FORMALIZATION, CERTIFICATION, AND TECHNOLOGY: THE COMPLEX LANDSCAPE OF ARTISANAL AND SMALL-SCALE GOLD MINING INTERVENTIONS IN PERU

by

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ABSTRACT

In recent years, the lucrative nature of artisanal and small-scale gold mining (ASGM) has attracted millions of people from rural and developing communities who are seeking economic opportunities. This has caused a widespread, exponential expansion of the ASGM sector globally. Current estimates suggest that ASGM, generally characterized by low-tech, labor-intensive mineral extraction and processing, provides direct employment to 20 million people and millions more indirectly. ASGM occurs in over 70 countries, generating approximately 20% of the global annual gold production. Despite the ASGM sector providing a livelihood for millions of people in rural communities, the social and environmental issues associated with the sector overshadow its economic importance leading to the exclusion of the sector in regional and national development plans.

In the last decades, the formalization of ASGM activities has become a key strategy for governments and policymakers to better govern and regulate the sector. Proponents of formalization argue that the social and environmental issues associated with the ASGM sector are largely due to the lack of regulation and ASGM activities taking place outside the legal sphere. However, examples of analyzing formalized operations are scarce as most research has focused on the viability of formalization itself and the various barriers to entry. As governments continue to focus on formalizing as many miners as possible, there is a lack of emphasis on what comes after formalization and how to transform the sector into a more sustainable livelihood. This dissertation is a compilation of four research articles which seek to answer the following research questions:

1. What are the outcomes of ASGM formalization and are state-led efforts sustainable?
2. Are voluntary gold certification programs a viable mechanism to enhance ASGM formalization efforts and improve the sector?
3. What are the prevailing issues after becoming formalized and how to overcome them to achieve sustainable ASGM formalization?

This dissertation informs these questions with four research activities:

A case study of formalized ASGM operations in the Puno region of Peru: The Peruvian government has made great strides on simplifying the ASGM formalization process in hopes to

formalize the greatest number of miners possible. The Puno region of Peru leads the country with the greatest number of formalized miners. Formalization efforts proved to have mixed results. In what can be considered a successful case of formalization, miners were able to obtain all the necessary permits, legal titles, and complete all the formalization requirements. Although formal miners were able to operate peacefully without being subject to government-led military interventions, miners remain frustrated with the lack of technical support and lack of channels to access capital. Rather than miners feeling more protected by the state, miners feel more pursued and scrutinized than when they operated informally.

A critical assessment of voluntary gold certification programs and their impact on improving rural livelihoods and minimizing environmental impacts: Voluntary gold certification programs, created and administered by international NGOs, have emerged as a solution to the social and environmental issues associated with the ASGM sector. This research critically examines the practical impacts when certification is achieved and examines the shortcomings and pitfalls. This research concludes that voluntary gold certification programs are providing miners with economic incentives that are driving the implementation of better environmental management and health and safety practices. However, there are challenges that will have to be overcome for small-scale mining organizations to achieve and maintain certification status.

A critical examination of gravity separation and concentration interventions implemented in the ASGM sector: As ASGM continues to expand, it has raised concerns about mercury use leading to an increased number of projects designed to reduce or eliminate the use of mercury in ASGM. Through a critical examination of the gravity separation and concentration interventions that have been globally implemented in ASGM, the shortcomings and challenges for artisanal miners are addressed. This research highlights how gravity concentration can reduce the amount of material to be amalgamated or treated thermally or chemically to extract gold from concentrates. However, it also concludes that this process has the potential to eliminate the use of mercury in very rare, specific cases. Ultimately, this research concludes that although gravity concentration can drastically reduce the use of mercury and its release into the environment, it is not the final solution to eliminate mercury use in ASGM.

A three-pillar, bottom-up framework to achieve sustainable formalization: The sustainability of top-down ASGM formalization efforts relies on the retention of artisanal miners in the legal

sphere as well as the transformation of rudimentary miners into educated, responsible miners. This research examines formalized ASGM operations in three of the most important ASGM regions of Peru (Arequipa, Puno, and Madre de Dios) to identify some of the remaining challenges faced by formal miners. This research developed a bottom-up framework incorporating miner's perspectives that can be used to guide capacity building initiatives to prevent miners from reverting to informality. The framework concludes that although solutions to improve formalized operations must be site-specific, there are overarching themes which formal miners continue to struggle with regardless of geographic location or time accumulated in the legal sphere.

Collectively these studies conclude that formalization alone is unsustainable, as miners who achieve formalization feel more pursued and scrutinized than miners who continue to operate informally. In addition, formalization policy cannot exist without education, training, and capacity-building initiatives, otherwise governments cannot expect miner's rudimentary practices to transform into clean, environmentally responsible practices. However, NGOs and their voluntary gold certification programs have the potential to enhance formalization efforts by providing miners with technical support and market-based incentives for compliance with environmentally and socially responsible mining practices. This research also highlights that the technical interventions implemented to reduce or eliminate mercury use in the ASGM sector have overly emphasized gravity methods, which cannot be seen as the final solution for all ASGM operations. This dissertation calls on governments, policymakers, donors, and civil society actors to place a greater emphasis on educating and supporting formal miners beyond technical improvements to ensure mid to long-term sustainability and social development.

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– Lebron James

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DEDICATION

for

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my rock, my world, my biggest supporter

CHAPTER 1
INTRODUCTION

Artisanal and small-scale gold mining (ASGM), generally characterized by low-tech, labor-intensive mineral extraction and processing, provides rural populations a source of income and significantly contributes to regional and national economic growth. It involves over 20 million people directly and millions more indirectly and takes place in over 70 countries producing almost 600 tonnes/a of gold (Heymann, 2020; Yoshimura et al., 2021). This accounts for approximately 20% of the global annual gold production (World Gold Council, 2022).

Although governments around the world recognize the economic importance of ASGM (Hilson, 2002; Fisher, 2007; Verbrugge and Besmanos, 2016; Mkodzongi and Spiegel, 2019), it has generated significant negative impacts on the environment, society, and human health. Artisanal and small-scale gold mining is currently the largest source of mercury emissions releasing over 2000 tonnes of mercury per year, accounting for approximately 35% of global mercury pollution to the environment (UNEP, 2020). In addition, the ASGM sector can also contribute to deforestation (Caballero Espejo et al., 2018) and involve child labor, money laundering, and other illicit activities (Hinton, 2006; Hilson, 2010a). Furthermore, gender inequalities (Arthur-Holmes, 2021), adverse impacts on human health (Tschakert and Singha, 2007; Smith et al., 2016), and conflicts with owners of mineral titles (Verbrugge, 2017; Veiga and Fadina, 2020) are also very common among the sector.

This work highlights an underexamined sub-set of the ASGM sector: formalized ASGM operations. The study challenges some of the negative characterizations of the sector while highlighting the progress that has been made by certain actors in the sector.

1.1 Artisanal and Small-Scale Gold Mining (ASGM) and Formalization

Globally, governments have undertaken efforts to formalize the ASGM sector, as formalization is often perceived to be a way to better govern and regulate the environmental and social impacts of the sector (Verbrugge and Besmanos, 2016; Hilson and Maconchie, 2017). Many government officials continue to blame informality in the ASGM sector on miners' unwillingness to comply with legal requirements, without considering other barriers, such as the government's lack of capacity to enforce legislation or the general feasibility of legislation itself

(Van Bockstael, 2014). In addition, many ASGM operations are in remote areas with very little governmental presence, making enforcement a difficult task (Hilson, 2002; Hilson and Vieira, 2007).

The ability to become formal relies heavily on mineral tenure and property rights (Siegel and Veiga, 2009). This makes it challenging for many artisanal and small-scale gold miners, as the majority do not possess the mineral rights or land titles (Fisher, 2007; Geenen, 2012; Fold et al., 2014; Verbrugge and Besmanos, 2016; Veiga and Marshall, 2019). Some scholars have also argued that formalization frameworks that largely focus on formal titles and mineral tenure rights do not guarantee success, as property rights do not directly translate to poverty eradication and tend to gloss over complex organizational arrangements (Bromley, 2009; Verbrugge and Besmanos, 2016). In Zimbabwe, Spiegel (2009a) argued that government initiatives and policy frameworks to manage the ASGM sector have been counterproductive, as illegal activities have increased and artisanal and small-scale gold miners have continued to rely on illicit economies. In other countries, like Sierra Leone (Maconachie and Hilson, 2011a, 2011b) and the Democratic Republic of the Congo (Geenen and Radley, 2014), researchers have observed that artisanal and small-scale gold miners have limited incentives to comply with existing legislation, as the state is unable to provide them with tangible benefits in return. Researchers have also highlighted that without proper education and training, formalization initiatives are not sustainable and do not translate to better practices (Veiga and Marshall, 2019).

Globally, examples of successful ASGM formalization are rare. This is in part due to the fact that most of the efforts to formalize and support ASGM have been focused on technical and financial aspects, with a strong emphasis on controlling activities rather than proactively engaging and supporting ASGM stakeholders (Hilson et al., 2019). In Colombia, over a 15-year span (1993-2008), only 23 mines out of more than 3,000 applicants became formalized (less than 1%) (Veiga et al., 2014). In Bolivia, Salman et al. (2015) highlights that government agencies were aware of their limited capacity to effectively monitor and impose policy compliance. Researchers have concluded that, regardless of location, formalization of the ASGM sector is a daunting task, especially if there is a lack of political will (Hilson et al., 2019). As Hilson (2020, p. 10) states, “when a government believes that there are financial gains to be made, it will embrace the ASGM formalization challenge.”

