7 Mining and Sustainable Livelihoods: Mercury, God of Finance

People have long mined and used minerals from the Earth's crust. The extraction of nonrenewable resources continues to be essential to much production and consumption in contemporary societies. Although large companies run many mining operations, artisanal and small-scale mining provides an important source of income for tens of millions of miners and their family members, predominantly in developing countries. Resource extraction also leads to a number of social and environmental harms, including through the use of mercury in artisanal and small-scale gold mining (ASGM). This raises fundamental questions about whether nonrenewable resource extraction can be reconciled with efforts toward greater sustainability both locally and globally. Intervening to improve human well-being in artisanal and small-scale mining communities requires attention not only to local conditions but also to the transnational drivers of production and consumption of minerals. The strong link between mining and poverty in developing regions also raises important issues of equity in promoting human well-being.

Peru's environment minister Manuel Pulgar-Vidal proclaimed a 60-day state of emergency for the country's remote Amazonian region of Madre de Dios on May 23, 2016. The emergency declaration was prompted by concerns about high levels of mercury in people and the environment from widespread ASGM. Government authorities banned catching and consuming a local species of catfish because of elevated mercury levels (Tegel 2016). This decision was announced a little more than four years after the government had launched a violent crackdown using the military and the police against illegal (or "wildcat") miners who did not possess formal mining permits, resulting in arrests and fatalities (Anonymous 2012; Redacción Gestión

2019). At that time, it was estimated that ASGM in Madre de Dios was a billion-dollar industry that produced 19 tonnes of gold annually, involving 40,000 people who largely entered the often-dangerous ASGM sector because there was little or no alternative employment. Despite the government's actions, unlicensed ASGM had surpassed coca and cocaine production by 2016 as the most profitable unlawful activity in Peru (US Agency for International Development 2018).

Unlicensed ASGM in the informal sector continues to expand in Madre de Dios. It is an important source of income for many miners, who have few other options to support their children and other family members. ASGM also exposes people in mining communities to multiple environmental and social risks. It has led to the destruction of over 60,000 hectares (nearly 150,000 acres) of old-growth rainforest (US Agency for International Development 2018). This has major impacts on biodiversity and the carbon cycle. Inhabitants of Madre de Dios have many misconceptions about the dangers of mercury and how to effectively protect themselves from exposure. Some miners believe, for example, that eating large amounts of cilantro can help the body get rid of mercury (Goldstein forthcoming). The mercury used in Madre de Dios is smuggled into the region in large amounts. Some of this mercury likely originates from illegal mercury mines in Mexico. Edwin Vásquez, the coordinator of an umbrella group for indigenous peoples founded in 1984 in Lima, referred to the human toll of ongoing ASGM when he forcefully stated: "We need an alternative to hell, and hell is mining" (Rochabrún 2018).

The story of ASGM in Madre de Dios is only one example of a much larger phenomenon. ASGM occurs in roughly 70 developing countries throughout Africa, Asia, and Latin America, and "has become an indispensable part of the socioeconomic fabric in the developing world" (G. M. Hilson 2002, 866). As we highlight in the chapter title, much use of mercury has had a close relationship with the extraction of gold, which serves as a monetary instrument in many economies. Roughly half of the 1 million tonnes of elemental mercury that were mined during the past 500 years were used to extract gold and silver (Hylander and Meili 2003). Although major gold mining firms have stopped using mercury, large-scale gold mining still results in some mercury emissions and releases due to the extraction and processing of rocks that contain trace amounts of mercury. But total mercury discharges from ASGM are much greater than those from large-scale gold mining. The use of mercury in ASGM causes local problems, and adds to the amount of mercury that is transported long distances in commerce and through the atmosphere (IGF 2017).

The current global boom in ASGM goes back at least to the start of the gold rush in Serra Pelada in Brazil in 1980 (Mallas and Benedicto 1986). ASGM is frequently a low-skill activity that requires little capital investment. Much ASGM worldwide takes place in the informal sector, where vulnerable miners who are often looking to escape poverty can face strong opposition, whether from large mining firms or local and national governments. As a result, ASGM is an area where issues of power relations are integral to both mercury use and abatement efforts. When Pope Francis visited Madre de Dios in January 2018, he specifically highlighted the threat to indigenous peoples and the Amazonian region stemming from environmental problems of gold mining, and from other kinds of damaging natural resource extraction and use (Chauvin 2018). The pope's comments built on his 2015 Encyclical Letter *Laudato Si*, where he noted the existence of an important "ecological debt" between the Global North and the Global South, as raw materials are exported from developing countries to satisfy consumers in industrialized countries (Francis 2015, para. 51).

In this chapter, we examine the extensive use of mercury in the ASGM sector, and the efforts to reduce and ultimately eliminate such use. In the section on system components, we identify the human, technical, and environmental components associated with the use of mercury in ASGM and resulting environmental discharges and human exposure, and related institutions and knowledge. We discuss factors that drive people into the ASGM sector, and those that influence the continued use of mercury in mining processes and its impacts on human health and well-being, in the section on interactions. We detail in the section on interventions the ways in which different actors have attempted to address mercury-related problems in ASGM, including efforts trying to balance the socio-economic benefits with the environmental and human health problems that stem from the use of mercury in ASGM. In the section on insights, we examine local to global factors and dynamics that shape ASGM and related mercury use and discharges, the relationship between mining, mercury use, and sustainability in short-term and long-term focused interventions, and the need for addressing ASGM with locally specific governance approaches that recognize the importance of justice and power.

System Components

Gold has played many important roles in both ancient and contemporary societies, and it has been mined on every continent except Antarctica. It was extracted in what is now Saudi Arabia going back 3,000 years (Kirkemo et al. 2001; Eisler 2003). It is estimated that over 190,000 tonnes of gold have been mined throughout human history, and roughly two-thirds of that amount has been extracted since 1950 (World Gold Council 2019c). Mercury has been used in gold mining since at least Roman times, and its use continues in contemporary ASGM. The ASGM sector and associated mercury demand have grown substantially since the 1980s. Many more people may enter the ASGM sector in the future, as it remains economically attractive to potential miners and others who seek to make a living in mining communities. The main present-day human, technical, environmental, institutional, and knowledge components for the mercury and ASGM system are summarized in figure 7.1.

The ability to mine gold depends on knowledge of different *gold extraction techniques*. Much early gold mining relied on mercury-based amalgamation methods, but major mining companies currently extract gold using a cyanide leaching technique that was first introduced in the late 1800s. In contrast, most *ASGM miners* continue to use mercury-based amalgamation

Human components	Technical components	Environmental components
ASGM miners Gold supply chain participants Other ASGM community members Mercury supply chain participants Gold processors People living far from ASGM sites	Mercury used in ASGM Mercury in commerce Transportation and communication infrastructure Mining and amalgamation equipment ASGM mercury capture devices	Ore at mining sites Ecosystems near ASGM sites Ecosystems far from ASGM sites

Institutional components	Knowledge components
Mercury markets National and local laws and regulations Gold markets International certification schemes Standards set by international organizations Global Mercury Partnership Minamata Convention	Gold extraction techniques Health impacts from mercury exposure Health protection techniques Mercury concentrations in the environment Environmental impacts from mercury discharges

Figure 7.1
Components in the mercury and ASGM system (referenced in the text in italic type).

techniques. Small-scale mining is used as a general label for largely non-mechanized and labor-intensive mining operations when compared with the operations that are run by large mining companies (United Nations 1972; Siegel and Veiga 2010; Spiegel and Veiga 2010). Artisanal mining is the subset of the small-scale operations that use rudimentary techniques to extract minerals from *ore at mining sites*. The Minamata Convention defines ASGM as "gold mining conducted by individual miners or small enterprises with limited capital investment and production" (Article 2). There have been efforts to specify further quantitative criteria including mine output, labor productivity, and levels of technology use and organization, but definitions vary across international organizations and countries (G. M. Hilson 2002).

