, health, and socio-economic impacts of ASM requires broad understanding of the complexity of ASM and the micro- and macro-level forces. In particular, understanding the context and conditions within which ASM takes place is critical to effectively implementing any measures to prevent or mitigate the negative and optimize the positive effects of these activities in the context of responsible development – both globally and locally. In light of the micro- and macro-level contextual layers discussed previously, project implementers should conduct a baseline or community diagnostic assessment of existing conditions in order to identify the range of activities that could be associated with or impacted by ASM. Understanding these questions will help focus project design and maximize impact and sustainability.

Projects should be designed to consider environmental baseline criteria, such as:

- Local soils and their susceptibility to degradation, erosion, etc.;
- Water quality and availability (e.g. ground water access for drinking or irrigation, aquifer resources, etc.);
- Topography and geology;
- Weather patterns (e.g., rainy season versus dry season);
- Status of biologically significant areas (protected areas, wetlands, waterways, fish nurseries, high endemism areas, etc.); and
- Air quality.

Other socio-economic or socio-political considerations might include:

- Community health status and challenges, such as HIV/AIDS status in the area, access to healthcare or sanitation infrastructure;
- Land tenure, including conflicts over ownership, status of land where ASM takes place (e.g. privately owned or on an LSM concession); and
- Gender and labor issues.

In addition to planning for these local considerations, participatory involvement of local communities is critical to the sustainability and overall success of the project. Traditional knowledge and practices can offer invaluable insight into local customs, environmental patterns, political systems, etc.

There are other activities specific to various phases within a mine lifecycle where project design elements can be considered, as shown in **Figure 11.**

| Site Prospecting & Exploration | Mining | Processing | Site Closure | Legacy Issues |
|---|---|---|---|---|
| • Providing technical support<br>• Conducting environmental and health impact assessments<br>• Securing rights and access (e.g., licenses, titles) | • Implementation of mitigation measures<br>• Education and capacity building on best practices | • Implementation of mitigation measures<br>• Education and capacity building on best practices | • Providing technical support<br>• Conducting environmental and health impact assessments<br>• Minimizing abandonment of mines | • Providing technical support<br>• Remediation planning<br>• Identification of alternative use of land<br>• Good governance and community involvement |

*Figure 11. The ASM mine lifecycle and possible project interventions.*

## IMPACTS, MITIGATION STRATEGIES, AND INDICATORS

The tables below serve as a quick reference to various impacts and associated best practices, mitigation measures, and indicators that can be incorporated throughout various phases of the program lifecycle. They should not be interpreted as the only resource to inform program designers of possible best practices in ASM mitigation, particularly given the dynamic nature of these sectors and the constant emergence of new strategic approaches and practices. The "best practices" column in the tables below shows *goals* that project managers should strive for in project implementation or interventions. "Mitigation strategies" are specific steps or *approaches* that can be taken to reach the stated goal. Finally, the "indicators" column lists metrics for measuring and monitoring progress toward best practices. Many of these mitigation strategies may require capacity building and technical assistance. Expertise should always be shared directly with the relevant stakeholders so that they can continue with more sustainable practices after the project ends.

While the tables below are organized by impact category, many best practices, mitigation measures, and indicators are common across impacts and will have cross-cutting relevance and co-benefits to multiple categories or sectors. These kinds of activities should be prioritized when possible. For example, minimizing the use of mercury will have co-benefits to the environment and to human health. Minimizing erosion is good for the environment but also supports the sustainability of communities that also rely on subsistence agriculture.

## ENVIRONMENT AND HEALTH

Possible environmental impacts and best practices range across water, land, air, and biological resources. Note that many of these environmental impacts also have direct impacts on human health and safety; therefore, a number of best practices and mitigation measures are cross-cutting across both environment and health.

**TABLE 6. BEST PRACTICES, MITIGATION MEASURES, AND INDICATORS FOR ADDRESSING ENVIRONMENTAL AND HEALTH IMPACTS OF ASM.**

| IMPACTS | BEST PRACTICES | MITIGATION STRATEGIES | INDICATORS |
|---|---|---|---|
| Land degradation | Minimize soil loss and erosion | -Minimize deforestation or land clearing practices<br>-Implement soil cover and conservation methods<br>-Enhance soil fertility and revegetate land to protect topsoil<br>-Protect riverbeds<br>-Educate miners on environmental impacts and sustainable practices | -Trainings conducted with relevant stakeholders<br>-Water quality testing showing improvement<br>-Fewer acres cleared |
| | Prevent or minimize soil contamination | -Prevent improper production waste disposal<br>-Provide and maintain adequate sanitation infrastructure<br>-Educate miners on environmental and health impacts and sustainable practices<br>-Technical training on alternative, cleaner, or more sustainable practices<br>-Ensure proper mine closure and signage of land in light of legacy issues | -Trainings conducted<br>-New practices implemented<br>-Soil testing showing improvement in soil fertility<br>-Number of miners putting more sustainable practices in use |

| TABLE 6. BEST PRACTICES, MITIGATION MEASURES, AND INDICATORS FOR ADDRESSING ENVIRONMENTAL AND HEALTH IMPACTS OF ASM. | | | |
|---|---|---|---|
| IMPACTS | BEST PRACTICES | MITIGATION STRATEGIES | INDICATORS |
| | Prevent or minimize landslides | -Minimize deforestation or land clearing practices<br>-Promote proper pit construction<br>-Educate miners on proper pit construction and mine closure<br>-Provide technical support on pit construction or closure<br>-Fill closed mines, cover with topsoil, replant vegetation to reduce landslide risk | -Trainings conducted<br>-New practices implemented<br>-Increased use of alternative construction methods<br>-Number of pieces of equipment distributed |
| | Reduce deforestation and major landscape change | -Minimize deforestation or land clearing practices<br>-Provide trainings on the importance of forest cover | -Trainings conducted<br>-Fewer acres cleared<br>-New practices implemented |
| Water Quality and Access | Prevent or minimize water contamination | -Prevent improper production and waste disposal<br>-Provide adequate sanitation infrastructure<br>-Educate miners on environmental and health impacts and sustainable practices<br>-Technical training on alternative, cleaner, or more sustainable practices<br>-Prevent mined rock, gravel, and soil from accumulating in streams or rivers<br>-Ensure panning, sluicing, washing of ores takes place downstream from where water consumption for food, irrigation, livestock takes place<br>-Prevent cyanide and mercury cross-contamination | -Trainings conducted<br>-Number of pieces of equipment or supplies distributed |

| TABLE 6. BEST PRACTICES, MITIGATION MEASURES, AND INDICATORS FOR ADDRESSING ENVIRONMENTAL AND HEALTH IMPACTS OF ASM. | | | |
|---|---|---|---|
| IMPACTS | BEST PRACTICES | MITIGATION STRATEGIES | INDICATORS |
| | Maintain or improve sustainable access to water | -Increase water-use efficiency/improve rainwater management<br>-Promote integrated watershed management<br>-Educate miners on environmental and health impacts and sustainable practices<br>-Technical training on sustainable practices | -Trainings conducted<br>-Gallons of water obtained through rainwater management or other more sustainable techniques |
| | Prevent stagnant water sources | -Prevent stream/river flow disruption activities<br>-Promote integrated floodplain management<br>-Promote proper pit construction<br>-Educating miners on environmental and health impacts, and proper pit construction and mine closure practices<br>-Technical support on pit construction or closure | -Trainings conducted |
| Air Quality | Prevent or mitigate occupational exposure and/or ambient air pollution from chemical processing | -Promote cleaner production methods (retorts, gold shop mercury capture technologies)<br>-Provide personal protective equipment (PPE)<br>-Promote handwashing<br>-Educate miners on environmental and health impacts and sustainable practices<br>-Technical training on alternative, cleaner, or more sustainable practices<br>-Technical training on use of PPE | -Trainings conducted<br>-Quantity of PPE distributed<br>-Informational materials distributed in communities or in schools<br>-Chemical capture technologies distributed and installed (mercury capture and retorts) |