1.2 Why Look at ASGM Formalization in Peru?

Artisanal and small-scale gold mining experienced a surge in the 1980s due to the political and social hardships (e.g., internal conflict, economic crises, and migrations) endured in the country of Peru (UNEP, 2012) and the need for rural communities to identify viable livelihood activities. This increase in ASGM activities can also be attributed to the increased global price of gold which spiked in the 1980s (Kitco, 2020), leading rural populations to rely on ASGM as a livelihood. Over the decades, the ASGM sector has grown in Peru, as it provides a livelihood for people in regions where economic alternatives are generally lacking (Hinton, 2005; Siegel and Veiga, 2010).

Peru is currently Latin America's top gold producer and the eighth largest gold producer globally (USGS, 2020). In 2018 and 2019 the ASGM sector was responsible for producing approximately 47 tonnes (total production: 157.6 tonnes) and 43 tonnes (total production: 143.3 tonnes) of gold in Peru, respectively. Although the exact number of artisanal and small-scale gold miners in Peru is not well-established, estimates suggest there could be anywhere from 100,000-500,000 miners (De Echave, 2016). However, according to the planetGOLD project in Peru, approximately one million people's livelihoods depend on the ASGM sector.

Today, ASGM activities exist in all 25 regions of Peru with the majority of miners operating outside the legal sphere, as they do not possess any legal titles or permits. However, ASGM activities are most predominant in six regions: (1) Arequipa, (2) Ayacucho, (3) Puno, (4) Apurimac, (5) Madre de Dios, and (6) La Libertad. Of these six regions, annual estimates suggest that the top gold producing regions from the ASGM sector are: (1) Puno, (2) Madre de Dios and (3) Arequipa (MINEM, 2019). The map below (Figure 1.1) highlights the 11 regions with the most ASGM activities in Peru.

Figure 1.1: Map of all 25 regions of Peru with the top six ASGM regions (Arequipa, Ayacucho, Puno, Apurimac, Madre de Dios, and La Libertad) shown in yellow and the following top five ASGM regions (Ancash, Lima, Cusco, Ica, Piura) shown in blue.

Ore extraction methods in Peru vary a great deal depending on the region and location in which they take place. ASGM activities in Peru occur in coastal areas, the Andes highlands, and the Amazon basin. Miners primarily rely on labor intensive, rudimentary technologies without health and safety or environmental protections (UNEP, 2012). The size of ASGM operations also vary from site to site, with some beginning to resemble medium-scale operations. Similarly, technologies have become more sophisticated, and some miners have begun to use heavy machinery leading to larger and more drastic environmental impacts.

To date, most ASGM research in Peru has focused on measuring and monitoring mercury exposure and concentrations in the environment and humans (Diringer et al., 2015; Langeland et al., 2017; Martinez et al., 2018; Feingold et al., 2020; Moody et al., 2020; Weinhouse et al., 2021), as well as deforestation and land degradation in the Amazonian region of Madre de Dios (Asner and Tupayachi, 2017; Caballero Espejo et al., 2018; Kahhat et al., 2019). However, only

a few studies have been conducted on ASGM formalization in Peru, and these have also solely focused on the Peruvian Amazon (Damonte, 2016; Salo et al., 2016; Damonte, 2018). Salo and his colleagues (2016) argued that formalization in Peru was constructed as top-down process that disregarded artisanal and small-scale gold miner's perspectives and local realities. They also argued that formalization failed to offer clear benefits to ASGM stakeholders, and they advocate for the inclusion of ASGM stakeholders in the creation of policies aimed at the sector (Salo et al., 2016). On the other hand, Damonte (2018), drawing on geographer James Scott's (1987) work, argues that the Peruvian government is facing challenges controlling ASGM through formalization due to the state's limited capacity to govern local society in general. These studies of ASGM formalization in Peru have confirmed that formalization efforts in the Amazon basin have proved unsuccessful. However, there are still questions about the relative success of formalization efforts in other ASGM regions.

Today, of the 10,554 artisanal and small-scale gold miners who have become formalized, almost a third of these (2,899) are located in the Puno region (Table 1.1), making it one of the most important regions for ASGM formalization. In spite of these numbers, Puno is a relatively understudied region, and very little data exists on formalized ASGM operations in the region. Chapters 2 and 5 fill this gap by investigating the ways in which formal ASGM operations in Peru are functioning, the factors that have allowed them to formalize, and the remaining challenges of formalization efforts.

Table 1.1: Number of formalized artisanal and small-scale gold miners in Peru per department in May 2022 (REINFO, 2022).

Department	Number of Formalized Miners
Puno	2899
La Libertad	2514
Ayacucho	1602
Arequipa	1432
Cusco	1005
Apurimac	339
Madre de Dios	325
Lima	120
San Martin	66
Pasco	41
Piura	36

Table 1.1 Continued

Ica	29
Ancash	27
Junin	24
Cajamarca	21
Tacna	19
Amazonas	12
Loreto	10
Huancavelica	9
Moquegua	9
Huanuco	8
Ucayali	4
Lambayeque	2
Tumbes	1
TOTAL	10554

1.2.1 Peru and ASGM Formalization

Peru's mining laws and regulations were originally designed to facilitate large-scale, multinational, mining investments in the country (Hinton, 2005) and until 2002 artisanal and small-scale gold miners were not recognized by the law. Since then, however, however, Peru has passed a number of decrees in an attempt to better govern the sector, exert more regulatory control over environmental and social aspects of ASGM, and ultimately capture the economic benefits of a growing and quite lucrative sector (Salo et al., 2016).

In 2002, Peru passed the Law of Formalization and Promotion of Small-Scale Mining and Artisanal Mining (Law 27651) which introduced a legal framework for regulating ASGM and support the sector's formalization, promotion, and development. This law also categorizes mining activities according to size and production capacity (Table 1.2). Although this law finally recognized artisanal and small-scale gold miners, the main priority was to eradicate illegal gold mining (Damonte, 2018). In 2012, various decrees (Legislative Decree 1099, 1100 and 1105) were passed to define and differentiate between informal and illegal gold mining (see Figure 1.2). Legislative Decree 1099 approved the use of interdictions against illegal mining specifically in the department of Puno, while Legislative Decree 1100 outlined guidelines for interdictions of illegal mining (e.g., when confiscation/destruction of supplies and machinery is allowable) that could be taken by the Peruvian government throughout the entire republic. During this period

there were numerous military interdictions to destroy ASGM operations and camps, aimed at discouraging the proliferation of the activity (Washington Post, 2014; New York Times, 2016).

Table 1.2: Breakdown of mining operations by size and production capacity in Peru according to Peruvian Law 27651 (area provided in hectares, production capacity provided in metric tons per day).

Item	Scale	Area (Ha)	Production Capacity	Regulatory Agency
1	Large	Not applicable	More than 5000 MTD	MEM-OEFA OSINERGMIN
2	Medium	Not applicable	Metals: Up to 5000 MTD	MEM-OEFA OSINERGMIN
3	Small	Metals: Up to 2000 Ha	Metals: Up to 350 MTD Non-metals: Up to 1200 MTD	Regional Government
4	Artisanal	Metals: Up to 1000 Ha	Metals: Up to 25 MTD Non-metals: Up to 100 MTD	Regional Government

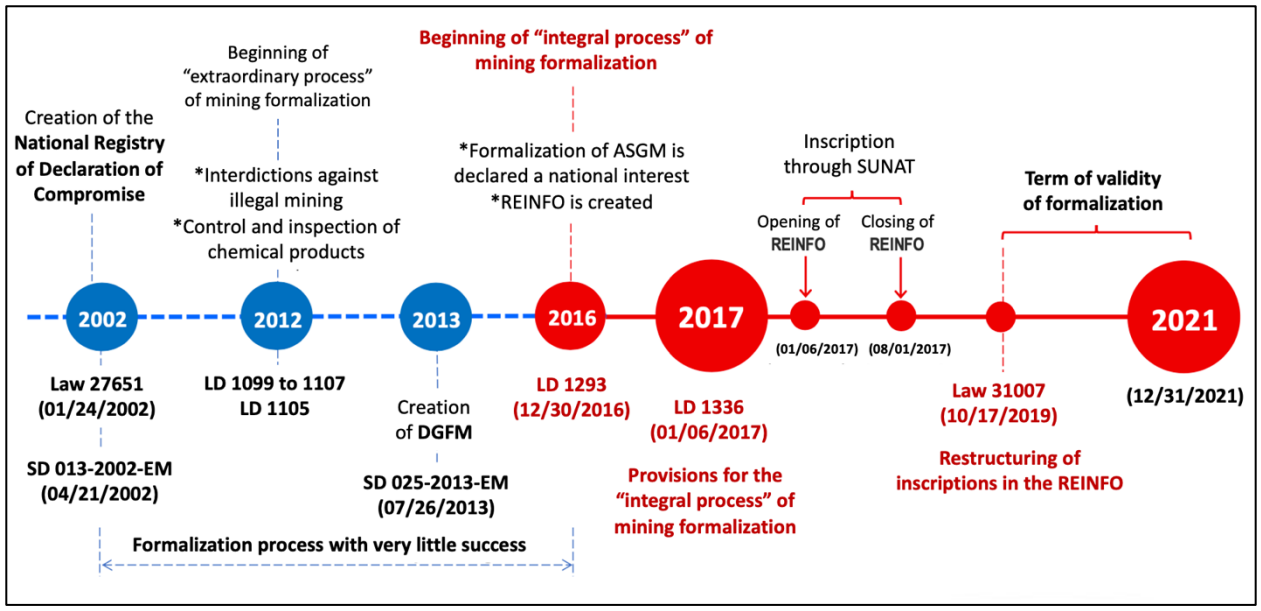

Figure 1.2: Timeline of ASGM formalization process in Peru.