Roughly 75 percent of the annual gold supply comes from mining, with the rest coming from the recycling of jewelry and technology (World Gold Council 2019a). Approximately 54,000 tonnes of gold remain in the ground, and all types of mining each year add 2,500 to 3,000 tonnes of new gold to the global stock (World Gold Council 2019c). Estimates vary about how much of this gold comes from ASGM. Many ASGM miners are reluctant to disclose how much gold they extract (Fold et al. 2014). *Gold supply chain participants* include local buyers who procure gold from different sources, including from ASGM miners who lack mining licenses or cannot document the gold's origin. Some gold from ASGM is smuggled across borders, sometimes linked with money laundering, before being refined in Switzerland and other hubs (Berne Declaration 2015; Werthmann 2017; International Peace Information Service 2019). Edward B. Swain and colleagues (2007) estimated that ASGM was responsible for 500 to 800 tonnes of gold in the early 2000s. Kevin H. Telmer and Marcello M. Veiga (2009) put the production in the ASGM sector a bit lower at 350 tonnes per year during that same time. In the mid-2010s, ASGM was believed to produce 600 to 650 tonnes of gold per year (UNEP 2017), which would account for about a quarter of all new gold produced. Participants at the end of the gold supply chain include central banks, jewelry buyers, technology producers, and private investors.

Data on the global scope of current ASGM are sparse and uncertain (IGF 2017). Countries with relatively large numbers of ASGM miners include Indonesia, Ghana, Colombia, Peru, Bolivia, China, Ecuador, and Sudan (UNEP 2017). One estimate puts the total number of ASGM miners at just over 20 million (IGF 2017). If this estimate is correct, it means that roughly

90 percent of all people who work in gold mining do so in the ASGM sector, with only the remaining 10 percent employed in large-scale, mechanized mining operations. Another estimate puts the total number of people who work in ASGM at 10 to 15 million miners, including 4.5 million women and 1 million children (UNEP 2017). Accounting for the total population of miners and *other ASGM community members* who both directly and indirectly depend on mining, at least 100 million people are believed to rely on this sector for their livelihoods in lower income economies in more than one third of the world's countries (UNEP 2017).

Mercury used in ASGM comes from local mercury suppliers who buy *mercury in commerce* from *mercury supply chain participants* on *mercury markets,* which are often international. The most recent estimate is that between 872 and 2,598 tonnes of mercury go into this sector annually (UNEP 2017). This large uncertainty range in global estimates of mercury use in ASGM is a result of substantial gaps in national data; although mercury use in ASGM remains legal in many developing countries, data on its use are incomplete and unreliable at best. Some other countries where licensed ASGM is legal, like Brazil, Colombia, French Guiana, Mongolia, and Peru, have banned the use of mercury in ASGM, but undocumented mercury use continues. Other countries like China have outlawed both ASGM and related mercury use, but ASGM activities using mercury still take place there (Spiegel 2009; Spiegel and Veiga 2010; Fritz et al. 2016). Much evidence exists of growing mercury use in ASGM in countries where it is not permitted, but a lack of data makes it difficult to calculate exact amounts (UNEP 2017).

Even though ASGM miners use rudimentary techniques to extract gold, modern technology plays an important role. *Transportation and communication infrastructure*, such as roads and mobile phone and data networks, provides access to mining areas and connects ASGM communities with mercury sellers and gold buyers (Canavesio 2014). ASGM miners use simple *mining and amalgamation equipment*, but many have access to basic power tools to extract the ore. ASGM largely exploits three different kinds of ore deposits (UNEP 2012). In alluvial deposits, free gold particles can be found in river sediments. Gold can also be found in saprolites (weathered bedrock) and hard-rock deposits. Panning for gold in alluvial deposits and extracting gold from saprolites and hard-rock deposits requires very different mining equipment. The application of *ASGM mercury capture devices* such as fume hoods and retorts, which are often small and round enclosures that allow for closed circuit burning of the amalgam, can capture mercury before it is emitted to air. *Gold processors* who work on mining sites or in nearby communities help miners separate the gold from the mercury and bring it to market.

Knowledge about the *health impacts from mercury exposure* to ASGM miners and other community members, including gold processors, has become more widespread over the past few decades. In turn, knowledge of *health protection techniques* is critical to reducing these impacts. Much of the mercury that is used in ASGM is released into land and water, but the amounts of these releases are uncertain globally (see chapter 3). Because of these releases into local environments, many *ecosystems near ASGM sites* contain high levels of mercury. Knowledge about *mercury concentrations in the environment* and *environmental impacts from mercury discharges* is thus necessary for understanding local environmental consequences of mercury use in ASGM. A large fraction of the mercury that is used in ASGM is emitted into the atmosphere (UNEP 2019). Some of the mercury emitted to air travels long distances before depositing in *ecosystems far from ASGM sites* and affecting *people living far from ASGM sites*.

Institutions at different spatial scales influence the ASGM sector. Many countries have adopted *national and local laws and regulations* on resource extraction and mining rights, which control who can legally mine where, and whether mercury use in ASGM is permitted or banned. The implementation and effectiveness of these laws, however, vary dramatically across countries. ASGM also occurs in the context of supply and demand dynamics on international mercury markets as well as *gold markets*. The commercial prices of mercury and gold influence how much miners have to pay for the mercury that they use, and how much they are paid for the gold that they extract. These prices may fluctuate substantially over time. *International certification schemes* set mining-specific standards, including for mercury use, for participating ASGM miners. Additional *standards set by international organizations* on tracing the origin of gold affect the ability of ASGM miners to bring their gold to international markets. Other international institutions focused on addressing the use of mercury in ASGM include specific guidelines formulated under the *Global Mercury Partnership* and mandates included in the *Minamata Convention*.

Interactions

ASGM and its associated mercury use results in both benefits and harms for human well-being. Figure 7.2 shows interactions in the mercury and ASGM system: we have selected three interactions in that matrix to focus on in this section (the three items in bold type in boxes 1-1 and 2-2); we then trace the pathways that influence them, which we summarize in figure 7.3 (where the bold boxes correspond to the selected interactions). First, people enter the ASGM sector in search of employment (box 1-1), influenced by ecological deterioration and infrastructure, as miners participate in markets with gold and mercury supply chain participants (boxes 1-1, 3-1, and 2-1). Second, mining and amalgamation equipment and techniques affect mercury use in ASGM (box 2-2), as the types of ore at ASGM sites determine

Knowledge

Institutions

	1. Human	2. Technical	3. Environmental
1. Human	(1-1) **People enter the ASGM sector in search of employment;** ASGM miners participate in markets with gold and mercury supply chain participants**; ASGM miners and community members experience mercury-related health impacts**	(1-2) ASGM miners purchase and use mercury, mining and amalgamation equipment, and mercury capture devices	(1-3) Mercury users directly discharge elemental mercury into ecosystems
2. Technical	(2-1) Infrastructure affects ASGM miners' ability to reach mining areas and buy and sell mercury and gold; Mining and amalgamation equipment and processes lead to elemental mercury exposure	(2-2) **Mining and amalgamation equipment and techniques affect mercury use in ASGM**; Mercury used in ASGM affects the amount of mercury in commerce	(2-3) Amalgamation equipment leads to elemental mercury discharges into ecosystems
3. Environmental	(3-1) Ecological deterioration affects people's decisions to become miners; Methylmercury in nearby ecosystems affects ASGM miners and community members; Methylmercury in ecosystems far from ASGM sites affects people	(3-2) Ore types at ASGM sites affect miners' choice of mining and amalgamation equipment and amount of mercury used in ASGM	(3-3) Ecosystem processes transport mercury and lead to production of methylmercury

Figure 7.2
Interaction matrix for the mercury and ASGM system.