| TABLE 6. BEST PRACTICES, MITIGATION MEASURES, AND INDICATORS FOR ADDRESSING ENVIRONMENTAL AND HEALTH IMPACTS OF ASM. | | | |
|---|---|---|---|
| IMPACTS | BEST PRACTICES | MITIGATION STRATEGIES | INDICATORS |
| | Prevent or mitigate occupational exposure and/or ambient air pollution from dust | -Provide and maintain adequate infrastructure (e.g., roads)<br>-Promote proper pit construction<br>-Promote cleaner or safer excavation practices<br>-Provide PPE<br>-Ventilate mine shafts and tunnels when possible<br>-Educate miners and community members<br>-Technical training on use of PPE | -Trainings conducted<br>-New mine construction using new methods |
| | Minimize emissions from mechanized equipment or vehicles | -Promote cleaner fuel usage when possible<br>-Limit distance traveled by vehicles | -Alternative fuel sources identified and procured<br>-Miles traveled |

## HEALTH AND SOCIO-POLITICAL

While health and socio-political impacts can be assessed individually as distinct impacts, the best practices and mitigation measures often provide co-benefits and are therefore presented in the table below jointly.

| TABLE 7. BEST PRACTICES, MITIGATION MEASURES, AND INDICATORS FOR ADDRESSING HEALTH AND SOCIO-POLITICAL IMPACTS OF ASM. | | | |
|---|---|---|---|
| IMPACTS | BEST PRACTICES | MITIGATION STRATEGIES | INDICATORS |
| Social and Community Health Issues | Reduce exposure to communicable diseases | -Promote integrated pest management<br>-Reduce sources of stagnant water pools (to reduce vector-borne and other disease spread)<br>-Promote safe sex options<br>-Educate miners and community members on communicable diseases and prevention measures<br>-Increase access to healthcare<br>-Build capacity for community health services and health education | -Trainings conducted<br>-Informational materials distributed in communities or in schools<br>-Use of healthcare services |

| TABLE 7. BEST PRACTICES, MITIGATION MEASURES, AND INDICATORS FOR ADDRESSING HEALTH AND SOCIO-POLITICAL IMPACTS OF ASM. | | | |
|---|---|---|---|
| IMPACTS | BEST PRACTICES | MITIGATION STRATEGIES | INDICATORS |
| | Reduce exposure to social hazards | -Provide health education on sexually transmitted infections, substance abuse, etc. | -Informational materials distributed in communities or in schools |
| | Reduced exposure to chemical hazards | -Promote alternative processing or production methods that do not use contaminants<br>-Educate miners on environmental and health impacts and sustainable practices | -Use of new methods in existing or new mine sites |
| Human Rights Protection | Protect or improve labor rights | -Prevent and monitor labor violations<br>-Enforce labor protection<br>-Strengthen labor protection legislations<br>-Promote equal compensation<br>-Acknowledge balance of mining and household activities<br>-Add counter-trafficking measures | -Surveys showing decreased child labor violations<br>-Coordination with community centers or mine associations<br>-Documentation of compensation |
| | Protect or improve gender-related rights and the rights of women | -Promote equal compensation<br>-Educate community members on specific risks to pregnant women and nursing mothers<br>-Prevent, monitor, and enforce against sexual harassment and exploitation | -Trainings conducted<br>-Documentation of compensation<br>-Systematic M&E efforts showing documented improvement |
| | Protect or improve the rights of vulnerable populations such as children and older adults | -Prevent and monitor labor violations on children<br>-Enforce labor protection for children<br>-Educate community members on impacts to high risk subgroups | -Coordination with community centers or schools<br>-Systematic M&E efforts showing documented improvement |
| Land Tenure | Protect or improve legitimate rights to land and resources<br>Reform of laws or regulations to increase formalization of miners | -Work through local mechanisms such as community centers, mining associations, or the local government<br>-Increase access to finance so that miners can invest in cleaner technologies | -Lowered counts of violence associated with land conflict |

## CROSS-CUTTING MITIGATION MEASURES

In addition to the impact-specific best practices and mitigation measures provided above, several mitigation strategies and best practices for sustainable interventions and ASM activities are cross-cutting and are not specific to any one impact area. Good project management involves mitigating climate change; therefore, climate change mitigation measures should be considered in cross-cutting best practices as well.

**Formalization of mining and proactive stakeholder engagement** can set the foundation for improved conditions and more sustainable mining practices. Formalization of miners and mining associations is an activity in which USAID has been involved, and it can ultimately result in more sustainable practices with greater oversight. Informality and illegality often result in poorly regulated activities, with few technical or financial resources available to miners. Where organized mining associations exist, training can more easily be offered in a coordinated way. Occupational safety training (e.g. in the use of PPE, safety measures, construction best practices for improving trenching) and more sustainable ASM extraction or mine development practices may help mitigate both short-term and long-term health hazards.

It is important to note that financial barriers may be a challenge if adoption of new technologies, equipment, or other supplies is needed. For example, proper mercury (or other chemical) storage can minimize exposure, but specific equipment is necessary. Additionally, supplying miners or mining organizations with equipment may not be sustainable long term due to scarcity of parts and/or skilled maintenance labor. For example, if equipment breaks down, will miners be able to fix it or purchase replacements? Providing or supporting access to micro-finance loans or other financial resources may allow miners to purchase different or more sustainable equipment. Formalization of miners or mining associations will also allow miners access to these resources. If miners have land tenure and mineral rights, they can access credit to invest in improved technology. However, it is easier for mining associations and formalized groups to obtain land tenure and mineral rights than it is for individuals.

Proactive and coordinated engagement with stakeholders at multiple levels connects the relevant ministries at a national or regional level with activity at the local level through non-profit organizations, community centers, or municipal government. A coordinated approach is important to ensure hazard mitigation is consistently and widely implemented. Capacity building in conflict resolution, which requires proactive and broad sustainable engagement, can assist local communities in establishing positive and productive relationships.

Local processing sites such as gold shops can serve as a main entry point to the community. Because one gold shop communicates with many miners, gold shop owners have been used as community opinion leaders by the World Bank, the United Nations Industrial Development Organization (UNIDO), and the U.S. Environmental Protection Agency (USEPA). Gold shops serve as critical locations for establishing relationships and lines of communication with the supply chain and the mining communities. Gold shops are also natural sites for demonstration projects to introduce new hoods, retorts, and other mercury capture technologies that reduce exposures to mercury and sodium cyanide. They are also sites through which to deliver health screenings and health education on issues like mother/child occupational risks, better environmental practices, and formalization/legalization approaches.

**Cleaner production methods, practices, and equipment** can help mitigate longer-term environmental and health hazards and can be shared with mining cooperatives to mitigate potential impacts. Retorts are simple devices that, when used correctly, capture most of the mercury for recycling before it enters the air. Mercury control technologies and retorts can be used to recover mercury and limit its release, but these still need to be used away from living areas and with good ventilation. There are other alternative methods to concentrate gold such as centrifugation or cyanide leaching in the ore milling process without prior mercury treatment. See Annex 2 for more details on cleaner production methods.