From 2002 to 2016, government efforts to formalize ASGM operators resulted in only 112 formalized miners out of a total of nearly 73,000 applicants (less than 0.2%). Because of these low numbers, the government passed a new decree (Legislative Decree 1293) in 2016 that

declared the formalization of ASGM as a national interest and created a new process aimed at advancing formalization efforts. This process was a simplified version of previous formalizations efforts. In contrast to the previous formalization process outlined in Law 27651, where miners had to complete one step before moving onto the next and were not able to conduct any mining activities until they completed all the steps, the new process allowed miners to complete the mandatory steps while they continued to operate. The decree also decentralized the formalization process and gave regional governments the authority to lead the formalization process in their jurisdictions.

According to Legislative Decree 1336 and Supreme Decree 018-2017-EM, in order to become formalized, artisanal and small-scale gold miners must complete five mandatory steps:

1. Show proof of ownership of a mining concession title or an agreement with the title owner
2. Show proof that they have access to the land or a land title
3. Have in place an approved Environmental Mitigation and Correction plan
4. Submit a declaration of the absence of archaeological remains
5. File a technical plan for the mining operation.

After all these prerequisites have been verified by the Regional Bureau of Energy and Mines, miners receive the authorization to begin or continue their mining activities. Despite the streamlining of the process, formalization for artisanal and small-scale gold miners continues to be a challenge, as most miners lack the title to a concession or permission to mine from the title owner. Although this is a significant bottleneck in the formalization process (Fold et al., 2014), this decree has resulted in the highest number of formalized artisanal and small-scale gold miners in Peru's history.

Despite the popularity of ASGM formalization, it is not always clear how and to what extent top-down, government-led formalization strategies improve ASGM operations and eliminate socially and environmentally irresponsible practices. Similarly, it is unclear whether the new requirements of formalization are strict enough to eliminate bad practices and replace them with more responsible ones, or whether miners continue to view formalization as protection against government-led military interventions. After thorough investigation, there is a clear lack of post-formalization plans or strategies that provide newly formalized miners with support to

remain in compliance, improve their operations, and take full advantage of operating in the legal sphere.

In Peru, there has been a decrease in the number of newly formalized artisanal and small-scale miners over the past five years. Due to a lack of governmental presence in mining communities, beyond the location and reported number of miners working at each formalized operation, there is virtually no data or information on any of the formalized operations. Thus, this warrants an examination of formal operations to understand the impacts of formalization as well as retention of miners and legal compliance (Chapter 2). As fewer miners are becoming formalized, there needs to be a shift in focus from attempting to formalize as many miners as possible to supporting formalized miners to ensure that formalization efforts are sustainable and that practices in the field are changing (Chapter 5).

1.3 The Rise of Voluntary Gold Certification Programs

In the last two decades, voluntary gold certification programs, created and administered by international NGOs have emerged as one response to tackle the social and environmental issues associated with the ASGM sector. In the case of ASGM, this led NGOs such as the Alliance for Responsible Mining (ARM) and FairTrade International (FLO) to develop their own voluntary gold certification programs directed at tackling social and environmental issues associated with the ASGM sector. Both certification programs emerged from the *Standard Zero for Fair Trade Gold and Associated Silver and Platinum*, a blueprint of ethical standards for ASGM developed by multi-stakeholder groups and officials from ARM and Fairtrade UK and refined through consultations with experts (Hilson et al., 2018). Unlike top-down, state-led formalization efforts which rely primarily on the threat of sanctions to discourage bad practices, voluntary gold certification programs provide artisanal miners with market-based incentives for compliance with environmentally and socially responsible mining practices (Glasbergen, 2013; Childs, 2014b; Sippl, 2015). However, for miners to be able to enroll in certification programs, their operations must first be formalized according to national laws.

Voluntary gold certification programs hold some promise for promoting increased legitimacy and transparency among the ASGM sector, however, the implementation and inspection of the certification standards are usually costly and hard to enforce (Veiga and Marshall, 2019). Furthermore, the requirements to become certified are challenging for many

ASGM operators, particularly those who are unable to secure licenses and mineral titles because of costly registration fees, complicated bureaucracies, or few available mineral titles (Hilson, 2008; Sippl, 2015; Hilson et al., 2018). This has led to the question of whether certification programs live up to their "pro-poor" narrative (McQuilken, 2016; Hilson et al., 2016, p.236) by only targeting the "low-hanging fruit" or medium-scale miners who are well-organized and able to meet the stringent certification standards (Hilson, 2014; Hilson and McQuilken, 2016; Hilson et al., 2016, p.241; Hilson et al. 2018). The transferability of these programs, particularly to countries of Africa, has also been questioned (Childs, 2008; Childs, 2014a; Hilson, 2008; Hilson et al., 2016).

Although voluntary gold certifications are gaining more traction, their contributions toward improving rural livelihoods and minimizing environmental impacts remain unclear (Fisher, 2018; Sippl, 2020). To date, there has been only one study published which evaluates the impact of the Fairmined certification program on the well-being of participating gold miners in Colombia and Peru (N. Martínez et al., 2021). This study concluded that participation in the Fairmined certification program improved miner's well-being and "might" have improved ASGM operations.

Building on N. Martínez et al.'s (2021) work, Chapter 3 provides a qualitative analysis of the impact voluntary gold certification programs are having on social development and environmental protection from the perspectives of certified miners and certifying agencies. Previous studies have focused on analyzing perspectives of jewelers, consumers, and certifying bodies, however, a key element that is constantly absent in the gold certification literature is the perspective of certified miners themselves.

Currently, there are eight certified artisanal and small-scale gold mining organizations (ASMOs) in the world (five Fairmined and three Fairtrade). However, when examining the uptake over time, Sippl (2020) highlights that from 2013-2019, 19 ASMOs gained and maintained certification, and 7 ASMOs gained certification and then decertified. Peru provides an important setting for this line of research as it is home to the greatest number of gold certified ASGM operations in the world (three Fairmined certified organizations, and three Fairtrade certified organizations). This dissertation focuses on the Fairmined certification because of its sole focus on gold sourced from the ASGM sector and their greater reach among the ASGM

sector. From 2013-2020, ARM worked with a total of 24 ASMOs in Colombia, Peru, Bolivia, and Mongolia, while Fairtrade worked with 13 ASMOs in Peru, Kenya, and Uganda (N. Martínez et al., 2021).

1.4 Contributions

1.4.1 Contributions to the Literature

This research makes significant contributions to the literature on ASGM policy. The research focused on formalized small-scale mining operations, probing research questions that have never been examined before. The first research activity contributes new knowledge about ASGM by highlighting a site where formalization has had some positive outcomes. The majority of the literature on ASGM formalization has examined its shortcomings from either a high-level perspective (i.e., policy analysis) or based on the perspectives of one particular stakeholder group (i.e., women miners). This work complicates these analyses by incorporating the perspectives of policy makers, regulators, *and* miners and others involved with small-scale mining operations. It demonstrates that formalization strategies diverge significantly between theory and practice, as do the perspectives on formalization held by different stakeholder groups. Although this research offers a critique of formalization policies and processes, it also evaluates the ways in which formalization has had positive impacts.

The second research activity focuses on NGOs and certification programs. Although certification programs were created and first implemented to ASGM operations in South America, there are no peer-reviewed articles which examine how certification programs have and are impacting ASGM operations. This study fills that gap. By demonstrating the benefits, challenges, and outcomes of certifications, as well as how certifications drive miners' behaviors, this research activity contributes to the governance literature specifically by analyzing the role that non-state actors play in governing a sector which has largely been plagued by informality. Lastly, this research activity assesses the on-the-ground impacts that advocacy methods are having on mining communities and the health of ecosystems.

The third research activity contributes to the ASGM literature by examining the shortcomings of gravity separation and concentration interventions that have been globally implemented in the ASGM sector. Globally, gravity concentration overwhelmingly continues to

be pushed as the solution to eliminate mercury use in the ASGM sector. This research demonstrates how gravity concentration can reduce the amount of material to be amalgamated or treated thermally or chemically to extract gold from concentrates. Additionally, in very rare, specific cases, this can be a solution to eliminate the use of mercury. However, it argues that gravity concentration can reduce, but not completely eliminate, mercury use in ASGM.