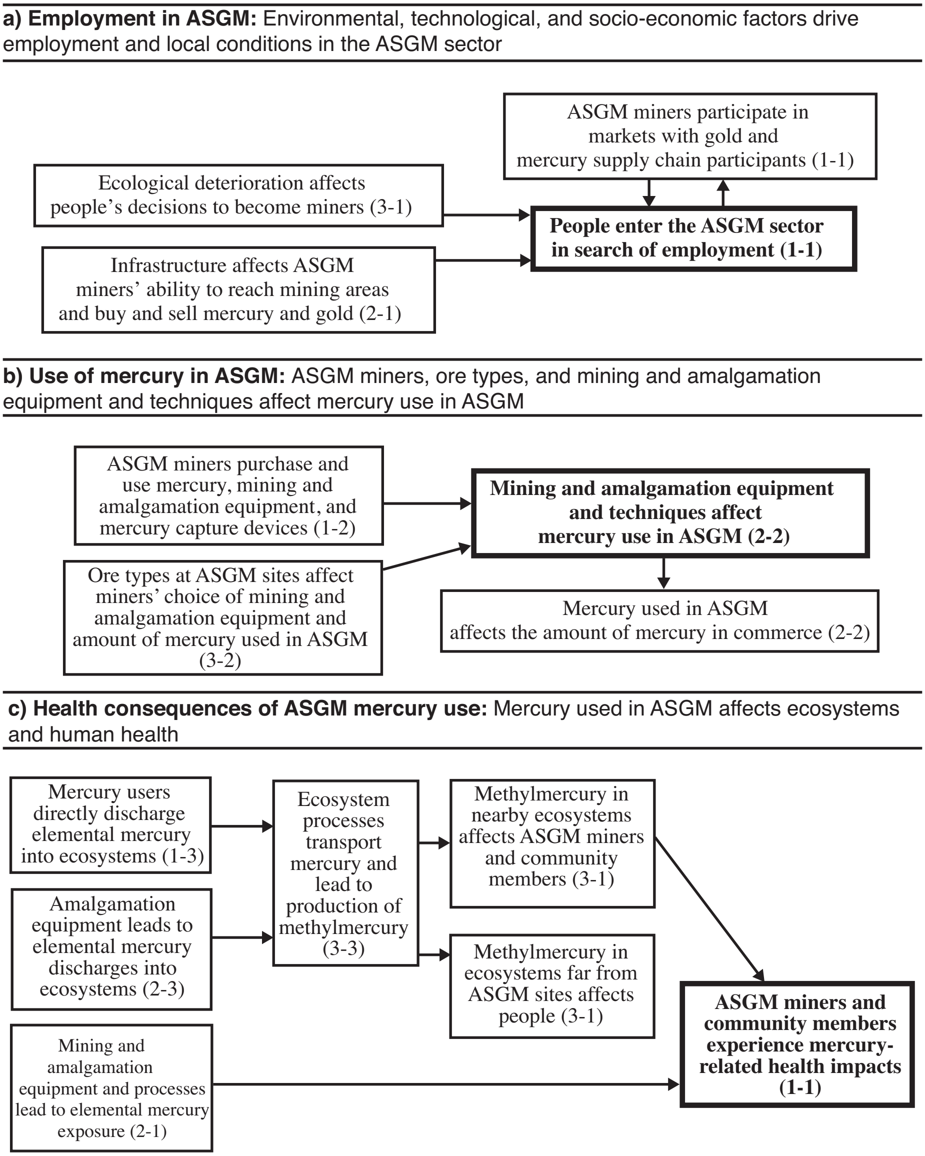

Figure 7.3

Pathways of interactions in the mercury and ASGM system. Bold box indicates focal interaction for each subsection.

the miners' choice of mining and amalgamation equipment and mercury capture device; these choices have an impact on the amount of mercury in commerce (boxes 3-2, 1-2, and 2-2). Third, ASGM miners and community members experience mercury-related health impacts (box 1-1), where the use of mining and amalgamation equipment leads to elemental mercury exposure and discharges into ecosystems; some of this mercury is transformed into methylmercury, which affects ASGM miners and community members as well as people living far from ASGM sites (boxes 2-1, 1-3, 2-3, 3-3, and 3-1).

Employment in ASGM

People enter the ASGM sector in search of employment for multiple reasons (box 1-1). Since the current ASGM boom started in the 1980s, many people have become ASGM miners because of poverty and a lack of other job opportunities. ASGM has relatively low barriers to entry in terms of formal education and financial resources, and thus offers an opportunity for people who struggle to find other kinds of employment to support themselves and their families (Gamu et al. 2015; Langston et al. 2015; Hilson 2016). ASGM miners can be less likely to be in poverty compared with other people who work in different sectors in the same area (Fisher et al. 2009). An expansion of ASGM may have further economic benefits for miners' families and other ASGM community members. Income from ASGM, for example, may allow parents to continue to send their children to school (Hilson et al. 2013; Jenkins 2014). An estimated six jobs per ASGM miner are created downstream, as other community members may work as drivers, cooks, clothing merchants, repair technicians, bookkeepers, and accountants (Hilson and McQuilken 2014).

Changes in international commodity prices and agricultural policy decisions in other countries can influence the income of small-scale farmers, pushing them to enter the ASGM sector (Hilson 2016). For example, when cotton dropped in price on the global market in the mid-1990s, the European Union (EU) and the United States decided to maintain their relatively high levels of domestic subsidies to protect their own cotton farmers from revenue losses. As a result of the price drop and the continued EU and US farm subsidies, 3 million people in Mali who fully or partly depended on cotton production were hit extremely hard, as the domestic cotton market plunged and they struggled to sell their harvests. Many of these farmers, who were no longer able to make a living growing and selling cotton, became ASGM miners. Switching from cotton farming to ASGM provided a means to buy food and lifesaving medicines as well as opportunities for rural families to buy insecticides, fertilizers, and cattle to allow for continued part-time farming (Hilson 2012).

People's decisions to enter and stay in the ASGM sector are affected by the market price of gold, as ASGM miners participate in markets with gold and mercury supply chain participants (box 1-1). The market price of gold between 2000 and late 2012 increased by more than a factor of six, to USD 1,746.50 per ounce, attracting many new miners. The global demand for gold in 2018 reached just over 4,300 tonnes, which at an average price of USD 1,250 per ounce equals a market value of roughly USD 190 billion. The demand for gold from different sectors changes from year to year, but in 2018, the main sectors were: jewelry (50 percent); investment products including bars and coins (27 percent); central banks and other institutions (15 percent); and the technology industry (8 percent) (World Gold Council 2019b). China and India combined for 58 percent of the demand for jewelry and 43 percent of the demand for bars and coins. Many central banks in emerging markets are increasing their gold reserves. The US government, however, remains the world's largest holder of gold at over 8,100 tonnes (US Department of the Treasury 2018). In late 2019, gold sold for just over USD 1,500 per ounce.