Building capacity to utilize cleaner production methods and providing training can help them sustainably minimize and ultimately avoid the usage of mercury, cyanide, and other chemicals. Plans can be developed with miners to process and resell waste rock for construction and create permanent sedimentation ponds to improve water quality. Practices such as backfilling pits and underground workings or stockpiling topsoil for future placement on cleared areas or waste dumps are simple measures that mitigate environmental impacts.

Training on and facilities for the proper usage of chemicals can reduce water or soil contamination, reducing chemical exposure. Chemical contamination of water can result from improper chemical storage, dumping, or weathering of mined materials. Chemicals and chemical wastes should be stored away from bodies of water, and care should be taken that a heavy rain event will not cause the chemicals to leak into a waterway. It is not good practice to dispose of chemicals in surface water. Mined materials, when exposed to air and water, can weather and produce acidic streams with high heavy metals content that may damage aquatic life and water quality. Mined materials should be stored where they have minimal contact with water flows. Mercury used in gold mining can also settle in waterways near mining sites. Where possible, mercury should be replaced with other technologies, but if it is used, the burning off of the mercury from the amalgam should be done in a well-ventilated area, away from living spaces and water sources. Avoiding destructive practices or methods will not only improve environmental conditions in the surrounding areas, but lower exposure risks and improve the health of miners, their family members, and the local community.

### ADDRESSING MERCURY USAGE AND CONTAMINATION

Practitioners should note that criminalizing or otherwise governing and regulating mercury use has important implication for miners; promoting alternative technologies or other efforts to mitigate mercury contamination is complex. In one study in Ghana, researchers showed that small-scale miners were perceived as "environmental criminals" for utilizing mercury due to its detrimental impacts to health and the environment, despite the fact that mercury amalgamation is simple, inexpensive, and often the only means of extracting gold. The study concluded that the government condemned mercury usage in ASM without providing adequate solutions or providing education on environmental and health impacts. Many miners in the study region recognized that mercury use could result in health problems, however they did not necessarily draw connections between mercury contamination in the environment or the risk to children and other community members.

Ultimately, sustainable promotion of safer and healthier mining practices, such as alternative methods, are not viable if the target population is uninformed about their usage and benefit. Practitioners and government officials should first seek to understand the knowledge base and needs of miners and community members, both male and female, before broadly applying new regulations or dictating the use of new technologies. The authors of this study argue that prevention or reduction or mercury usage in the environment should begin with a more holistic understanding or mercury usage in the ASM sector (e.g. the practical reasons why it is utilized), and focus on community-based and culturally/locally-based solutions.

*See:* http://inside.mines.edu/~ksingha/web_files/tschakert&singha,2007.pdf.

**Conceptualizing community adoption** of mitigation measures involves working directly with community leaders, health workers, and specifically vulnerable groups. In many ASM communities, this means working directly with women and children. Children are especially vulnerable and should be protected by changes in both policy and practice. Project managers should design and deliver education and outreach programs that aim to reduce child labor in ASM through broader development strategies. There should be a focus on educational opportunities for children and ensuring that children are afforded equal opportunity to participate. Project managers can help with education on and compliance with international standards on labor regulations. When ASM activities are formalized, enforcement agencies should monitor and penalize mines found to benefit from child labor practices that endanger or otherwise negatively impact children. Additional community capacity building on issues such as human rights and conflict resolution can benefit ASM communities as well.

The role that women play in ASM should remain a key consideration for project planning and should be considered separately from other labor issues, such as child labor. Projects should be designed to empower women, increase participation at all levels of ASM, and facilitate equal benefits for women for their work and recognition for the roles and contributions they play in development. Education and outreach on specific risks to pregnant and nursing mothers could help increase awareness of specific risks that should be avoided (e.g., chemical exposure) and capacity building in the healthcare sector should include focus on monitoring and prevention of maternal and child health risks specific to local ASM techniques.

**Linking to local policy or planning strategies** at multiple levels is critical to ensure coordination with ongoing activity. At the national level, NAPs for mercury/waste management exist in many countries and already outline actions or best practices based on local context. Ministries of environmental, health, agriculture, or mineral resources may have legislation, working groups, or other measures in place. Thinking more broadly, national policy measures focusing on poverty eradication will help communities in countries that practice ASM. At the international level, frameworks such as the Kimberly Process may also provide important linkages for addressing ASM impacts. Finally, USAID requirements should also be incorporated into project or program design. Within this multi-level context, development specialists and project managers should ultimately seek to understand and advocate for the potential for ASM to stimulate and serve as a basis for sustainable and/or economic development, with environmentally responsible processing techniques.

### PLANNING TOOLS FOR IMPROVING ASM AND MITIGATING IMPACTS

There are several specific planning tools that can improve ASM operations and/or mitigate impacts of ASM-related contamination or environmental damage. These include:

- Data and mapping (geographical information system (GIS), satellite data), obtained through participatory mapping, can be used by project planners (and taught to local practitioners or individuals) to understand the spatiality of ASM activity. Publicly documented validation of geo-referenced mining sites could also be obtained to add records of mining claims. Databases or other registries can play an essential role in establishing and strengthening the chain of custody for mining operations. The ubiquitous nature of cell phones –most miners are likely to have one – could allow for publicly sourced global positioning system (GPS) data to be obtained. Participatory mapping involves working with local organizations in mining, conservations, etc., to understand drivers of forest degradation, illegal mining activities, or other locally relevant issues.

- Mobile applications on cell phones can be used to share information and connect miners or community members with other networks. For example, information about rain forecasts could be shared to help miners prepare for and prevent flooding within mine structures. Information on commodity prices could help miners ensure they receive fair prices from local buyers as well.

- Community-based programming for mitigation/management; organizing mining cooperatives; and working through local health workers, community leaders, or other culturally or religiously significant individuals can give credence to development or intervention activities. Project managers can work alongside community groups to understand community characteristics, including transient and nomadic lifestyles (including of miners), vulnerable subpopulations, or other demographic trends. Mining cooperatives similarly provide an effective way to reach miners and their families.

- Social programming and community-based communication campaigns on risk and exposure can be leveraged to incorporate ASM-related environmental and health risks. There may be on-going activities, such as health-related campaigns, that project managers can expand on to ensure that mining communities also receive relevant messages.

- Monitoring and surveillance for evidence-based health data is needed to provide a better picture of health impacts, both for baseline determination and for impacts resulting from ASM or project activity. Health impact assessments are required for USAID-funded projects and are critical for understanding baseline environmental or health conditions in project communities.

- A thorough EIA and/or strategic environmental assessment (SEA) that considers the mining site, operation size, nature of activities, and related activities and how they may impact nearby land, water, and biodiversity resources will help USAID and implementers understand environmental conditions and meet USAID requirements. An SEA goes beyond an EIA to address multiple EIA deficiencies and integrate multiple development interests. Any assessment should consider how close the site is to the local community, communal land, and water resources; how the land will be used after mining; and whether an alternative site or no mining would be a better course of action. Additionally, if possible/applicable, plans should be made before mine construction regarding the mine area, where topsoil and mined rocks will be stored, how much land area needs to be cleared, and how erosion controls will be implemented. This assessment should also consider water and air effects. Pre-intervention identification of particularly sensitive areas (protected areas, endemic species habitats, fish nurseries, etc.), use of buffer zones, and other efforts to maintain or restore natural waterway flows can also help mitigate impacts to biodiversity and ecosystems services.