Lastly, this is the first time that a post-formalization framework has been developed to guide host governments on how to tackle the remaining challenges of formalization in order to help miners remain in the formal sphere rather than falling back to informality. This framework is community-driven, designed and developed with the input of ASGM communities and formalized miners that are attempting to abide and follow laws, regulations, and standards. As many countries continue to struggle with formalizing ASGM activities, Peru boasts the title of most formalized artisanal miners globally. Therefore, Peru can serve as the pioneering country in establishing and implementing a post-formalization framework which aims to create a sustainable formalization process. As host governments continue to formalize artisanal miners, a framework or plan that attracts miners to operate or continue operating in the formal sphere does not exist. This research contributes to the policy literature by highlighting the roles that communities, government, donors, and civil society actors can play in order to fully achieve a successful, sustainable formalization plan.

One of the overall key contributions of this research is to recapitulate that ASGM formalization should be seen as *process* and *steppingstone* rather than an endpoint. Many host governments have attempted to formalize the ASGM sector in hopes that it would be the silver bullet to all issues surrounding the sector. However, this research aims to highlight the positive impacts of formalization, the shortcomings, the role of state versus non-state actors, and the steps forward to achieve a sustainable ASGM formalization.

1.4.2 Contributions to Society

This dissertation generates new knowledge on interventions being implemented in the ASGM sector. It contributes data and analyses that can potentially improve ASGM formalization efforts not only in Peru, but also in other parts of the world, and it provides suggestions for some of the ways in which governments and non-governmental organizations can support the ASGM sector. For a sector that provides a livelihood for over 100 million people in the world,

governments, donors, civil society actors, and private sector must work together to support rural livelihoods and promote sustainable development. This dissertation provides guidance for governments and NGOs to develop more effective policies and programs aimed at the ASGM sector; it advocates for continuous technical and economic support to be provided to miners before, during, and after becoming formalized; and it highlights the importance of considering artisanal and small-scale miners' on the ground realities when designing and planning various kinds of interventions.

1.5 Approach

As the ASGM sector is largely associated with lack of regulation, informality, and in some cases illegality, working with ASGM communities is extremely difficult due to miners' general lack of trust in outsiders. My journey working with the ASGM sector began in 2015 after I obtained an EPA STAR (Science To Achieve Results) Fellowship to examine mercury in aquatic ecosystems and other environmental impacts associated with ASGM activities in the Peruvian Amazon. Over the last seven years, I have visited over a hundred ASGM operations in Latin America (i.e., Peru, Bolivia, Colombia, and Costa Rica) and have spent an average of five months per year in the field. During my time in these countries, I have attended workshops, trainings, conferences, and meetings with miners, government officials, donors, civil society actors, private companies, among other stakeholders. Aside from being present as an attendee, I have also been invited to give presentations and conducted workshops on responsible mining practices for artisanal and small-scale miners on behalf of the Peruvian General Directorate of Mining Formalization, Center for Amazonian Scientific Innovation, as well as the Alliance for Responsible Mining.

To fully understand what drives ASGM operator's decision-making and practices, a deep examination of miner's life experiences and the local, regional, and national social, economic, and political contexts was necessary to prevent overgeneralizations. Throughout my years in the field, I confirmed that a key characteristic of the ASGM sector is the heterogeneity that occurs in terms of actors and their perspectives both within and between mining communities across space and time. Over the course of four years, I collected and analyzed quantitative data to show larger scale trends and patterns and qualitative data to provide an in-depth understanding of the nuances of a particular ASGM region in Peru.

Structure of Dissertation

Each research activity in this dissertation is its own standalone chapter, and the different methods used are discussed in each chapter. However, the chapters build on one another to address the following research questions:

- What are the outcomes of ASGM formalization, and are state-led efforts sustainable?
- Are voluntary gold certification programs a viable mechanism to enhance ASGM formalization efforts and improve the sector?
- What are the prevailing issues after becoming formalized and how can these issues be to overcome to achieve sustainable ASGM formalization?

Each research activity unfolds over the next five chapters, summarized below.

Chapter 2: Formalization is just the beginning: Analyzing post-formalization successes and challenges in Peru's small-scale gold mining sector

This chapter presents a case study of a formalized operations in one of the most important ASGM regions of Peru, Puno, and examines post-formalization outcomes. Findings from site visits and interviews with government officials and members of the ASGM community, demonstrate that formalization has yielded mixed results. Formal ASGM operations improved health and safety practices and labor conditions for their workers, and miners believed that their environmental awareness has increased. Despite these improvements, miners who have undergone formalization feel more pursued and scrutinized than they did when they operated informally, and they continue to face challenges obtaining technical support and accessing capital. The chapter elucidates that although some progress has been made in formalization efforts, the problems and weaknesses within the approach may inadvertently push miners back into informality. The chapter concludes that in order for formalization efforts to prove more fruitful for governments and artisanal miners, governments and policymakers would strongly benefit from the creation of a post-formalization strategy focused on educating and supporting formal ASGM operations. This chapter is published in the *Journal of Rural Studies*.

Chapter 3: Voluntary gold certification programs: A viable mechanism for improving artisanal and small-scale mining in Peru?

This chapter examines the practical impacts when certification is achieved and identifies the shortcomings of these programs. Through interviews with gold certification staff members and members of certified artisanal mining organizations, site visits, participant observation, and mercury data, it is demonstrated that gold certification programs are driving certified organizations to implement better environmental management and health and safety practices. This chapter also conducts a cost assessment to highlight that certified artisanal mining organizations are strongly benefiting from the economic incentives of selling gold internationally. The chapter concludes that although voluntary gold certification programs have the potential to improve environmental protection and contribute to rural development, artisanal and small-scale miners must overcome various challenges to achieve and maintain certification status. This chapter is published in the *Journal of Rural Studies*.

Chapter 4: The myth of gravity concentration to eliminate mercury use in artisanal gold mining

This chapter critically examines the gravity concentration and separation interventions which have been globally implemented in ASGM. The chapter begins by explaining key concepts of mineral liberation and gravity concentration. It then examines gravity concentration and separation interventions and addresses the shortcomings and challenges for artisanal miners. The chapter highlights that gravity concentration has the potential to reduce the amount of material to extract gold from concentrates. Yet this process can only eliminate the use of mercury in very rare, specific cases. The chapter concludes that although gravity concentration can drastically reduce the use of mercury and its release into the environment, it is not the final solution to eliminate mercury use in the ASGM sector. This chapter is published in the *Journal of The Extractive Industries and Society*.

Chapter 5: "I am formal, what comes next?": A proposed framework for achieving sustainable artisanal and small-scale mining formalization in Peru

This chapter builds on findings from the previous research activities and develops a post-formalization framework that can help guide government officials, donors, civil society organizations, and researchers on how to best support formal miners remain and grow in the legal sphere. The chapter begins by examining the many shortcomings observed with top-down formalization efforts and explains why a sustainable formalization framework is necessary. Over 20 ASGM operations were visited, and interviews were conducted with miners, civil society

actors, and government officials, in three of the most important mining regions in Peru (Arequipa, Puno, and Madre de Dios). The findings suggest that regardless of geographical region and time elapsed in the legal sphere, miners continue to struggle implementing more responsible mining practices. The chapter proposes a three-pillar approach to make formalization more sustainable consisting of: (1) Mining Operations and Processing, (2) Business Development, and (3) Partnerships & Collaborations. This chapter concludes that due to the heterogeneity of the ASGM sector, there is not a single entity or solution that resolves all the issues associated with the ASGM sector. However, creating site specific solutions and addressing these pillars, can serve as a start to help transform formal operations. This chapter will be submitted for publication in the *Journal of The Extractive Industries and Society*.

Chapter 6: Conclusion

The conclusion summarizes the findings of each chapter and suggests possible future directions for post-formalization efforts in Peru. In this chapter I argue that the efficacy of post-formalization efforts depends upon the political will to support, improve, and promote the ASGM sector rather than pursue and demonize artisanal miners. Such efforts must also overcome the broken relationship between government entities and artisanal miners based on empty promises and lack of support.

Each of the research activities builds on and informs each other. Chapter 2 provides essential baseline information on ASGM formalization in Peru and examines the successes and remaining challenges of formalization policy. Chapter 3 focuses on voluntary gold certifications which were developed to ameliorate the shortcomings of regulatory frameworks. Formalization and certification programs work in tandem: in order for ASGM operations to pursue gold certifications they must first become formalized and operate in the legal sphere. A key objective for both government-led ASGM formalization and voluntary gold certification programs is to improve governance and tackle the many environmental and social issues associated with the ASGM sector. One of the most pressing issues for governments, policymakers, donors, and civil society actors is the reduction and elimination of mercury use to protect human and environmental health. Chapter 4 goes on to critically examine gravity separation and concentration interventions that have been globally implemented in ASGM, to address the shortcomings and challenges faced by artisanal miners. Lastly, Chapter 5 combines the findings

from all the research activities and develops a post-formalization framework aimed at achieving a sustainable formalization and highlighting the needs of formalized miners. The investigation of the status, as well as the successes and shortcomings of formalization policy and the role that NGOs and certification programs play in advancing formalization by incentivizing responsible mining practices, will contribute to the post-formalization framework developed in the final research activity that considers the processes, actors, and programs that should be included in a sustainable formalization program.