High gold prices attract people from other mining sectors to ASGM. This can be further influenced by policy measures on other minerals. A temporary ban on the export of diamonds from Ghana was introduced in 2006 together with the implementation of production and export controls under the Kimberley Process Certification Scheme (Nyame and Grant 2012). These measures, related to the issue of conflict diamonds, led to increased extraction costs and reduced opportunities for small-scale diamond miners to sell to foreign markets. Many diamond miners were unable to find other employment outside the mining sector. With gold prices rising sharply, miners who had the skills to take advantage of a favorable geological terrain switched to mining gold. Gold has been mined in Ghana for more than 1,000 years: before Ghana gained independence in 1957, it was the British colony called the Gold Coast (G. Hilson 2002; Wilson et al. 2015). However, the events of 2006 led to an expansion in ASGM. It is estimated that ASGM produced 34 percent of all gold in Ghana in 2013, involving 1 million people out of a total national population of just over 25 million (IGF 2017).

Many ASGM miners and other community members are vulnerable to different forms of exploitation. Much ASGM mining takes place in the informal sector without worker or social protections. Many mining communities are affected by armed non-state groups, organized crime, high levels of violence and the extortion of protection money and bribes, smuggling of drugs and other goods, and high rates of infectious diseases such as malaria, tuberculosis, and HIV/AIDS (Rees et al. 2010; International Peace Information Service 2019). In some mining areas, there is widespread human trafficking and an extensive sex industry involving both adults and children, leading to much human suffering (Goldstein forthcoming). Already-dire social situations in mining communities can be made worse by widespread government corruption involving local officials. Sometimes tense conflicts over land and mining rights can erupt into violent and deadly conflicts between people associated with large mining firms and ASGM miners (Global Witnesss 2016).

Ecological deterioration can affect people's decisions to become miners (box 3-1). Subsistence farmers may enter the ASGM sector after worsening environmental conditions affect their ability to farm and provide enough food for their families. Many small-scale farmers and herders in Africa became ASGM miners after prolonged periods with little or no precipitation (Gamu et al. 2015). Contemporary ASGM in Burkina Faso started in the 1980s during the major drought in the West African Sahel and Savanna zones. ASGM then became a last resort for many farmers who lost their fields and animals and faced starvation; mining has since been the primary source of income for many of these former farmers (Werthmann 2017). Accelerating climatic changes and other environmentally destructive forces, such as soil erosion and desertification, may have an even greater impact in the future on crop and animal farming in developing countries. This may result in a growing number of people leaving the agricultural sector to enter the ASGM sector in the coming decades.

Infrastructure affects ASGM miners' ability to reach mining areas and buy and sell mercury and gold (box 2-1). This can be seen in the case of the 2,600 kilometer–long Interoceanic Highway that connects the Andes with the Amazon, completed in 2011 as part of a large transportation infrastructure agreement intended to promote economic development between

Brazil and Peru. Madre de Dios quickly became known as the "El Dorado" or "El Wild West" among the locals and the migrant workers because the new highway facilitated the explosion of new mining into areas that were previously too remote to access (Goldstein forthcoming). The highway furthermore spurred the building of secondary and tertiary roads, opening up even greater access to areas with unsettled land tenure rights. Widespread use of the internet and mobile phones made it easier for miners to exchange information about new gold discoveries and to bring the extracted gold to domestic and international markets. This combination of road building and ASGM has led to significant and long-lasting damages to local forests and biodiversity (Elmes et al. 2014).

Transportation and communication infrastructure also facilitates cross-border movements of people. For example, tens of thousands of Chinese nationals moved to rural parts of Ghana in the early 2000s to become ASGM miners. This migration followed in the wake of a large increase in Chinese investments in extractive industry projects in Ghana and other parts of Africa. Chinese-owned service companies in Ghana often actively prompted this movement of miners from China (Hilson et al. 2014). More recently, Ghanaian authorities have repatriated thousands of Chinese miners in the informal sector back to China (Zinsuur 2018). In another example, many ASGM miners in Burkina Faso come from neighboring countries, such as Niger, Mali, Ivory Coast, Ghana, Benin, or Nigeria, and many miners who are from Burkina Faso in turn go to mine in those same countries (Werthmann 2009). Similarly, people in the Amazon frequently move across the national borders of Brazil, Peru, and Bolivia to find work as ASGM miners. A large number of Brazilian miners also operate in Guyana and Suriname.

Use of Mercury in ASGM

The use of mining and amalgamation equipment and techniques affects mercury use in ASGM (box 2-2). Miners predominantly use one of two mercury-based amalgamation techniques to separate gold from ore (UNEP 2012). During whole ore amalgamation, miners mix 100 percent of the ore with liquid mercury (in steel drums, for example) where the mercury forms an amalgam with the gold as the ore is further crushed. This rarely captures more than 30 percent of the gold, and requires quantities of mercury that often range from 4 to 20 parts mercury for every part gold. During concentrate amalgamation, miners instead first concentrate the gold-bearing ore into a smaller mass by, for example, pouring a mixture of ore and water into a sluice box that consists of a tray with a rough surface (such as a carpet) positioned at an inclined angle and open at both ends. The gold-containing particles that get trapped in the carpet, called the concentrate, are washed in a basin. Miners mix liquid mercury into the concentrate to draw the particles into a heavy liquid. Finally, they use a simple panning technique to separate the gold-containing mercury before filtering it through a cloth to get an amalgam of roughly 50 percent gold and mercury. This allows for less mercury use, generally at a 1:1 to 1.3:1 ratio with gold.

Ore types at ASGM sites affect miners' choice of mining and amalgamation equipment and the amount of mercury used in ASGM (box 3-2). The combination of alluvial deposits, saprolites, and hard-rock deposits varies greatly between mining areas, requiring different extraction methods and tools. ASGM is by definition smaller and less mechanized than large-scale commercial gold mining, but the introduction of relatively cheap power tools facilitates more aggressive resource extraction, especially from saprolites and hard-rock deposits. Katja Werthmann (2017, 422), focusing on Burkina Faso, noted: "Some artisanal mines have changed into semi-mechanized operations with cemented shafts, winches and crushers. Ventilators powered by solar panels blow air into the shafts. Instead of donkey carts and bicycles, tricycles (motorized three-wheeled vehicles from China) now transport water, ore and goods as well as passengers." More extraction thus requires more mercury.

ASGM miners' purchase and use of mercury, mining and amalgamation equipment, and mercury capture devices are essential features of ASGM (box 1-2). Suppliers sell elemental mercury to ASGM miners through both legal and illegal channels. In turn, miners must sometimes sell their gold to the same mercury suppliers, often at reduced prices, in order to buy more mercury in a continuing cycle of dependency (Spiegel et al. 2018). Domestic mining provides the mercury that is used in ASGM only in very few countries, including China and Indonesia. In most other countries, the mercury going to the ASGM sector either comes from domestic recycling from other sources, is imported for other legal uses such as dental amalgam and then sold illegally to miners, or is smuggled across national borders. The increase in ASGM-related mercury demand encouraged the resurgence of illegal primary mercury mining from previously closed mines in Mexico and Indonesia (UNEP 2017). Data on the legal trade in mercury are incomplete, and the mercury that comes from illegal mining or enters ASGM through smuggling is not included in any formal statistics (Camacho et al. 2016; Spiegel et al. 2018).

Mercury used in ASGM affects the amount of mercury in commerce (box 2-2). ASGM is currently a leading sector that contributes to the demand for mercury, and thus it has a large impact on international mercury markets. Many of the main mercury-exporting firms were located in the EU (mainly in Spain and the Netherlands) and the United States until the early 2000s. This situation shifted quickly as the EU and US elemental mercury export bans entered into effect in 2011 and 2013. These export bans by two actors that had previously been major mercury suppliers restricted the sources and amounts of mercury available on international markets, especially excess mercury from the chlor-alkali industry and other recycled mercury (since primary mercury mining at that time was already phased out in the EU and the US). ASGM became an important driver in the international demand for mercury following these supply restrictions, as mercury use in ASGM was increasing while other commercial uses of mercury were declining in many regions. The adoption of the export bans by the United States and the EU resulted in mercury price dynamics that are unique to different markets—in contrast to gold, there is no longer a global price for elemental mercury (see chapter 3).