### MINIMIZING CLIMATE CHANGE EMISSIONS FROM ASM ACTIVITIES

USAID promotes the integration of climate change considerations into project design via the climate risk management (CRM). The contributions to climate change by ASM activities will be described in more detail in the next section on climate change implications and ASM, but emissions could be minimized by the following best practices:

- Minimize deforestation and land clearing practices in ASM siting that contribute to the loss of carbon sinks.
- Ensure any machinery or vehicles utilized in ASM processes are maintained and optimized for fuel efficiency to reduce greenhouse gas emissions.
- Increase access to alternative energy sources to provide electricity, heating, and lighting power both within mines as well as across the community (e.g., maximizing opportunity for solar or hydro power) to reduce reliance on carbon-heavy energy sources.
- Minimize transport requirements through the placement of processing facilities in close proximity to mine sites to reduce greenhouse gas emissions from vehicular or other fossil-fuel based transportation methods (consider full market value chain from overview section).
- Minimize the use of mining practices that alter ecosystems (e.g., river morphology that could increase flood risk).
- Educate miners and community members on climate change, impacts, and potential mitigation and adaptation actions they can take to reduce contributions to and impacts from climate change.

# CLIMATE CHANGE IMPLICATIONS AND ASM

## BACKGROUND

The Intergovernmental Panel on Climate Change (IPCC) has found that populations that are socially, economically, culturally, politically, institutionally, or otherwise marginalized have increased vulnerability to impacts of climate change. Some impacts of climate change may be more acute (e.g., extreme storms or flooding), while others are more long-term (e.g., drought's impact on food security). Impacts may also be direct, such as mortality due to extreme heat, or indirect, such as changes in food production or water availability due to changing climate. In addition, it is important to understand not only how ASM activities may contribute to climate change, but also how the populations that participate in ASM may best increase their adaptive capacity and resilience to the impacts of climate change in both the short and long term.

Additionally, ASM may present an opportunity for more sustainable development of rural and peri-urban communities, increasing socio-economic status in a way that improves adaptive capacity and overall resilience to the impacts of climate change and other global environmental change.

## PLANNING FOR CLIMATE CHANGE

Many of the communities in which ASM occurs are already at increased risk for climate change impacts. Additionally, specific physical changes from climate change will vary from region to region; therefore, development specialists and project managers supporting ASM projects should have a basic understanding of the specific impacts likely at their project locations, pulling from historical records, current trends, and future models and projections. From a risk management perspective, it is less costly to account for the potential direct and indirect impacts of climate change on mines and community members in project design than to continue "business as usual" and risk paying the full cost of damages or lost income in the future. Planning ahead reduces vulnerability, increases resilience, and facilitates adaptation to climate change by ecosystems and communities alike.

USAID supports countries in climate change action, including low emission development, adaptation, clean energy, sustainable landscapes, and climate integration to ensure food security, infrastructure, disaster preparedness, and other programmatic work. As such, development specialists or project managers working with ASM communities should provide guidance on increasing the adaptive capacity of ecosystems surrounding ASM projects, ensuring protection and sustainability of critical natural resources, and ensuring resilience of the people who are dependent upon such resources in the wake of climate change. USAID's Global Climate Change Office offers a variety of tools and resources to support climate-resilient development.

Climate change will intensify the environmental impacts described previously. In particular, ASM activities are heavily dependent on the availability of water resources. If the area experiences extended drought conditions, there may not be enough water to wash and separate ores by traditional means. Additionally, the reduced flow of water will result in higher concentrations of contaminants that are washed from the ores, making it a larger environmental and health hazard. If the area experiences heavy precipitation, then mine pits and shafts can fill with water, requiring draining to continue mining activities. Additionally, the water will expedite erosion and its impacts, possibly cause overflowing of waste pits into drinking and irrigation water supplies, and increase weathering of mined rocks, releasing their heavy metals into soil and water at higher rates. Heavy rains can cause landslides that partially fill in mine excavation sites or damage nearby communities.

**CLIMATE-RESILIENT DEVELOPENT: A FRAMEWORK FOR UNDERSTANDING AND ADDRESSING CLIMATE CHANGE (2014)**

The Climate-Resilient Development Framework developed by USAID provides a simple five-stage approach to help development specialists or project managers systematically assess climate change-related risks and prioritize actions to promote climate-resilient development across multiple sectors.

The five steps in the framework include:

- Scoping
- Assessing
- Designing
- Implementing and managing
- Evaluating and adjusting

Addditional annexes include specific focus on:

- Climate change and coastal zones
- Climate change and conflict
- Climate change and water
- Governing for resilience
- Working with marginal populations
- Climate vulnerability assessment

The framework has been utilized in multiple countries, including Barbados, Jamaica, Nepal, Peru, the Philippines, St. Lucia, Tanzania, and West Africa.

*See:* https://www.usaid.gov/climate/climate-resilient-development-framework.

If ASM activities are in a valley that is subject to inversions, climate change may increase the frequency or severity of the inversions. During an inversion, colder air is trapped underneath warmer air, and emissions within the valley become trapped with the colder air. This would cause emissions such as diesel exhaust or mercury from mining to be trapped also, exacerbating their negative impacts.

Mitigation of these impacts are discussed with more detail in the Best Practice Guidance and Mitigation Strategies section, with consideration of climate extremes such as drought or flooding. Some key mitigations are placement of the mine site downstream from where water is withdrawn for drinking or irrigation, minimized clearing of vegetation for mine development, avoiding accumulation of washed ores and gravel in streambeds, storing mined rock and mine wastes away from water sources and farmland, and reducing air emissions of mercury by replacement or use of a retort.

### CONTRIBUTIONS TO CLIMATE CHANGE

As described previously, ASM is conducted via manual or semi-mechanized labor (e.g., limited to water pumps and earth-moving equipment), so therefore, in comparison to large-scale or industrialized extractive processes, the use of fossil fuels in ASM is negligible. Underground mines may release greenhouse gases. Coal mines, for example, are frequently associated with methane seams that can leak into the atmosphere. Looking across the value chain described previously, however, transportation of mined commodities into processing and ultimately the market can also contribute to the overall carbon footprint and greenhouse gas emissions. Additionally, as ASM communities often face underlying poverty, the lack of access to reliable and efficient energy sources for everyday needs (e.g., cooking, heating) often result in reliance on carbon-intensive sources of energy (e.g., wood, charcoal, and gasoline), which also contribute to greenhouse gas emissions.

However, the more urgent and consequential contributions to climate change by the ASM sector are deforestation; alterations to river morphology; air, soil, and water pollution from tailings, waste, and sewage; and abandoning and leaving mining pits un-reclaimed. These pollutants and degraded sites lead indirectly to climate change, as even after mining is completed, land cover will change, and reforestation is unlikely. In addition to the removal of greenhouse gas sinks that deforestation and land clearing cause, such activities also negatively impact overall ecosystem resiliency and thereby the adaptive capacity of adjacent communities.

### CLIMATE CHANGE IMPACTS ON ASM

The majority of ASM activities occur in countries that are at increased vulnerability to impacts of climate change. Changes in temperature and precipitation may alter the seasonality of mining, possibly contributing to additional shifts in livelihoods and population migration. Such shifts could result in increasing social conflict. Additionally, such physical changes could also cause additional stress on underlying socio-economic and health status of community members, resulting in reduced adaptive capacity and resilience to climate change impacts. More specific impacts and potential adaptation responses follow in **Table 8**.