CHAPTER 2

FORMALIZATION IS JUST THE BEGINNING: ANALYZING POST-FORMALIZATION SUCCESSES AND CHALLENGES IN PERU'S SMALL-SCALE GOLD MINING SECTOR

An article published in the Journal Resources Policy[1]

Gerardo Martinez[2,3], Nicole Smith[3,4], and Aaron Malone[3]

2.1 Abstract

In recent years, the formalization of artisanal and small-scale gold mining (ASGM) activities has become a key strategy for governments to better govern and regulate the sector. While scholars have focused on examining the viability of formalization itself, little is known about the outcomes once ASGM operations become formal, or whether formalization efforts are sustainable. Peru has made great strides on simplifying the formalization process and has formalized over 9,000 artisanal miners; this article uses a case study of a formalized ASGM operation to analyze post-formalization outcomes. Drawing on findings from interviews with government officials and members of the ASGM community in one of the most important ASGM regions of Peru, Puno, we highlight how formalization has yielded mixed results. Formal ASGM operations have made clear improvements in health and safety practices, labor conditions, and environmental awareness. However, we found that formal miners are implementing these changes through their own initiatives, without state support that had been promised. We conclude that in order for formalization to be more fruitful for governments and miners, governments working on formalizing ASGM activities would greatly benefit from the creation of a solid post-formalization strategy focused solely on supporting formal ASGM operations.

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2.2 Introduction

In recent years, the lucrative nature of artisanal and small-scale gold mining (ASGM) has attracted millions of people from rural and developing communities who are seeking economic opportunities. This has caused widespread expansion in ASGM operations globally. It is estimated that ASGM is a livelihood for about 16 million people in over 70 countries, who are responsible for between 12-15% of the world's total annual gold production (Seccatore et al., 2014; UNEP, 2017). Despite this rapid expansion, the majority of ASGM activities continue to take place in the informal sector.

There is an emerging consensus that ASGM formalization must be designed to protect and improve livelihoods and address the environmental impacts and social problems associated with the sector (Siegel and Veiga, 2009). Donor pressure (e.g., World Bank and United Nations) to prioritize the ASGM sector in development strategies (Fold et al., 2014; Hilson and Maconachie, 2017), governments' recognition of the potential economic benefits from ASGM activities, and increasing global attention to ASGM's environmental and social impacts have resulted in efforts to draft and enforce legislation focused on ASGM formalization (Verbrugge and Besmanos, 2016; Hilson and Maconachie, 2017).

Unfortunately, formalization poses significant challenges for governments and artisanal small-scale gold miners alike, with estimates that 70-80% of the sector continues to operate informally (IGF, 2017). The complexity of the sector, including the differences between operations, mining districts, and mining communities (Fisher, 2007; Verbrugge, 2014; Verbrugge and Besmanos, 2016) and a general lack of government enforcement capacity have contributed to the relative lack of success of government led formalization efforts. Furthermore, legislation aimed at ASGM formalization has often been designed with large-scale, mechanized, foreign-financed operations as a model while neglecting the current practices and needs of artisanal and small-scale gold miners (Hilson and McQuilken, 2014). Complicated procedures and fluctuating policies and guidelines also make formalization difficult for miners. Often, artisanal and small-scale miners are discouraged from initiating the process of becoming formalized, as the challenges are perceived to outweigh the benefits (Salo et al., 2016; Veiga and Marshall, 2019).

With most research focusing on formalization itself, however, little is known about the outcomes once ASGM operations become formal, or whether formalization efforts are sustainable. Despite the emerging consensus that formalization is the pathway to "fix" the ASGM sector, to our knowledge there are no studies that focus on formalized ASGM operations. Therefore, this study explores an underexamined sub-set of the ASGM sector: formalized ASGM operations. Here we draw on research we conducted in one of the most important ASGM regions of Peru, Puno, which boasts the largest number of formalized miners in the country.

Through an analysis of perspectives on formalization garnered from government officials and members of the ASGM community, we demonstrate that formalization has yielded mixed results. On one hand, there have been improvements in health, safety, and labor organization and practices at formal ASGM operations, as well as increased environmental awareness among miners. Despite these changes, miners who have become formalized feel even more pursued and scrutinized than they did when they operated informally, and they continue to face challenges obtaining technical support and accessing capital. We conclude that although some strides have been made in formalization efforts, the problems and weaknesses within the approach may inadvertently push miners back into informality. A deeper understanding of the formalization process and its outcomes can yield important insights for governments and international organizations as they refine and tailor policies, regulations, and donor projects aimed at supporting miners in becoming formalized. Our research also underscores the fundamental importance of developing robust post-formalizations frameworks and plans to support miners in maintaining their formal status and fully realizing the purported benefits of formalization.

2.3 ASGM Formalization

Governments and policymakers often see formalization as a method to better govern and regulate the ASGM sector, which is commonly linked to social and environmental problems such as crime and conflict, child labor, health and safety concerns, deforestation, and mercury pollution (Verbrugge and Besmanos, 2016; Hilson and Maconchie, 2017). Governments have often struggled with formalization, and often blame miners for its failures without considering their own capacity to enforce legislation or the problems inherent to the legislation itself (Van Bockstael, 2014). The majority of ASGM operations are located in remote areas with very little governmental presence, making enforcement a difficult task (Hilson, 2002; Hilson and Vieira,

2007). Furthermore, often formalization initiatives are not well suited to the ASGM sector and require informal and small-scale operators to comply with the same regulations as large-scale, mechanized, foreign-financed operations (Hilson and McQuilken, 2014).

Environmental concerns are a central focus of most discussions about ASGM formalization. Artisanal and small-scale gold mining is currently the largest source of mercury emissions into the environment, releasing over 2000 tonnes of mercury per year, approximately 35% of the global total (UNEP, 2020). Mercury pollution and other environmental problems stem from the ASGM sector's use of rudimentary mining and processing technologies, low levels of occupational health and safety practices, as well as the lack of long-term planning and control (Hinton et al., 2003; Fritz et al., 2018). Stakeholders also often vilify the ASGM sector due to its susceptibility to social conflict and human rights and labor violations (World Gold Council, 2017). In addition, public perceptions of the sector are shaped by unfavorable media coverage focusing on the negative human and environmental health impacts (e.g., New York Times, 2019a; New York Times, 2019b). In broad strokes then, the ASGM sector is marginalized and criminalized due to its informality and human and environmental problems, with most artisanal and small-scale miners lumped into the category of "illegal gold miners."

The process to become formal relies heavily on mineral tenure and property rights (Siegel and Veiga, 2009). Because the majority of artisanal miners do not possess mineral rights or land titles, and the regulatory processes and policies tend to be rigid and inflexible, securing a license and operating in the formal sphere is exceedingly challenging (Hilson, 2020a). These and other bottlenecks keep miners from becoming formalized (Fold et al., 2014). In addition, some have argued that formal titles and mineral tenure rights do not necessarily guarantee successful formalization (Bromley, 2009; Verbrugge and Besmanos, 2016).

Examples of failed, incomplete, or even counter-productive formalization efforts abound. In Zimbabwe, Spiegel (2009a) found that government initiatives and policy frameworks to manage the ASGM sector have proved counterproductive, as illegal activities have increased and artisanal miners have continued to rely on shadow economies. In other countries, like Sierra Leone (Maconachie and Hilson, 2011a, 2011b) and the Democratic Republic of Congo (Geenen and Radley, 2014), researchers observed that artisanal miners had limited incentives to comply with existing legislation, as the state was unable to provide them with tangible benefits in return.

In Colombia, over a 15-year span (1993-2008), government efforts to formalize ASGM operations proved to be unsuccessful as only 23 mines of the total 3,631 applications were able to formalize – less than 1% (Veiga et al., 2014). In Bolivia, Salman et al. (2015) found that government agencies were aware of their limited capacity to monitor and enforce policy compliance. Researchers have concluded that, regardless of location, formalization of the ASGM sector is a difficult task, especially if there is a lack of political will (Hilson et al., 2019).

Globally, examples of successful ASGM formalization are rare. This is in part due to the fact that most of the efforts to formalize and support ASGM have focused on technical and financial aspects, with a strong emphasis on controlling activities rather than proactively engaging ASGM stakeholders (Hilson et al., 2019). Researchers have also highlighted that without proper education and training, formalization initiatives are not sustainable and do not translate to better practices (Veiga and Marshall, 2019).

2.3.1 ASGM Formalization in Peru – "Illegal" versus "informal"

Peru is Latin America's top gold producer and the eighth largest gold producer globally (USGS, 2020). Artisanal and small-scale gold mining is responsible for up to 20% of the total gold production in the country (planetGOLD, 2020). The exact number of artisanal and small-scale gold miners in Peru is not well-established, but estimates range from 100,000-500,000 miners (De Echave, 2016). Despite considerable efforts to formalize the sector, the majority of ASGM activities in Peru continue to operate informally.