Health Consequences of ASGM Mercury Use

Many ASGM miners and community members experience mercury-related health impacts (box 1-1). The body burden of mercury in some miners is affected by the use of mining and amalgamation equipment and processes leading to elemental mercury exposure (box 2-1). ASGM miners and other community members are exposed to dangerous levels of elemental mercury vapor when burning the amalgam, especially when working indoors in poorly ventilated gold processing centers. People have been found to breathe air with mercury concentrations higher than 50 ug/m^3, which is 50 times higher than the maximum public exposure guidelines set by the World Health Organization (WHO) (Swain et al. 2007). A synthesis of studies from gold-mining communities in 19 different countries demonstrated that measured urinary mercury concentrations (a biomarker of elemental mercury exposure) were well above WHO health guidance values (Gibb and O’Leary 2014).

Mercury users directly discharge elemental mercury into ecosystems (box 1-3). This happens through accidental spills in the field. Use of amalgamation equipment also leads to elemental mercury discharges into ecosystems (box 2-3), but the use of mercury capture devices can reduce the amount of mercury discharged. The process occurs as follows: Miners heat up the amalgam to evaporate mercury. This leaves them with a porous product of sponge gold, which still contains 5 to 10 percent mercury. Open-air burning of the amalgam results in substantial losses of mercury from vaporization, but the use of retorts and other mercury capture devices can capture up to between 75 and 95 percent of the mercury, which can then be reused (UNEP 2012). The sponge gold is further melted to produce a solid bar of unrefined gold (called a gold dore). Miners either do this themselves, or take the sponge gold to nearby gold shops for further processing. This takes out the remaining mercury, which can also be reused if captured. In gold shops, the dore is refined by gold processors up to a 24-karat level of purity, which is considered to be 100 percent gold but in reality is only 99.9 percent pure.

The health of ASGM miners and other community members can be affected by ecosystem processes that transport mercury and lead to production of methylmercury (box 3-3). These processes can occur in local water bodies near ASGM sites. Once methylmercury has formed in ecosystems near ASGM sites, it builds up in living organisms and can affect ASGM miners and community members (box 3-1). This happens through the consumption of local fish (Gibb and O'Leary 2014). Yet, many of the health damages resulting from both elemental mercury and methylmercury may be unknown to those who are affected. Local health care workers may lack not only the knowledge of mercury's dangers but also the ability to distinguish the symptoms of mercury poisoning from those of infectious diseases prevalent in many mining communities. Elemental mercury discharges from ASGM can also travel worldwide, and then be converted to methylmercury in ecosystems far from ASGM sites, where methylmercury affects people (box 3-1).

Interventions

A number of actors with a variety of goals have intervened to change the mercury and ASGM system, including international organizations, national and local governments, international non-state standard-setting bodies, and experts. The matrix in figure 7.4 shows interventions for the mercury and ASGM system. First, some interventions have targeted the ASGM sector by aiming to legalize ASGM and by advocating for better working conditions, thus helping to improve human well-being for miners and community members (box 1-1). Second, international standards shape decisions by ASGM miners on how and where to mine for gold (box 1-1). Third, other interventions specifically target mercury use in ASGM, with the goal of minimizing its use and associated health and environmental damages, largely through targeting mining and amalgamation techniques and equipment (boxes 1-2 and 2-2).

Knowledge

Institutions

	1. Human	2. Technical	3. Environmental
1. Human	(1-1) National and local governments take legal actions that influence ASGM activities; International organizations and international non-state standard-setting bodies target gold supply chains	(1-2) International non-state standard-setting bodies formulate rules about mercury use for certification; Experts and international organizations design and disseminate new mining and amalgamation equipment and mercury capture devices; National governments ban mercury use	(1-3)
2. Technical	(2-1)	(2-2) Experts design efficiency improvements in mercury capture and amalgamation techniques; National governments ban the import of mercury for ASGM	(2-3)
3. Environmental	(3-1)	(3-2)	(3-3)

Interveners
International organizations; National and local governments; International non-state standard-setting bodies; Experts

Figure 7.4
Intervention matrix for the mercury and ASGM system.

Legal Approaches to ASGM

National and local governments have taken several kinds of legal actions that influence ASGM activities (box 1-1). Legal interventions affecting the ASGM issue in many developing countries are related to the often very close connections between small-scale and large-scale mining. ASGM was largely absent from national and international discussions on poverty alleviation and economic development until the late 1990s (Hilson and Gatsinzi 2014). Many developing-country governments instead focused on large-scale mining as a way to attract more foreign direct investment. To this end, governments rewrote national laws and fiscal policies beginning in the 1970s to open up access to mining operations for foreign firms, with strong encouragement from the International Monetary Fund, the World Bank, and other multilateral donor agencies (World Bank 1992; Hilson and Potter 2005; Hilson et al. 2019). These new policies sometimes led to a pronounced legal separation between formal and informal mining (Perks 2013). Policies favoring mining companies in many cases also ended up pushing more ASGM miners into the informal sector (Hilson and Potter 2005).

Governments have sometimes taken legal actions in the ASGM sector that have had major negative implications for working conditions and levels of mercury use. Governments have occasionally initiated punitive law enforcement actions against ASGM miners operating without permits, as the majority of the world's ASGM miners do (Spiegel et al. 2015; Spiegel 2015). These actions have included steps to outlaw informal ASGM. Unlicensed ASGM miners are then deemed to be criminals, and the police move in with force to shut down mining operations for the purpose of driving miners and other community members from the area. This happened, for instance, in Madre de Dios, as discussed above. The government of Ghana also introduced a ban on ASGM in April 2017, aiming to arrest miners and confiscate equipment (Arthur-Mensah 2018). Approaches that make ASGM mining illegal may also include actions by governments, sometimes with the assistance of the media, to vilify miners as contaminators, or as being contaminated themselves (Goldstein forthcoming).

Bans on unlicensed ASGM can lead to escalating conflicts and deadly confrontations over land tenure and mining rights where ASGM intersects with larger gold mining operations (Patel et al. 2016; IGF 2017; Marshall and Veiga 2017; Werthmann 2017; Bebbington et al. 2018). In some cases, these conflicts are the result of ASGM miners moving into areas where large mining companies have already been given mining concessions, which may have been the result of corruption by government officials. In some cases, these concessions were granted without consulting local communities living on or near mining sites. In other cases, large mining companies move into areas in search of deposits where ASGM miners are already operating without permits. During violent confrontations, governments often side with the larger mining companies over the interests of ASGM miners. A confrontational approach can push miners into even further social marginalization, leading to additional unregulated mercury use and the associated environmental and human health risks that accompany it (Spiegel et al. 2015).

Some governments, in contrast, have taken legal steps to formalize the ASGM sector (Perks 2013). Political support for formalization has grown over the past two decades (G. M. Hilson 2002; Hilson 2016). Formalization makes it easier for governments to collect taxes and other fees from ASGM miners who are licensed by public authorities. It can also create more transparency and afford greater regulatory control with respect to mercury use (Hruschka 2011; Fritz et al. 2016). Bringing more ASGM miners into the formal sector often requires creating simpler licensing procedures. Yet, formalization is often a slow and difficult process in many countries, and is held back by bureaucratic hurdles and weak state structures (Marshall and Veiga 2017; Rochlin 2018). National governments in many countries that have close political and financial ties to large mining firms have also been reluctant to change their attitudes and approaches to ASGM, in part because the mining firms want to protect their land claims and mining rights over those of ASGM miners (Sippl 2015).