**TABLE 8. CLIMATE CHANGE IMPACTS ON ASM.**

| CLIMATE STRESSES (VARY BY REGION) | DIRECT IMPACTS | INDIRECT IMPACTS | POSSIBLE ADAPTATION RESPONSES |
|---|---|---|---|
| Increasing Temperatures | -Hotter working conditions could result in impacts to worker/community health (heat stress, vector-borne disease, etc.) | -May cause shifts in seasonality of mining<br>-May result in additional changes in livelihoods or migration<br>-May lead to drought-like conditions that reduce food and water access and quality (e.g., increased hunger and malnutrition) | -Rural livelihood diversification<br>-Education and capacity building in occupational health<br>-Adoption of adaptation options to protect miners and community members (e.g., water or cooling stations, mosquito netting) |

| TABLE 8. CLIMATE CHANGE IMPACTS ON ASM. | | | |
|---|---|---|---|
| CLIMATE STRESSES (VARY BY REGION) | DIRECT IMPACTS | INDIRECT IMPACTS | POSSIBLE ADAPTATION RESPONSES |
| | | -May cause alterations in vector habitat ranges, resulting in increased vector-borne disease<br>-Additional stress to underlying socio-economic and health status (reduced adaptive capacity and resiliency) | -Adoption of alternative energy and innovative technology for cooling |
| Changes in Precipitation (Lack of or excess water availability) | -Reduced access to potable water<br>-Changing river flow patterns<br>-Reduced access to water for ASM activities and operation<br>-Increased risk of floods or drought<br>-Higher concentration of contaminants in water during drought events | -May cause shifts in seasonality of mining<br>-May cause shifts in mining practices, e.g. ability to use water-intensive practices<br>-Reduced food and water access and quality<br>-May result in additional changes in livelihoods or population migration<br>-May cause alterations in vector habitat ranges, resulting in increased vector-borne disease<br>-Sanitation challenges<br>-Flooding could damage infrastructure<br>-Additional stress to underlying socio-economic and health status (reduced adaptive capacity and resiliency) | -Invest in infrastructure resilience<br>-Rural livelihood diversification<br>-Integrated watershed management<br>-Rainfall capture/water efficiency<br>-Education regarding what to do in drought or flood situations<br>-Adoption of adaptation options to protect miners and community members (e.g., mosquito netting) |
| Extreme Events | -Damage to infrastructure<br>-Increased risk of floods<br>-Possible landslides or mine collapse | -Additional stress to underlying socio-economic and health status (reduced adaptive capacity and resiliency)<br>-Population displacement/ forced migration | -Invest in infrastructure resilience<br>-Rural livelihood diversification<br>-Education and capacity building for emergency preparedness and response |
| Sea Level Rise | -Increased risk of floods or storm surge | -Additional stress to underlying socio-economic | -Invest in infrastructure resilience |

| TABLE 8. CLIMATE CHANGE IMPACTS ON ASM. | | | |
|---|---|---|---|
| CLIMATE STRESSES (VARY BY REGION) | DIRECT IMPACTS | INDIRECT IMPACTS | POSSIBLE ADAPTATION RESPONSES |
| | -Increased risk of disease (e.g. cholera if water sources are contaminated with sewage)<br>-Damage to infrastructure<br>-Population displacement/forced migration due to loss of land | and health status (reduced adaptive capacity and resiliency) | -Rural livelihood diversification<br>-Education regarding what to do in drought or flood situations |
| Biodiversity Loss | -Reduced food and water access and quality | -Potential changes in infectious disease agents<br>-Additional stress to underlying socio-economic and health status (reduced adaptive capacity and resiliency) | -Reducing other threats to biodiversity (e.g., hunting or poaching, pollution, habitat fragmentation)<br>-Maintaining habitat connectivity |

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# ANNEX 1: ASM GLOSSARY

**Acid rock drainage**: The acidic water created from large-scale earth disturbances (such as mining) of rocks containing sulfide materials, creating environmental and health-related risks of contamination and exposure, such as leaching of heavy metals.

**Amalgamation:** A concentrating process in which mercury is mixed with an ore containing metallic gold or silver, or an alloy of the two. The precious metal bonds with the mercury to form the metal-laden mercury amalgam and the waste (barren) ore pulp to effect separation.

**Artisanal and small-scale mining (ASM):** Mining conducted by individual miners or small enterprises with limited capital investment and production.

**Commodity:** A raw material or primary agricultural product that can be bought and sold.

**Conflict mineral:** Minerals or ores that are mined in an area of armed conflict and traded illicitly to finance that conflict.

**Crushing or grinding:** Crushing and grinding are the two primary processes to reduce the size of excavated materials. Crushing is normally carried out on dry ore, while grinding (normally carried out after crushing) may be conducted on dry or slurried material.

**Exploration:** The process of searching for and finding ores (viable concentrations of minerals) to mine.

**Extraction:** The removal of valuable minerals or other geological materials from the earth.

**Kimberly Process:** A joint government, industry, and civil society initiative to stem the flow of conflict diamonds – rough diamonds used by rebel movements to finance wars against legitimate governments.

**Large-scale or industrial mining (LSM):** Mining typically undertaken by big companies using many employees and a large labor force. The company mines at large sites and continues the operations until the mineral or metal can no longer be recovered economically.

**Mercury capture technology:** A series of technologies used to capture mercury during ASGM, to reduce release of mercury into the environment.

**Milling:** The process of breaking solid materials into smaller pieces by grinding, crushing, or cutting.

**Minamata Convention on Mercury:** A global treaty implemented by the United Nations Environment Programme (UNEP) to protect human health and the environment from the adverse effects of mercury. The Minamata Convention includes a ban on new mercury mines, the phasing out of existing ones, the phasing out and down of mercury use in products and processes, control measures on emissions to air and on release to land and water, and the regulation of the informal sector of ASM.

**Mine/site closure:** The process of shutting down mining operations on a temporary or permanent basis. Mines have a limited lifetime, which is typically determined by the size and quality of the mineral deposit being extracted. Mines are closed when the supply of ore runs out or the commodity prices drop, making the mine uneconomical to operate.

**National Action Plan (NAP):** A requirement of countries participating in the Minamata Convention on Mercury outlining national objectives and reduction targets, actions for elimination of mercury and related mercury processing, steps for facilitating the formalization or regulation of ASM, baseline information on mercury use, strategies for promoting the reduction of mercury use and managing trade, methods for involving stakeholders, public health capacity building in training healthcare workers, preventing exposure of vulnerable populations, and strategies for sharing information.

**Permanent ASM:** Mining that relies on established mineral resources that are often located where previous large-scale industrial or formal mining is present. Seasonal miners become permanent if the compensation is a reliable source of income.

**Processing:** The step within the ASM commodity life cycle of separating valuable minerals from their ores. Sometimes referred to as ore dressing.

**Prospecting:** The search for mineral deposits in a place, especially by means of experimental drilling and excavation.

**Rare-earth elements:** A set of seventeen chemical elements with unique magnetic, phosphorescent, and catalytic properties that are critical for technology and electronics. While named rare earths, they are in fact not that rare and are relatively abundant in the Earth's crust. What is unusual is to find them in quantities significant enough to support economic mineral development.

**Refining:** The process of purification of a substance, usually a natural resource that is almost in a usable form, but which is more useful in its pure form. In ASGM, it is typically completed by gold shops through heating the gold ore and vaporizing residual mercury.

**Remediation/reclamation:** The process of restoring land or waterways that have been mined to an acceptable standard of productive natural or economically usable state.

**Reuse:** Using former mine sites for alternative purposes after the close of a mine, whether closed formally or not.

**Rush ASM:** Mining that typifies many diamond and gold mines where the news of a major strike can create a stream of skilled and unskilled miners to an area over a short period of time.

**Seasonal ASM:** Mining that provides a source of employment in agricultural off-seasons, where ASM may provide an alternative livelihood.

**Shock-push ASM:** Mining that refers to rapidly established mining sites where workers relocate due to severe drought, social disruptions, conflicts, or the hope of more productive and lucrative livelihoods.