Prior to 2002, artisanal and small-scale miners were not legally recognized in Peru, and the country's mining laws and regulations were designed to facilitate large-scale mining and multinational investments in the country (Hinton, 2005). The government treated ASGM as a nuisance to be eliminated, including using military force against miners (Damonte, 2016; Salo et al., 2016; Toledo Orozco and Veiga, 2018). However, in 2002, Peru passed the Law of Formalization and Promotion of Small-Scale Mining and Artisanal Mining (Law 27651) which introduced a legal framework for formalizing ASGM. One of the principle goals of the law was to facilitate the formalization of miners, but it was mostly ineffective. In addition, despite finally recognizing artisanal and small-scale miners, the law did not define the difference between illegal and legal ASGM mining, creating tensions because eradication of *illegal* gold mining remained a central focus (Damonte, 2016; 2018).

In 2012, the government passed Legislative Decree 1100, which regulated interdictions of illegal mining and outlined the actions (e.g., confiscation/destruction of supplies and machinery) that could be taken by the Peruvian government throughout the entire republic. Legislative Decree 1099 approved interdiction actions that could be taken against illegal mining specifically in the department of Puno. During this period there were numerous military interdictions to destroy ASGM operations and camps and discourage the proliferation of the activity (Washington Post, 2014; New York Times, 2016). That same year, Legislative Decree 1105 was passed to define and differentiate between *informal* and *illegal* gold mining. According to this decree, illegal mining refers to activities that are conducted without complying with the laws and regulations (permits or titles) or in zones where mining activities are prohibited (rivers or protected areas). Informal mining are those activities that take place in areas that are legally allocated for mining activities, and where miners are in the process of obtaining the legal titles and permits and complying with the standards to become formalized.

From 2002 until 2016, only 112 artisanal and small-scale gold miners became formalized, just 0.2% of the 72,959 applicants who enrolled in the formalization process. A major cause of this failure was the requirement, at that time, for artisanal and small-scale miners to comply with the same requirements as large-scale mining companies. Due to the little progress that was made, a new decree (Legislative Decree 1293) was passed in 2016 that declared the formalization of ASGM as a national interest and created an "exceptional" procedure aimed at advancing formalization efforts. In contrast to previous formalization processes in which miners had to complete each step before moving on to the next (Legislative Decree 1105) and were not allowed to conduct any mining activities until they completed all the steps, the exceptional procedure allowed miners to complete the mandatory steps, in any order, while they continued operating. This new decree also decentralized the formalization process and gave regional governments the authority to lead the formalization process in their respective territories.

In order to become formalized under the current Peruvian regulations (Decree 1105), artisanal and small-scale gold miners must complete five mandatory steps: (1) obtain a mining concession title or come to an agreement with title owner; (2) gain access to the land or land title; (3) have an approved Environmental Impact Assessment (EIA); (4) declare the absence of archaeological remains; and (5) prepare a technical mine plan. In return for achieving these steps

and becoming formalized, the government has promised miners professional support to help them improve their operations (Law 27651, passed in 2002). Despite the simplification of the process, formalization for artisanal and small-scale gold miners continues to be challenging, especially for the majority of miners who lack the titles to mining concessions. This creates a bottleneck in the formalization process (Arista, 2017). No less, this simplified process has led to the highest number of formalized artisanal and small-scale miners in Peruvian history. Today, out of 88,736 applicants, 9,647 (11%) are formalized. After years of failure, this first hint of successful formalization makes it even more important to diversify research on formalized ASGM operations to understand ways in which formalization policies and regulations can be more effective.

2.4 Methodology

This research draws on fieldwork conducted over a 14-month period from July 2018 to September 2019. We collected data through in-depth semi-structured interviews, focus group discussions, and participant observation with community members, a formal small-scale mining company's employees and *socios* (associates who invest as shareholders in the cooperative), and government officials. We individually interviewed thirty people, including twenty-two cooperative employees or socios and eight government officials. Of the cooperative representatives, twenty were men and two women, holding various positions at the mines including miners, supervisors, accountants, lawyers, engineers, consultants, warehouse keepers, board of directors members, and security guards. In these interviews, to understand the impacts of formalization, we asked both open- and closed-ended questions about peoples' perspectives on formalization, what if any changes they had observed as a result of formalization, and the challenges they continued to face despite formalization. We conducted three initial focus groups with coop representatives to identify topics to explore in more depth during the individual interviews. In this article we have anonymized the cooperative we worked with, as well as the research participants, apart from indicating whether he or she was a member of the mining community or a government official.

2.5 The Site – from alpaca herders to gold miners

This study examines a formal ASGM operation in the Andean highland region of Puno, in southeastern Peru, bordering Bolivia (Figure 2.1). Puno is a key site because almost a third

(2,893) of the 9,647 artisanal and small-scale miners who have become officially formalized are located in this region. Although an examination of the potential reasons for these relatively high rates of formalization lie outside of the scope of this paper, there has been very little research to date on the characteristics and outcomes of ASGM formalization efforts in this region. Most studies on ASGM formalization in Peru have been limited to the Amazonian regions (i.e., Madre de Dios) (Damonte, 2016; Salo et al., 2016; Damonte, 2018), leaving out some of the most important ASGM zones in the country. According to the Ministry of Energy and Mines (MINEM), Puno produces more ASGM gold than any other region of Peru (MINEM, 2019). Mining is a significant economic driver in Puno, and from January 2018-June 2019, it represented 98.5% of the region's exports (MINCETUR, 2019).

This study took place in the province of San Antonia de Putina, in the town of Ananea, one of the most important mining towns in the region. Located at 4,800 meters above sea level, Ananea, nationally known as *La Ciudad Dorada* (The Golden City), has very distinct attributes that set it apart from other mining towns, including thousands of hectares allocated for mineral extraction and approximately 30 formalized mining *cooperativas*, some of which export certified gold to international markets. Despite the high altitude and extremely cold temperatures, much of the landscape has been excavated and stripped by miners working in large open-pit operations to extract gold from alluvial deposits.

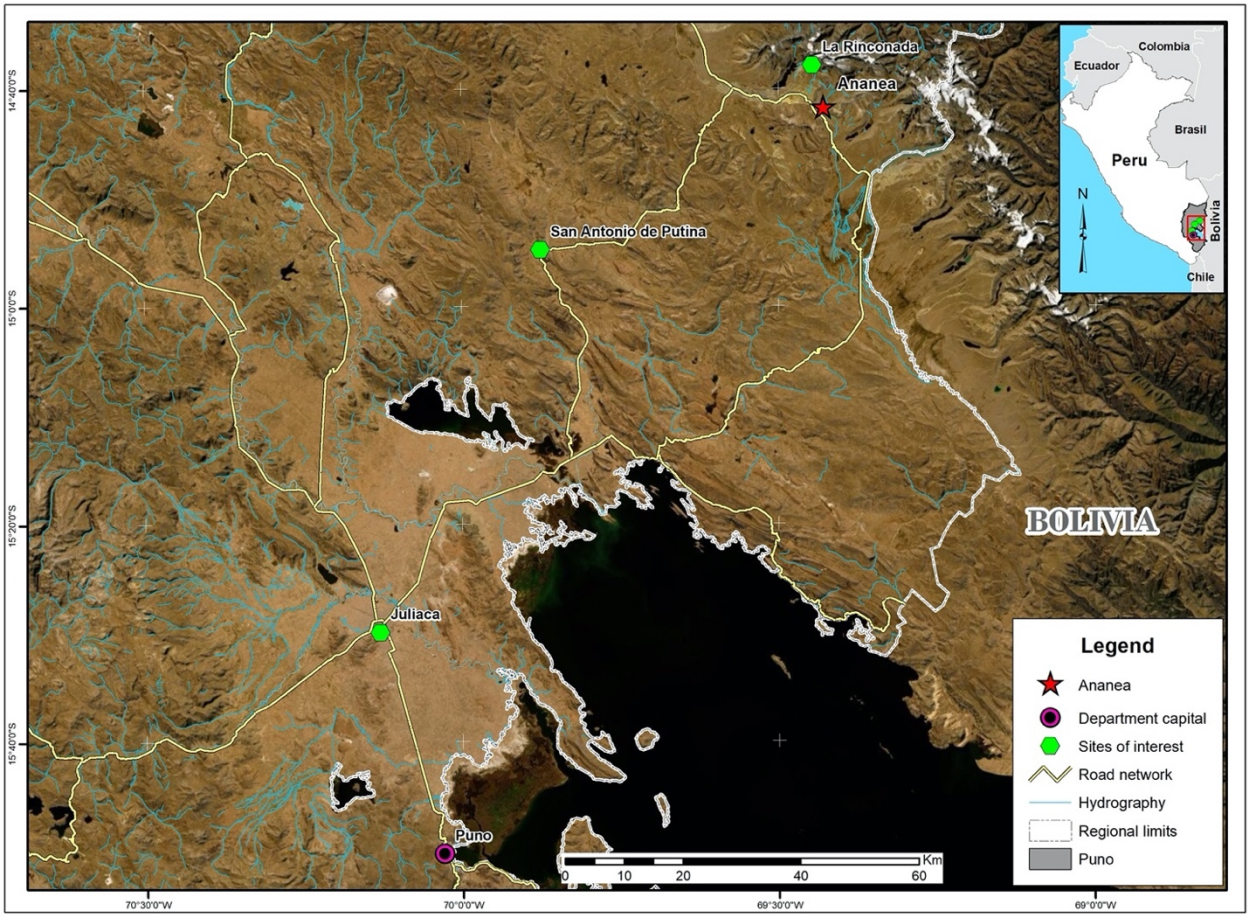

Figure 2.1: Map of the study region. Sites of interest are shown in the hexagons (green). Ananea is shown with a star (red). Artisanal and small-scale gold mining operations take place in Ananea and La Rinconada. The nearest city to these sites is Juliaca, which is a 5-hour car ride away.