The Minamata Convention provides support for measures to bring more ASGM miners into the formal sector. Parties with “more than insignificant” ASGM must include steps to facilitate the formalization and regulation of the ASGM sector in their national action plans. This may involve developing new national policy frameworks and strategies for integrating ASGM and smallholder farming (Hilson 2016). ASGM miners in some countries have formed organizations to facilitate their negotiations with governments and mining companies (Werthmann 2017). Awarding miners official mining rights can help domestic authorities tackle pervasive socio-economic problems—such as child labor and other forms of forced labor that occur in many mining communities—because addressing these kinds of issues is more difficult when large numbers of people are operating without documents in the informal sector (International Labour Office 2006; Hilson and Osei 2014). Greater government involvement can also improve the social and economic status of women and girls, provide better tools to fight the sex trade and human trafficking, and reduce the risks from the outbreak and spread of infectious diseases (Jenkins 2014).

National governments can also take political and economic actions aimed at human development by encouraging people to voluntarily move out of the ASGM sector. This requires counteracting the decades-long trend of more people entering ASGM. Because ASGM provides short-term economic benefits to many people who may otherwise fall into (greater) poverty, longer-range efforts must involve the promotion of alternative livelihoods that address problems of unemployment and poverty while supporting sustainable development (Sippl and Selin 2012). Revised government policies can aim to provide alternative means of support for human development so that miners leave the ASGM sector for employment in other sectors (Hilson 2016). In Madre de Dios, for example, fish farming and the harvesting of Brazil nuts may provide income that is comparable to ASGM with much less damage to the environment and human health (Fisher et al. 2018). Forest conservation can also be supported by implementing payments for ecosystem services programs (Agencia AFP 2019). It can, however, be difficult to successfully implement alternative livelihood programs (Hilson and Banchirigah 2009). In addition, some observers argue that a more sustainable form of ASGM can provide an important source of viable livelihoods (Tschakert 2009).

International Standard Setting

International organizations and international non-state standard-setting bodies target gold supply chains in multiple ways (box 1-1). One initiative by an international organization is the due diligence guidance for responsible supply chains of minerals set by the Organisation for Economic Co-operation and Development (OECD). This guidance, intended to prevent gold buying firms from contributing to local conflicts when they decide which suppliers to use, affects the ability of ASGM miners in conflict-ridden areas to sell their gold on international markets (Organisation for Economic Co-operation and Development 2016). The EU in 2017 mandated that EU importers of gold (and other minerals) follow the OECD guidance, and China has also worked with the OECD to translate the guidance into domestic policy. In the United States, the 2010 Dodd-Frank Act requires that US companies determine whether several minerals including gold come from the Democratic Republic of Congo or an adjacent country. If so, companies must review the supply chain to determine if those minerals help fund local armed groups. Several non-state initiatives also promote transparency in the mining sector, including documenting the origin of the gold that enters international markets (Auld et al. 2018).

International certification schemes by international non-state standard-setting bodies—including efforts by the Alliance for Responsible Mining (ARM) and Fairtrade International (FLO)—are another form of standard setting that targets ASGM. These civil society organizations aim to make ASGM mining more socio-economically and environmentally sound by creating financial incentives for miners to change mining practices through a price premium on the gold they sell, and by convincing consumers to pay more for jewelry made from ethically sourced gold. Building on efforts started by ARM in 2004 with the small mining cooperative Oro Verde in Colombia, ARM and FLO launched a joint pilot project in 2011 that covered the entire gold supply chain from miners, through cooperatives, traders, refiners, manufacturers, and retailers, to consumers of jewelry. ARM and FLO decided to go their separate ways after the pilot project ended in 2013, and now operate separate schemes. The ARM and FLO schemes are slightly different, but for both, in order to have their gold certified, miners must take actions such as organizing democratically, gaining legal mining permits, preventing child labor, and making other behavioral changes to support community development and protect the environment (Sippl 2016).

The design and implementation of the ARM and FLO certification schemes have been criticized, however. John Childs (2014, 129) found a "substantive gap" between how fairness in trade is characterized in the international ARM- and FLO-led discourse compared to the on-the-ground situation for many ASGM miners who participate in these certification schemes. In Tanzania, the fair trade price offered to miners was often significantly lower than local market prices, and many miners mistrusted such external interventions. Gavin Hilson and colleagues (2016) furthermore argue that certification schemes often fail to do enough when it comes to helping the poorest and most marginalized miners. Because certification organizations only work with the relatively small number of miners who have organized collectively and have formal mining permits, they often ignore those miners who are less networked, and who thus need assistance and opportunities the most. Many of the miners excluded from the certification schemes are also those who face the most significant political, economic, and administrative obstacles in obtaining formal mining licenses—and because it is difficult for them to join a certification scheme, they are stuck in the informal sector (Sippl 2020).

In 2018, ARM launched the Code of Risk mitigation for Artisanal and small-scale mining engaging in Formal Trade (known as the CRAFT Code), in large part as a response to criticism of its certification scheme and its low participation by miners (Sippl 2020). The CRAFT Code is designed to help miners document the origin of their gold, and thus relates to efforts by the OECD, the EU, the United States, and others to restrict the trade in conflict minerals. It is intended to apply to artisanal gold but also to be adaptable for other minerals. The code is based on self-reporting without the requirement of external audits that come with the certification schemes, and as such is a less demanding alternative for miners who struggle to meet the certification requirements. This documentation is intended to help ASGM miners continue to sell their gold on international markets. However, the code is less stringent about formal permits than earlier certification schemes, and fulfilling the code does not provide the miners with a price guarantee, as do the certification schemes. ARM has nevertheless expressed a dual hope for the code: that it will provide an incentive for consumers to purchase non-conflict gold at a premium, and that it may attract miners to eventually join a more stringent but also more lucrative certification scheme (Sippl 2020).

Addressing Mercury Use in ASGM

International non-state standard-setting bodies formulate rules about mercury use for certification (box 1-2). The certification schemes that are operated by ARM and FLO specifically focus on gradually reducing and phasing out mercury use in ASGM by offering higher economic incentives. Miners who have been certified and who are able and willing to go mercury free can go beyond the standard price premium and upgrade to the ecological standard, which further increases the price that they are paid for their gold (Sippl 2016). Both ARM and FLO pay the miners 95 percent of the London Bullion Market Price for fulfilling their basic standards (which is higher than the 70 percent that they would normally get on the gold market).

While FLO offers a 15 percent premium on the market price for gold that meets their ecological standard (Sippl 2020), ARM instead offers a fixed premium of USD 6,000 per kilogram for the miners who upgrade to their ecological standard. Both of these ecological standards require mercury-free mining. The 15 percent premium offered by FLO equals a larger dollar amount than the USD 6,000 premium given by ARM when the gold price is above USD 40,000 per kilogram (USD 1,134 per ounce) (Sippl 2016). The market price of gold has almost always been above this level since 2011. The CRAFT Code is less stringent in restricting mercury use than the ARM and FLO certification schemes.