**Smelting:** A form of extractive metallurgy; its main use is to produce a base metal from its ore. In a furnace, chemicals are added to the ore so that when heated, liquid metal is formed, allowing it to be separated from minerals with no value.

**Washing:** Rinsing to sort dirt or debris away from valuable ore.

# ANNEX 2: ASM PRODUCTION, PROCESSING, AND TECHNOLOGIES

## GENERAL ASM OVERVIEW: PRODUCTION AND PROCESSING

Valuable minerals are generally found in low concentrations, mixed with rocks, soil, and other materials that have comparatively low value. Mining is therefore a progression of steps to increase the concentration of valuable minerals, and ultimately purify them into a saleable product.

The specifics of the mining **production** steps and operations depend on the type of mineral deposit, since hard rock deposits are mined very differently than alluvial deposits in sand or gravel in a riverbed, and the chemistry of each mined commodity is different. However, at each step, a stream of less-valuable material is generated and requires proper handling and disposal in order to not contaminate the surrounding environment or cause health impacts.

Typically, the first step in the production process is to extract the valuable minerals/ores and associated rocks and dirt out of the ground. If the mineral/ore deposit is in stone, then explosives are commonly used to break the rock and liberate the ore. Alternatively, extraction could involve digging either by hand (with hand tools) or with small-scale machinery (like jack hammers), but can be expedited with the use of diesel-powered backhoes, dump trucks, and other excavation equipment. Within an excavation site, a first-level separation is often completed to avoid moving rocks and dirt with no value, so that miners can focus on excavating valuable ores and minerals. This can lead to excavation of tunnels, troughs, and pits that follow veins of higher concentration ore.

Once the material has been excavated, it needs further separation and **processing** to select just the portions that contain valuable minerals. Frequently, the valuable material differs in density (usually it is denser) from the surrounding rock and soil. This allows for a physical separation to be realized by passing water over the mined material. Less dense rocks and soil are carried further by the flowing water than the dense ores, which sink faster. There are many devices that use this density difference for separation, including gold pans, sluices, shaking tables, spiral concentrators, centrifuges, and many others.

In larger or more complex mining operations, physical *beneficiation* (the process of removing rocks and dirt from the ore, creating waste tailings in the process) of the ores is continued by crushing and grinding the ore to release valuable minerals from the rock, and floating the removed minerals in water by adding special chemicals similar to soaps. This extra concentration of ores decreases the use of chemicals later in the mining process.

After the ores have been separated by physical means such as sluicing or flotation, the next step is usually purification by pyro- or hydrometallurgical methods. *Pyrometallurgy* refers to refining the ores by heating them to very high temperatures, with chemical additions that lead to separation and/or purification of the valuable metals. *Hydrometallurgy* requires leaching of the ores with solutions of chemicals, extracting valuable compounds and enabling further purification and separation. Both methods benefit from a crushed feed material that allows for better access to the target material. Additionally, the feed to this process should be of relatively high concentration in the target material, since other components consume energy and chemicals, and in the case of hydrometallurgical processing, the waste stream will contain the chemicals used for leaching.

Depending on where they are mined, ores can have a significant amount of heavy metals like lead, copper, and silver. Apart from chemical processes used to refine gold and diamonds which may cause environmental impact, it is equally important to recognize that the ores are not pure and can also be a source of contaminants.

Many different minerals are mined by ASM, including gold, gemstones, silver, coal, building materials, and base metals. Each of these commodities are mined in a different way, and variations between mines for the same material can be seen due to the nature of the deposit and local geologic, geographic, economic, and cultural differences. Gold and diamonds are chosen here as examples for how ASM is conducted. Cobalt is selected as an example of an ore-based mining operation more relevant to other base metals.

**GOLD MINING PROCESS**

Gold is an important part of the ASM sector worldwide, and it is notable for its extensive use of mercury by small-scale miners. A number of ASGM production and processing techniques require mercury, however not all.

*Extraction of Alluvial Gold Flakes.* Alluvial gold occurs as pure grains that weather away from the source rock, and these grains are transported with other sediments, primarily in rivers and streams. Extraction of alluvial gold is performed next to rapidly moving water well above ground and requires fewer resources. ASM operations directly dredge rivers and streams to access gold particles, and miners use different kinds of gravity concentrators to extract gold from the river sediment. These methods use water but no chemicals in the process.

*Figure 1. A sluicing station in an artisanal mine. Source: http://www.briloon.org/hgcenter/minamata.*

*Figure 2. Panning mercury in open water in Indonesia. Source: http://news.ubc.ca/ubcreports/2005/05dec01/mercury.html.*

- Sluicing – uses channeled water to wash ore or alluvium down a series of declining troughs and platforms. As water washes sediment down a sluice, heavier gold particles sink between riffles and are captured by carpeting laid at the bottom of the sluice. Loaded carpets are then washed in a holding pool or bucket to remove the material. Most ASM sluices are wooden but modern ones are more elaborate metal designs to increase recovery. The resulting gold concentrate is usually low and most miners then pan the sediment.
- Panning – uses water to separate heavy gold particles from other lighter particles within a medium sized hand held pan. In this process sediment that could contain gold is placed in a wide pan along with water. The miner repeatedly shakes the pan to eject lighter sediments. The density of gold keeps it on the bottom. This works if gold is coarse. Miners can then further

recover the gold by direct smelting (described below). Panning is also done after sluicing to increase recovery.

- Shaking tables (motorized) – use water to wash the sediment feed through a tilted table with raised ridges running horizontally down to a narrow channel. The sediment and water are released at one end of the table. The grooves trap gold and direct it to collection points on the side of the table. The table is continually shaken by a motor, which aids gravimetric separation of gold particles.
- Spiral concentrators (motorized) – a rotating spiral pan with a collection hole is continually fed concentrate by an operator. A pipe placed across the pan sprays water along the surface of the pan as the concentrator spins. The water washes lighter particles down the spiral concentrator into a bucket while denser gold particles are carried by the spiral grooves toward the hole in the center of the concentrator. The concentrate is still crude but purer than panning.
- Vortex concentrators – use a rotating flow of water in a tub to separate lighter materials from a concentrate. The vortex pulls lighter material up and heavier gold remains in the bottom of the tub.
- Centrifuges (motorized or manually powered) – are more effective than vortex concentrators but cost more to operate. They separate sediment mixtures by density. The concentrate is fed into the centrifuge through a pipe at the top of the machine in a slurry. The rotation forces lighter material up the sides of the vessel's walls and the gold remains in the ridges. These are more often found at local processing centers due to cost. A small one cycles for 20 minutes to two hours so different owners can use it over a day and the yield is higher than other methods of gravity concentration.

*Figure 3. Non-mechanized centrifuge. Source: unu.edu*

*Extraction of Gold from Rock.* Gold in rock must be broken and graded down prior to separation. Large rocks are broken by a jack hammer and then either crushed mechanically at the mine or at a processing center. Crushing is also done manually in a hand stamping cylinder. An iron cylinder is welded to a long rod and placed inside a pipe that is one size larger. Small more promising rocks are pulverized by the drop hammer inside the metal pipe, which captures the finer particles. The particles are then ready to be separated and refined without chemicals as discussed above, or with the use of mercury and cyanide as discussed below.

*Processing Gold Using Mercury.* Gold can be more rapidly refined to as high as 85 percent purity using amalgamation with mercury. Amalgamation is a concentrating process in which metallic gold is mixed with liquid elemental mercury, either in a drum or table. The precious metal naturally bonds with the mercury to form an amalgam and the waste is removed. Water helps disperse the ore, increasing yield.