Ananea has a long history of gold mining that has shaped the organizational structure that exists today. From 1924-1937, a Peruvian mining company operated in the principal area of Pampa Blanca (or White Plains). After a 23-year pause, in 1960, Natomas Company, a North American based corporation began working the area using dredges and abandoned its operations in 1972 due to threats of expropriation. At that time, the state-owned company Minero Peru, took over the mining titles of over 30,000 hectares with the intent to develop a large-scale mine. However, according to Minero Peru's reports, a late 1980s feasibility study determined that the mine was not economically justified to continue operating (Minero Peru, 1996). In 1992, Minero Peru began promoting privatization of the auriferous concessions in Ananea by holding two international public auctions, but they were not able to attract any investors (Minero Peru, 1996).

When Minero Peru took over in 1972, small areas of their concession were being mined artisanally by individuals and families from Ananea. However, the very first reports of artisanal mining in Ananea date back to 1878 by Italian geographer Antonio Raimondi (Raimondi, 1878). In Ananea, community members relied on mining during months with high precipitation (November-April), and they relied on alpaca herding, the traditional livelihood in this region, during the dry months (May-October). However, with the growing presence of larger scale mining companies in the 1960s and 1970s, the community realized the economic potential of mining in this area, and many people sold their alpacas to invest in mining activities, while others relocated their alpacas in order to mine the land.

Several interviewees stated that Minero Peru served as an example of how a formal, legal mining company worked and operated in their zone, and that they assimilated some of its processes and procedures. While they recognized the importance of organizing and working together, they ultimately saw that being formal allowed Minero Peru to continue to operate, while informal operations were subject to government interdictions. In 2013 in Ananea, national police and military raided, confiscated, and destroyed mining equipment and materials (Bnamericas, 2013). Community members confirmed that many of them were without jobs for months.

During interviews, we were also told that many young men left Ananea in the 1970s to pursue educational opportunities in urban areas such as Arequipa and Lima. In these cities, they were given greater exposure to the cooperative business model used in sectors, such as agriculture, transportation, housing, and the closest comparison to them—alpaca husbandry. The cooperative business model is built upon solidarity in which members voluntarily come together to reach shared economic, social, and cultural goals. Decisions are made democratically, and each member has one vote; the goal is to equitably distribute costs and profits among all members. At the time, alpaca cooperatives existed in Ananea, but when these men returned to Ananea in the 1980s, they proposed starting a mining cooperative to unite miners from the region. Community members explained that it took a significant amount of time and effort to convince people to form mining cooperatives, as miners had always worked individually and for themselves.

In the early 1980s, the community of Ananea formed the very first mining cooperative, *Cooperativa Santiago*, composed of 130 socios. *Cooperativa Santiago* paved the way for other cooperatives to form in the region—with their own visions, missions, values, and organizational structures. Eventually, all of these cooperatives created an umbrella organization called Mining Cooperatives of San Antonio de Ananea that is comprised of ten cooperatives. With this unifying organization, in the early 1990s, members traveled to Lima during public land auctions to advocate for the rights to obtain the titles to the mining concessions on which they had been working. Minero Peru's reports from the time highlighted that the community prohibited visits from Minero Peru's personnel in areas that artisanal miners occupied and blocked their ability to conduct any studies in neighboring zones (Minero Peru, 1996).

To avoid further conflicts with the community and after failing to find an international investor to purchase the concessions, in 1993, Minero Peru and the Mining Cooperatives of San Antonio de Ananea signed a contract transferring two large concessions (Maria and San Antonio de Poto) to the community. After returning to Ananea with the concession rights, the community divided them into 24 smaller concessions that were auctioned off to the cooperatives. Today, there are over 30 mining cooperatives in the region, of which 17 are formalized, the rest are in the process of becoming formalized (REINFO, 2020).

2.6 Results

2.6.1 Improvements in Health, Safety, and Labor

Globally, the ASGM sector is generally associated with injuries and hazards due to a lack of health and safety practices and procedures (Hinton et al., 2003; Calys-Tagoe et al., 2015; Smith et al., 2016; Calys-Tagoe et al., 2017). However, the mining operations in the Ananea mining district present an alternative image. Here, the large open pit operations resemble medium to large-scale operations with security gates at each operation's entrance (Figure 2.2). During site visits, we observed miners being fed breakfast, lunch, and dinner in the dining hall. Similar to formal large-scale mining operations, at the beginning of every shift miners checked in at the security gate with their required personal protective equipment (PPE), while unauthorized visitors were turned away. Upon entering formal ASGM operations, visitors are met with signage that continues throughout the entire site and dozens of excavators, front loaders, and dump trucks. Security guards patrol the grounds, while supervisors inspect the

operations to make sure workers are following proper protocols and the machinery and processes are running correctly.

Miners in Ananea stated that prior to formalization, health and safety were not prioritized, PPE was not required, accidents were more prevalent, and it was common for miners to work long hours, resulting in fatigue and other health issues, as well as accidents. In interviews with miners, the second most frequently mentioned benefit (91%) from formalization was improvements in health and safety (Figure 2.3). Now, wearing PPE has become a norm. As one miner shared, “workers don’t second guess wearing PPE anymore, it is a daily habit, just like waking up and brushing your teeth.” Some government officials (50%) also acknowledged that formalization had improved health and safety practices and reduced accidents and fatalities.

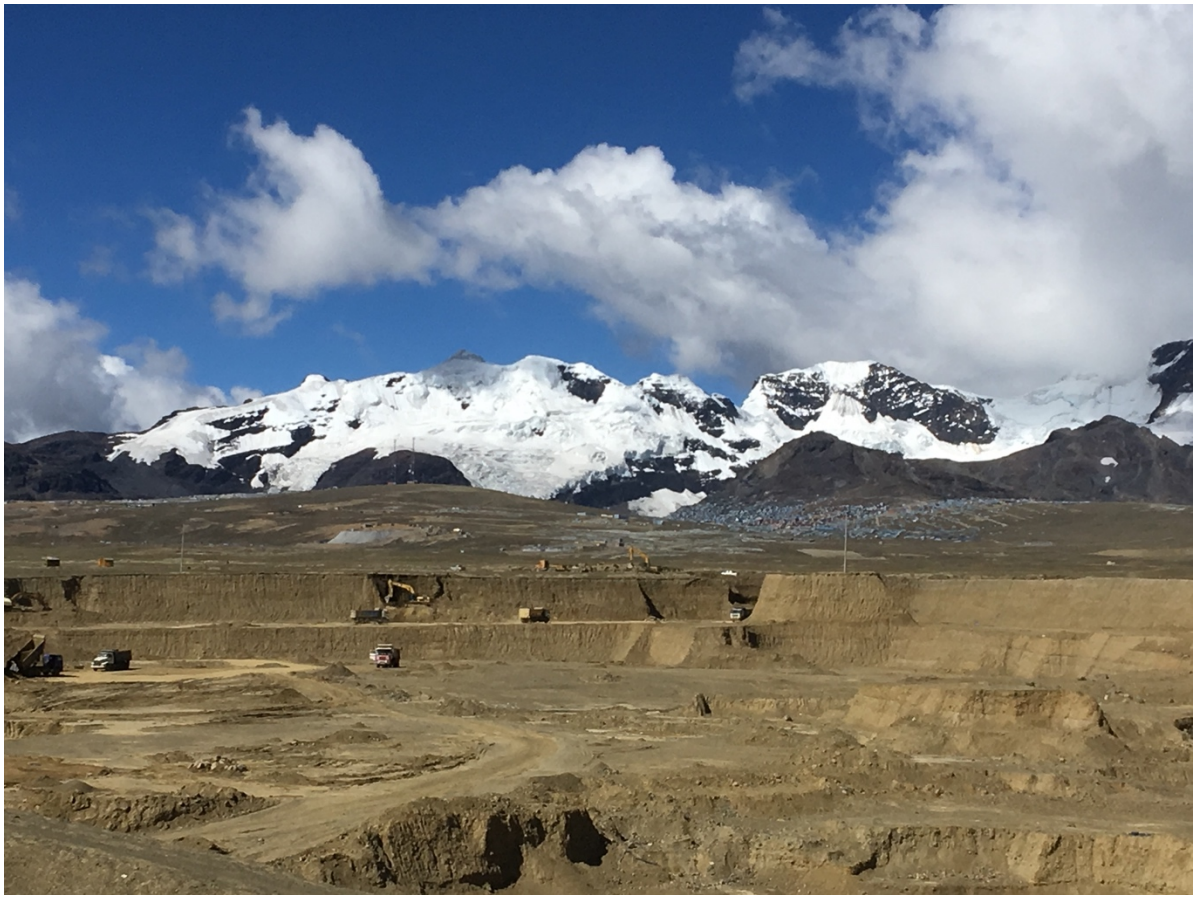

Figure 2.2: Photo of one of the open pit mines in Ananea with excavators and haul trucks in the distance.