Experts and international organizations design and disseminate technological solutions to mercury use in ASGM in the form of new mining and amalgamation equipment and mercury capture devices (box 1-2). Experts also design efficiency improvements in mercury capture and amalgamation techniques (box 2-2). Challenges associated with the introduction of such equipment vary from country to country, and sometimes even from mining site to mining site (Sousa and Veiga 2009; IGF 2017). The often-significant variations in situations across ASGM communities make it impossible to design a single universal approach to effectively address all aspects of mercury use, discharges, and exposure in ASGM (Sousa and Veiga 2009). It thus becomes important for governments and other interveners to recognize country-specific and site-specific conditions across different mining sites, and to take bottom-up and participatory, multi-stakeholder community-based approaches when engaging individual miners and mining communities (Spiegel 2009; Spiegel and Veiga 2010; Fritz et al. 2016). This has often not been the case in the past.

The Minamata Convention calls for parties to take actions to eliminate whole ore amalgamation. It also mandates parties to develop strategies to encourage mercury-free mining methods. This can involve using cyanide instead, which can allow miners to recover more of the gold from the ore than using mercury-based methods (Veiga et al. 2009). But cyanide-based methods are often more expensive, and they can be difficult and dangerous to use in the field. Mercury and cyanide that are used in the same area may also interact and increase the bioavailability of mercury in the environment, potentially leading to more mercury methylation (Spiegel 2009; Spiegel and Veiga 2010; Spiegel et al. 2018). Several other mercury-free technologies also allow miners to yield more gold, particularly the use of various gravity-based methods, including Gemini (or gold shaking) tables, sluice boxes, and centrifuges (Davies 2014; Veiga et al. 2015). Yet some mercury-free alternatives can be more expensive and complicated to introduce because of cultural and technological factors (Spiegel and Veiga 2010; UNEP 2012; Amankwah and Ofori-Sarpong 2014).

Other mercury-focused interventions engage experts who design efficiency improvements in mercury capture and amalgamation techniques (box 2-2). A central component of such a strategy, which is supported by provisions in the Minamata Convention, involves expanding the use of more effective retorts and other mercury capture devices, and instructing miners how best to use them. The correct use of mercury capture devices yields health benefits as well as economic benefits, as it results in much higher levels of mercury recycling and reuse, and thus reduces the frequency with which miners need to spend money to buy new mercury. There can nevertheless be technical and behavioral barriers to successfully implementing retort use in mining communities. Such challenges require careful attention from experts, particularly those from outside mining communities, when they aim to introduce novel technologies and techniques (Spiegel et al. 2015). A related intervention aims to reduce, and eventually eliminate, open-air burning of amalgam and all burning of amalgam in residential areas, including in gold processing centers (Veiga et al. 2018).

Technology-focused interventions to reduce mercury use are more likely to succeed when they are coupled with initiatives to improve knowledge of mercury risks (Clifford 2014; Spiegel et al. 2015; Veiga et al. 2015). Several international programs have been involved in such twin efforts, including the Global Mercury Project, which was launched in 2002 by the United Nations Industrial Development Organization (UNIDO) with support from the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) (Chouinard and Veiga 2008). The Global Mercury Partnership has had ASGM as one of its main partnership areas since 2009. Partnership efforts on ASGM shaped the negotiations of the Minamata Convention as well as early treaty implementation (Sun 2017). The Global Mercury Partnership mobilizes knowledge by providing education and raising awareness about amalgamation techniques and mercury-minimizing techniques. For these programs to work, they must often apply a bottom-up approach and be implemented alongside other measures and provisions that ensure the availability of finance and access to equitable gold markets, and in the context of other efforts to reduce human health risks and maximize benefits of mining to local communities (Spiegel 2009; Spiegel et al. 2015; Veiga et al. 2018; Stocklin-Weinberg et al. 2019).

Many miners and other people who live around mining areas and work in gold processing centers are unaware of the health risks of breathing in mercury vapor. Successful science-based risk communication often goes further than just identifying mercury-related environmental and health problems; it offers miners specific health protection measures to address at least some of these problems (Zolnikov 2012). It is important to develop community-targeted information and communication strategies when generating and sharing information on how to reduce mercury use and exposure in ASGM. People in mining communities, especially in former European colonies, can be skeptical of external information about the dangers of mercury; they may fear it comes in the guise of "green colonialism" where outside actors try to impose their environmental protection ideas at the expense of local communities (Zaitchik 2018; Goldstein forthcoming). Without active involvement by local governments, many technical, financial, and social support efforts on awareness raising and training stand a greater chance of failing (Fritz et al. 2016).

Other mercury-focused interventions have addressed the transnational supply of mercury going to ASGM communities. A growing number of national governments have banned the import of mercury for ASGM (box 2-2). Such governmental regulatory actions are also connected to the argument that curtailing the legal international trade in mercury will result in price increases that in turn will lead to reduced use—especially in ASGM, where miners who typically have limited financial resources are sensitive to price changes in mercury (Hylander 2001). However, restrictions on the legal trade in mercury can lead to short-term increases in domestic stockpiling and illegal trade, which can be difficult to monitor and prevent (Greer et al. 2006). This shows the risks of interventions by international organizations and governments that focus on mercury supply without corresponding efforts to reduce demand. In addition, some national governments have banned mercury use in ASGM (box 1-2). Rapid phaseouts and bans on mercury uses in ASGM are also supported by some international organizations and donor-led initiatives.

The introduction of governmental bans on mercury use has rarely (if ever) completely stopped ASGM miners from using mercury. Miners will often look instead to the black market for buying mercury. This continuing reliance on unlawfully smuggled mercury into many ASGM communities is thought to have been a major driving force behind the resurgence of illegal mining in Mexico and Indonesia (Camacho et al. 2016; Spiegel et al. 2018). Most of this increase in the informal supply of newly mined mercury is likely used by ASGM miners, either domestically or once it has been exported illegally to other countries. In a situation where so much mercury use is unregulated, it can be more difficult to set up and implement abatement programs. In the absence of such programs, mercury-related problems in and around ASGM sites can grow, even where there is an official mercury-use ban. A ban on mercury use can also lead to a greater dependency on illegal gold buyers, who provide socially and economically vulnerable miners with smuggled mercury in exchange for exclusive gold buying rights, sometimes at exploitative prices (Spiegel 2009).

Insights

The story of the miners of Madre de Dios illustrates how small-scale gold mining activities are part of a broader ASGM system that occurs in multiple countries simultaneously and is linked with national laws and international markets. In this section, we draw insights from the mercury and ASGM system. First, ASGM is characterized by place-based and global-scale interactions and rapid adaptation to change. Second, past interventions have emphasized an incremental transition that minimizes harm without addressing fundamental questions of mining. Third, effective governance approaches will require coordination of institutions at multiple scales and attention to issues of power and justice.

Systems Analysis for Sustainability

Place-based and global-scale interactions combine to influence not only the use of mercury in ASGM but also the environmental and human health impacts associated with it. The way in which miners operate in ASGM—by looking for gold in alluvial deposits, saprolites, or hard rock deposits; engaging in whole ore amalgamation or concentrate amalgamation; and carrying out open air burning or closed circuit burning of the amalgam—affects the amount of mercury they use and the resulting environmental discharges as well as human exposure levels. Discharges can lead to elevated concentrations of methylmercury in nearby as well as distant bodies of water. International gold markets and commodity chains connect local gold miners and sellers to gold buyers and consumers in faraway places. International codes and certification schemes seek to change local gold production methods, including practices of mercury use. International markets for mercury link individual ASGM miners with foreign supply sources and transnational networks of mercury smugglers. Support from the Global Mercury Partnership and international organizations affects the ability of many governments to reduce socio-economic and environmental problems in ASGM.