A cast iron heated retort is best used to recover the mercury fumes so they cannot escape except by a condenser. The amalgam is placed in a vessel, which is then connected to the cooled condenser. The vessel is heated, vaporizing the mercury, and the mercury is re-condensed to a metallic state that is submerged in water during the distilling operation. It then can be reused. There are many different designs of retorts, and if used properly they can significantly reduce mercury emissions. However, they still should not be used indoors, and the heating process takes longer than a typical open-air heating.

*Processing Gold Using Dilute Sodium Cyanide Solution.* Cyanide leaching is now more common in the world and is safer than extraction with liquid mercury, but it remains dangerous. Cyanide leaching is usually done after milling, crushing, or gravity separation. The pH of the resulting slurry is raised by adding lime to ensure that cyanide ions do not change into toxic cyanide gas (HCN). The gold is then further concentrated and reduced, before being smelted into gold bullion.

It is common to observe cyanide leach processes used to recover additional gold from the large amount of tailings of a mercury amalgamation process. Cyanide solutions in large open pools of water will dissolve the gold more efficiently than mercury, so the tailings are mixed with the solution. The pool is drained and the gold is recovered from the solution. Combining mercury amalgamation and cyanide leaching is practiced, but not recommended, as cyanide will make mercury more mobile, contaminating more land, water, and air resources than either process alone.

*The Role of the Gold Shop.* After the miner, the gold shop is the next link in the informal gold supply chain. Shops can both process raw gold or gold-mercury amalgam and buy the raw gold product from miner or middle buyer at a London fixed price for the level of purity. Gold shops can use nitric acid cascaders to further digest impurities like copper and refine gold to close to 24 k purity (>99 percent).

Gold shops also use chemical leaching in smaller enclosed systems. The gold in solution is recovered with activated charcoal, or by electrowinning, where the gold is plated out onto electrodes. An emerging technology for chemical leaching is the use of thiosulfate instead of cyanide, which is even less toxic. Gold shops also smelt the gold and pour it into gold ingots. The process works by heating the ore until it melts. Chemicals are added to the ore before smelting to lower the melting points. The dense gold settles to the bottom of the melted material, and can be separated after it cools. The ore fed to the smelting process should be as pure as possible to reduce the energy required to melt it and end up with a pure gold material.

*Alternative Technologies for Gold Mining.* The heavy use of mercury in ASM gold mining is dangerous to local communities and wildlife, and impacts the safety of the local and global food supply. There are alternatives for traditional mercury amalgamation that can reduce or eliminate mercury usage, with co-benefits for both the surrounding environment and human health and safety. These alternative technologies or methods allow the recovery of gold more economically, allowing miners to realize higher prices.

Gravity concentration methods (described above) include:

- Panning;
- Sluicing;
- Shaking tables;
- Spiral concentrators;
- Vortex concentrators; and
- Centrifuges.

Other concentration and separation methods include:

- Magnets: if the ore surrounding the gold happens to be magnetic, then a magnetic separation can be used to concentrate the gold. Magnetic ore particles will attach to a magnet, leaving behind non-magnetic gold and other non-magnetic materials.
- Flotation: chemicals are added to a slurry of gold ore, and air bubbles are then mixed in. The chemicals will cause gold and some other minerals to stick to the air bubbles, causing them to rise and concentrate at the top of the vessel where they are skimmed off. Other minerals sink to the bottom of the tank.

Gold recovery methods include:

- Direct smelting: high grade concentrate is heated until the gold melts. The liquid is then cooled to form a solid mass of gold semi-pure alloy. A crucible, or high temperature bowl for smelting, must be used in combining the gold concentrate with a mixture of borax or other materials. A blow torch can be used to heat the mixture.
- Chemical leaching: using chemicals such as cyanide to leach gold from ore, concentrate, or tailings via gravity techniques. This technique is used mostly in larger scale mining but increasingly in ASM due to high gold recovery rates at lower costs. However, cyanide is highly toxic and should never be mixed with mercury, though cyanide does not persist in the environment as long as mercury does.

The U.S. Environmental Protection Agency (USEPA) has more detailed descriptions on most of these operations at its International Cooperation website: https://www.epa.gov/international-cooperation/artisanal-and-small-scale-gold-mining-without-mercury.

### DIAMOND MINING

ASM of diamonds and other gemstones is typically done in alluvial deposits, which means the gemstones weathered away from their source rock and were deposited with gravel in streambeds. Source rock for gemstones is generally mined by major companies due to the increased capital requirements and higher payoff.

ASM can be done in an existing stream/river bed, but may also take place in locations where a river used to flow, but is not flowing any longer.

The first step of ASM diamond mining is removal of sand, dirt, and silt that covers the gravel more likely to contain gemstones. This can be done by hand, but is sometimes done mechanically, and often entails dredging an active river or stream. In some cases, divers will manually remove gravel from the bottom of a river, or a dam will be built to assist in gravel removal.

The equipment is basic and includes the use of sieves and pans to search for the diamonds. When the gravel has been excavated, it is washed, screened, and sized. It can then be sorted for diamonds by hand, or other gravity separation devices as described in the gold mining section (sluices, pans, spiral concentrators, etc.). Rough diamonds are sold to traders, who may also have financed the mining process or provided tools.

Exposure to inhalable dust is a health concern. Diamond mining can expose workers to contaminants such as silica from dust. Moved soil, or tailings, associated with diamond mining could contain lighter metals like zinc and cadmium. Diamond miners can also be exposed to asbestos due to the location of diamond mines in relation to asbestos deposits (Nelson et al., 2011).

More details on the diamond mining process can be found from a Diamond Development Initiative report: "Mechanization of Alluvial Artisanal Diamond Mining: Barriers and Success Factors," available at http://www.ddiglobal.org/login/resources/mechanisation-alluvial-artisanal-diamond-mining.pdf.

### COBALT MINING

Cobalt mining takes place primarily in the Democratic Republic of the Congo (DRC), which contains the world's largest cobalt deposits. The ore accessed by artisanal miners is commonly shallow deposits of weathered cobalt ores that can be mined with picks and shovels, along with tailings from past copper processing activities. Teams of diggers will work in hand-dug pits to remove ore, which is taken to the surface where it is crushed, washed to remove soil and other unwanted impurities, hand sorted, and packed into bags for sale. These bags are sold to traders, and the ore at this point contains several percent cobalt (Tsurukawa et al., 2011). Traders in this scenario can be several entities with access to the market, including private traders, larger companies, mine owners that charge for access to the deposit, local administrators, and police forces.

Ore traders will send the bags to a centralized concentrator, which upgrades the ore before passing it along to a final refiner. The final refiner produces a high purity (>99 percent) saleable product. Ore concentrators and refiners are larger companies due to the capital-intensive processes required. Refer to Tsurukawa et al., "Social Impacts of Artisanal Mining in Katanga, Democratic Republic of Congo." (2011) for additional information.

Cobalt toxicity may occur through three pathways: ingestion, inhalation of dust, or sustained dermal exposure. Cobalt may cause breathing problems and thyroid problems and is thought to be linked to serious birth defects.[1]

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[1] Described in a Washington Post article available at https://www.washingtonpost.com/graphics/business/batteries/congo-cobalt-mining-for-lithium-ion-battery/.

# ANNEX 3: ENVIRONMENTAL CONSIDERATIONS FOR PROJECT DESIGN

| ENVIRONMENTAL CONSIDERATIONS FOR PROJECT DESIGN | | |
|---|---|---|
| CATEGORY | COMPONENT | PRIMARY ENVIRONMENTAL COMPLIANCE ISSUES |
| Environmental Impact Assessment | EIA | 1) Has the IEE been prepared per Reg. 216?<br>2) Has the IEE or EIA been approved by the mission and BEOs?<br>3) Is host country approval needed? Has it been granted?<br>4) What, if any, are the conditions outlined in the IEE or EIA? |
| | Stakeholder Engagement | 1) Have the appropriate stakeholders been identified?<br>2) Has the project, its goals, and potential impacts been adequately explained to local stakeholders?<br>3) Have comments from stakeholders been adequately addressed and/or integrated into project design?<br>4) Has the project information been presented in a way that is relevant and understandable to local stakeholders? |
| | Alternatives Analysis | 1) Have alternatives for the project been appropriately evaluated accounting for direct, indirect, and cumulative impacts?<br>2) Are the alternatives feasible and appropriate for the context?<br>3) Have benefits and costs been accounted for? |
| Pollution Control | Air Quality | 1) Will any air pollutants be emitted, such as soot, dust, sulfur oxides, nitrogen oxides, etc., as a result of the project?<br>2) Do these emissions comply with the host country's emission standards?<br>3) What mitigation measures are being taken? |
| | Water Quality | 1) Will any effluents be generated as a result of project activities, such as oils, chemicals, wastes, or other toxicants?<br>2) Is there a possibility the effluent will negatively impact water quality?<br>3) Are adequate mitigation measures included to prevent contamination of surface water, groundwater, and/or soils by effluents from project activities? |
| | Solid Waste | 1) Will any solid wastes be generated as a result of project activities, such as oils, chemicals, wastes, or other toxicants?<br>2) How will any wastes generated from the project be properly treated and disposed of?<br>3) Are adequate mitigation measures taken to prevent contamination of soils, surface water, groundwater by wastes generated? |

| ENVIRONMENTAL CONSIDERATIONS FOR PROJECT DESIGN | | |
|---|---|---|
| CATEGORY | COMPONENT | PRIMARY ENVIRONMENTAL COMPLIANCE ISSUES |
| | Noise | 1) Will any noise or vibrations be generated as part of the project activities?<br>2) Do the noise and vibrations comply with host country standards?<br>3) What mitigation measures are included to prevent unintended effects from noise? |
| | Odors | 1) Will any odors be generated as part of the project activities?<br>2) If yes, will these odors cause negative health, social, or ecosystem impacts?<br>3) Are mitigation measures adequate to address the generation of odors? |
| Natural Environment | Protected Areas | 1) Will the project occur within or adjacent to protected areas designated by host country laws or international treaties/conventions?<br>2) Will the project impact protected areas? And how?<br>3) Do mitigation measures adequately prevent unintended impacts to protected areas? |
| | Ecosystems | 1) Will the project occur within or adjacent to critical habitat, primary forests, or ecologically valuable or rare habitats?<br>2) Will the project involve land clearing, deforestation, or other physical impacts on natural resources?<br>3) Does the project site overlap with protected habitats of endangered species designated by either national law or international treaties/conventions?<br>4) If impacts to ecosystems are anticipated, are mitigation measures adequate to address those impacts?<br>5) Will the project reduce the quantity of available surface OR groundwater? Will this usage adversely impact aquatic environments, such as rivers, wetlands, or streams?<br>6) Are mitigation measures adequate to address aquatic impacts?<br>7) Will the project adversely affect biodiversity? If so, are mitigation measures adequate to address impacts to biodiversity? |

| ENVIRONMENTAL CONSIDERATIONS FOR PROJECT DESIGN | | |
|---|---|---|
| CATEGORY | COMPONENT | PRIMARY ENVIRONMENTAL COMPLIANCE ISSUES |
| | Topography and Geology | 1) Has project design considered the topography and underlying geology for the project and possible impacts (e.g., leaching, etc.)?<br>2) Will the project alter topographic features via cut and fill, excavation, ground clearing, earthmoving or other activities?<br>3) Will the project generate soil runoff from earthmoving activities, waste disposal sites, and/or borrow pits?<br>4) Are mitigation measures adequate to prevent soil run off and/or impacts of improperly placed waste sites or borrow pits?<br>5) Will the project negatively impact shorelines, coastal areas, wetlands, rivers, or other waterbodies? |
| Social | Resettlement | 1) Will involuntary resettlement occur because of project activities? If yes, how are resettlement impacts minimized? Is there a Resettlement Action Plan?<br>2) Have compensation and resettlement plans been developed and explained to affected people prior to initiation of project activities?<br>3) Did a socio-economic assessment inform the resettlement action plan?<br>4) When will resettlement compensation be paid during the project cycle?<br>5) Are the compensation policies publicly available and presented in accessible formats to the affected populations?<br>6) Are there vulnerable groups, such as women, children, elderly, ethnic minorities, etc., affected by the project?<br>7) Have agreements been reached with the affected peoples?<br>8) How will impacts of resettlement be monitored and evaluated?<br>9) Has the grievance mechanism been developed? |
| | Living and Livelihoods | 1) Will the project adversely affect living conditions of inhabitants? How will the project impact livelihoods, living conditions, and/or social networks?<br>2) Are mitigation measures adequate to address those?<br>3) Will the project strain existing infrastructure? If existing infrastructure is insufficient, are there plans to either improve or develop new infrastructure?<br>4) Will large vehicle traffic associated with the activity impact traffic, impede movement of inhabitants, or cause risks to pedestrians?<br>5) Is there a possibility that diseases or other unintended health or social impacts will be introduced via in-migration of workers associated with the project? |

| ENVIRONMENTAL CONSIDERATIONS FOR PROJECT DESIGN | | |
|---|---|---|
| CATEGORY | COMPONENT | PRIMARY ENVIRONMENTAL COMPLIANCE ISSUES |
| | Cultural | 1) Have local communities been consulted regarding existence of important cultural sites in the project area?<br>2) Could the project damage or destroy important archeological, historical, cultural, or religious sites?<br>3) Are any cultural sites in the project area protected by local or national law?<br>4) Are mitigation measures adequate to address these potential impacts? |
| | Landscape | 1) Could the project adversely affect the local landscape via land clearing, deforestation, or other activities? Would these effects diminish or obliterate usage of the local landscape?<br>2) Are mitigation measures adequate to address these potential impacts?<br>3) Has land tenure been appropriated and adequately considered related to project activities? |
| | Ethnic Minorities and Indigenous Peoples | 1) Are all the rights of ethnic minorities and indigenous peoples, including customary rights, to land and resources respected?<br>2) Are mitigation measures adequate to reduce impacts on culture and lifestyle of ethnic minorities and/or indigenous peoples? |
| | Labor and Occupational Health | 1) Does the project comply with host country laws related to labor and working conditions?<br>2) Are appropriate and implementable safety considerations in place and operational?<br>3) Is a worker safety plan and safety training plan in place? Do workers have access to proper PPE? Have workers been instructed on proper use?<br>4) Have workers been trained on labor laws and rights relevant to the host country? |

| ENVIRONMENTAL CONSIDERATIONS FOR PROJECT DESIGN | | |
|---|---|---|
| CATEGORY | COMPONENT | PRIMARY ENVIRONMENTAL COMPLIANCE ISSUES |
| Other | Monitoring | 1) Has an appropriate monitoring and evaluation plan been developed to monitor impacts anticipated for the activity, where impacts are anticipated in the impact assessment, pollution control, natural environments, and/or social sectors?<br>2) Are the components, methods, and frequencies of monitoring included in the EMMP?<br>3) Does the EMMP establish an adequate monitoring framework (e.g., organization, personnel, equipment, budget)?<br>4) Is there appropriate training and capacity (such as tools, access, transport) to conduct monitoring in an effective way?<br>5) Are the regulatory requirements for monitoring for host country and USAID identified clearly? |