The mercury and ASGM system has shown a capacity to adjust rapidly to changes in local and global conditions. This has had mixed implications for human well-being. The steep increase in the international price of gold has encouraged a growing number of people to become miners, allowing them to make more money. Ecological deterioration, policy actions on conflict diamonds, and price changes in the gold market have also pushed more people into the ASGM sector in search of an income. This has resulted in an increase in mercury use, exposure, and discharges. Recently, some ASGM miners have taken measures to meet international standards on conflict-free gold to allow them to continue selling their gold on international markets. Some miners have also joined transnational gold certification schemes, which can sometimes (but not always) contribute to both higher incomes and less mercury use. At the same time, mercury suppliers and miners have responded to mercury export bans and other supply and use restrictions by finding alternative, often illegal ways of transporting mercury into ASGM communities. This has solidified mercury's central role in ASGM, even as mercury continues to be a major human health and environmental problem.

The high degree of locally concentrated use and discharge of mercury in ASGM shows the variability of mercury impacts at different scales. Mercury from ASGM is thought to be the largest global source of emissions to the atmosphere, but it remains uncertain how much of the mercury that is discharged from ASGM stays in the local environment and how much travels to other regions. There are variations in human exposure to mercury both within and across ASGM communities. Based on their choice of mining area and extraction techniques, some miners will use more mercury than others and thereby face a higher degree of exposure. The conditions under which the amalgam is burned off to refine the gold also have major implications for environmental discharges and human exposure. Open air burning without the use of retorts leads to atmospheric mercury emissions, and indoor burning can result in very high concentrations of mercury vapor in poorly ventilated gold shops. All of these factors can result in variable and dangerous local environmental and human health conditions that may not be visible when looking at trends in total emissions or global average mercury levels.

Sustainability Definitions and Transitions

A more sustainable ASGM sector would use less or no mercury, but some analysts and advocates would argue that mining itself is unsustainable by definition. Mining, including ASGM, can be seen as inconsistent with definitions of sustainability that stress the importance of not depleting stocks of non-renewable resources. Eliminating mining would remove all mercury use in ASGM, but few actors who work on addressing socio-economic and environmental problems in ASGM argue for this solution. The long-term goal of the Minamata Convention—to phase out all mercury use in ASGM to protect human health and the environment—is linked to a perspective that sees mercury use as inherently dangerous and undesirable. Many short-term efforts, however, look to reduce (not eliminate) mercury use and implement measures that better protect people in mining communities and limit discharges of mercury to the environment. This is based on the recognition that mercury use in ASGM has some positive value, as it is integral to the ability of many miners to earn a basic livelihood to support themselves and their families. It would also be extremely difficult to implement and enforce an immediate ban on mercury use in all the world's ASGM sites.

A gradual transition away from mercury use in the ASGM sector, with the aim of ultimately phasing out all use, requires considering trade-offs in resource allocation. It is often necessary to decide how much limited human and financial capital should be spent on short-term fixes such as the introduction of retorts, medium-term efforts that focus on the promotion of mercury-free mining techniques, or long-term restructuring that looks toward getting people out of the ASGM sector by providing alternative livelihoods. Expanding the use of retorts reduces the short-term exposure risks and discharges of mercury, but it allows for continued mercury use that does not reduce exposure and discharges to zero. Many mercury-free mining alternatives are more expensive and require practices unknown to miners, making it difficult to immediately expand their use. Phasing out ASGM would address the mercury problem, but the ability for ASGM miners to find other work that provides a livable income depends on the creation of those jobs as well as the miners having the necessary skills to fill those positions. It is also important that those jobs do not create other forms of social and environmental problems.

International institutions and knowledge play important roles in supporting a transition away from mercury use in ASGM. The Global Mercury Partnership, the negotiations of the Minamata Convention, and the creation of gold certification schemes were instrumental not only in highlighting mercury-related and other problems in the ASGM sector that had been largely overlooked by earlier international development efforts, but also in pushing action to reduce mercury use, environmental discharges, and human exposure. The design of new technologies and the formulation of information campaigns on awareness raising, alternative mining techniques, and behavioral change, all of which are essential to this transition, are underpinned by engineering, natural science, and social science knowledge. Greater use of retorts and expanded information sharing about the dangers of mercury exposure in mining communities have had positive effects in some cases. At the same time, the transition toward a mercury-free ASGM sector is severely hindered by a steady supply of mercury, the lack of a simple and cheap alternative to mercury use, and the economic profitability for ASGM miners of a high price of gold.

Sustainability Governance

The Minamata Convention sets out a global approach to address mercury use in ASGM, but much national implementation and on-the-ground change will be up to domestic actors. The requirement for parties with "more than insignificant ASGM" to develop their own individual national action plans is important for institutional fit in that it provides important country-level flexibility. Many large-scale drivers of the recent expansion in ASGM—such as lingering poverty, a continuing lack of alternative employment opportunities, and a high price of gold—are similar across Latin America, Africa, and Asia. Yet, there are significant legal, political, economic, cultural, and environmental variations among countries with ASGM, as well as across individual mining sites, that affect national and local governance efforts.

As a result, countries will identify partly different domestic problems and design different solutions in the national action plans. Moving forward, it is important that global efforts on ASGM under the Minamata Convention and supported by the Global Mercury Partnership are designed to reinforce national-level efforts in ways that recognize variations in domestic conditions.

Governance of mercury use in ASGM involves a combination of approaches to address various leverage points in different ways. The Minamata Convention supports efforts on formalization as an important way to bring miners out of the informal sector. This can allow for greater protection of ASGM miners and better controls on mercury use. Evaluations of field programs show that efforts to address mercury use, exposure, and discharges in ASGM are often more likely to have the desired impact when they consist of a combination of interventions that address behavior and those that introduce new technology. It is often easier to get a miner to change from open air burning to closed circuit burning of the amalgam if a program both provides the miner with an opportunity to acquire a relatively cheap but effective retort and includes an educational component about how to use that retort to recapture mercury for subsequent reuse. International certification schemes seek to harness the power of gold buyers throughout the commodity chain to provide economic benefits in the form of a price premium to ASGM miners who move to mercury-free mining.

Governance of ASGM is deeply connected to socio-economic issues of poverty and marginalization. ASGM miners and other people who live in mining communities are often vulnerable to different forms of exploitation, including forced labor, child labor, human trafficking, organized crime, and actions by mercury smugglers and gold buyers who take advantage of miners' exposed legal and economic situation. In many past interventions by governments and international organizations, the representation of the poorest and least well-organized miners was often ignored. Their voices may also be excluded in conflicts with large mining firms and governments. This may increase the use of mercury because marginalized miners often operate without access to technology and other resources that would help reduce mercury use and thus protect human health. This makes it important for those looking to improve the well-being of the estimated 100 million people who directly and indirectly gain an income from the ASGM sector to pay close attention to dynamics of justice and power.

For societies beholden to Mercury, the god of finance, gold remains a desirable financial instrument. Resource extraction continues to power the world economy, but the process by which people turn gold in geological reservoirs into a resource is associated with multiple social and environmental problems. The use of mercury, which continues to be a valuable extracted resource for this purpose, is a key ingredient in ASGM. This mercury use helps people who are often marginalized and poor make a basic income from gold mining. Mercury used in ASGM also damages human health and the environment: it affects miners, gold processors, and other local community members, and simultaneously contributes a substantial portion of global mercury emissions and releases. Both local conditions and transnational forces drive ASGM, and thus influence efforts to address its negative environmental and human health effects. Different behavioral and technical measures target mercury use in local mining communities, but simultaneous changes in international prices of and trade in mercury and gold have a major impact on the decisions and ultimately the health and well-being of millions of miners, their families, and their communities.

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Mercury Stories

Understanding Sustainability through a Volatile Element

By: Henrik Selin, Noelle E. Selin

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