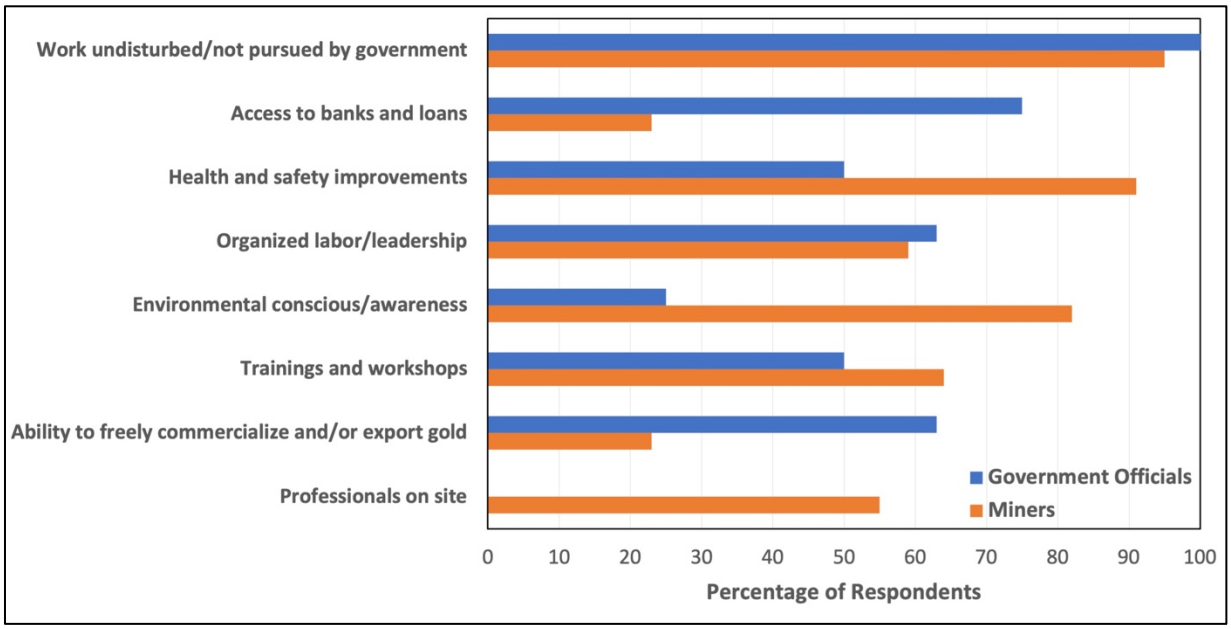

Figure 2.3: Responses of miners (orange) and government officials (blue), when asked "What are the benefits of formalization?"

Miners reflected that before formalization they worked *"totalmente artesanalmente"* or totally artisanally, with simple tools such as shovels, pickaxes, and wheelbarrows. They lacked heavy machinery, a mine plan, PPE, supervision, or professional input and claimed that they worked long, strenuous hours. One miner stated, "Before formalization we would work in groups in a filthy manner (*a lo cochino*) without any organization or planning, every group on their own. And we would work as many hours as we could." Another miner added, "There were more accidents because the bench was not controlled, the roads were not maintained, there was not any type of prevention. We all worked with whatever came out." Overall, there were not any health and safety measures in place to protect miners from accidents, injuries, or hazards, thus making miners more susceptible to risks on the job.

Miners also shared that prior to formalization they worked all day to produce a single concentrate which was then processed with mercury to recover the gold and sold weekly. They were generally paid once a week when the gold was sold and their pay was based on the amount sold. The more hours they worked, the more ore they could process daily, which in turn would lead to more gold recovered and higher pay. One miner, who currently holds a position in the municipal government, added that miners would leave for work before sunrise, sometimes without eating breakfast, and work in groups with their families or friends. This miner added that

even after they organized into cooperatives, but had yet to become formalized, the goal was to work as many hours a day as their "bodies and water sources permitted", sometimes working 16+ hour shifts.

Now miners in Ananea are compensated for their work regardless of the grade of the material or the amount of gold produced. They generally work two, four-hour shifts, in which two concentrates are produced and processed daily. Gold is recovered from these concentrates; however, ASGM organizations save all the gold they recover each day and sell it in bulk monthly. Employees are on the cooperative's payroll and have set work schedules, working 15 days followed by 15 days off, and all of them receive benefits through the cooperative, including insurance and paid time off.

Miners commonly stated that the incorporation of professionals was a catalyst for implementing better health, safety, and labor practices at the mine site. One miner stated, "At first, everyone was accustomed to informality and doing things however they wanted. . .But when the engineers are providing trainings and showing you examples of what can go wrong, then you listen to their explanation on how to avoid accidents and do things correctly." They made it clear that they hired professionals to work for the mine only because they needed their expertise to guide them through the process of formalization and fulfill the requirements. All miners, except one (21/22, 95%), responded that they had never received technical assistance from the government. But the formalization guidelines gave them the impression that the government would provide formal ASGM operations with technical support to improve production, environmental protection, and health and safety. A past president of a cooperative from 2012-2016, stated:

> Never, never, we have never received technical assistance. On the contrary, on behalf of the state we have received interventions and inspections with sanctions. We have never received any technical assistance, orientations, or trainings from the government, absolutely nothing. That is false. If there had been [support], we would have improved a long time ago. However, all this time we have had to sustain ourselves on our own projects.

The government's failure to invest in ASGM formalization and support for formal cooperatives belies the idea that the government is truly supportive of the sector and its growth.

Miners emphasized that they did not expect to receive money from the government, but they did expect to receive technical support to help them improve their operations.

The government officials interviewed confirmed the miners' sentiments and highlighted that the government's assistance has been focused on helping artisanal and small-scale miners fill out their EIA forms and Technical File in order to become formal. Furthermore, government officials pointed to a lack of field capacity. One official lamented, "there are miners working in zones of Peru that God does not even know about," demonstrating the magnitude of the sector and the lack of governmental presence. In fact, there are currently just ten state engineers assigned to provide technical assistance across seven regions (Arequipa, Ayacucho, Apurimac, Cusco, La Libertad, Madre de Dios, and Puno). This means that in Puno, one engineer is responsible to provide assistance to 6,646 miners who are in the process of formalization. The practical result, as noted, is that no substantive technical assistance is available, even to formalized or formalizing miners.

In contrast to the lack of state assistance, the cooperatives in Ananea have independently begun incorporating professionals such as engineers, accountants, supervisors, nurses, and security guards, allowing them to work in a safer and more organized manner. Some examples include: (1) optimizing haul truck usage to maximize production; (2) installing railings around all of the sluices to prevent slipping or falling; and (3) documenting the entire production process to improve traceability. In addition to a Board of Directors and Administrative Council, each cooperative now has an Occupational Health and Safety Committee. Aside from building capacity, the professionals at these cooperatives help bring legitimacy to ASGM operations with their focus on monitoring, supervising, improving operations, and reviewing and reporting data to the government.

2.6.2 Environmental Awareness

In Peru, formalization was intended to address environmental concerns related to ASGM activities, and government officials often referred to the EIA as a "tool" to hold miners accountable for implementing better environmental practices. The miners we interviewed overwhelmingly (100%) voiced that they were more environmentally aware now than prior to becoming formal, and the majority (82%) linked this awareness to the EIAs they were required to conduct as part of formalization. The EIA is composed of two parts, corrective and preventive.

In the corrective section, miners must identify the corrective measures they are going to take to mitigate the environmental impacts that have already been caused in their mining concession. The preventive section outlines the measures they will take to minimize any negative environmental impacts that occur in areas of their concession where they plan to mine in the future. The preventive section must be designed by an environmental engineer or an environmental scientist with prior experience in environmental management. Government officials base their annual inspections on the approved plan and give miners 40 days to rectify any issues. If they fail to comply, they are fined, and the government can revoke their formal status.

Some miners stated that prior to formalization, ASGM operations released tailings, turbid waters, fuel/oil spills, and waste directly into the streams and onto the land. They stressed that they were working to comply with the formalization requirements and take care of the environment. For example, at this cooperative, they were no longer releasing tailings into the environment, they had built tailings ponds, and they were researching best practice examples of how to treat tailings. Some cooperatives had constructed settling ponds where suspended solids in wastewater from mineral processing were allowed to settle, and the water was then recirculated and reused.

Formal cooperatives are required to report on water use and quality and collect water samples three times per year from the catchment point (lagoon) and the point of recirculation (at the cooperative) and send them to an accredited lab for analyses of a variety of physicochemical water quality (e.g., pH, temperature, dissolved oxygen, nitrates) and inorganic (e.g., arsenic, copper, mercury, lead, zinc) parameters. Cooperatives had also implemented flowmeters to measure the daily volume of water being pumped into their operations, as they are required to abide by monthly maximum limits according to water permits. Regional water authorities then analyzed the data to ensure that the mining operations remain in compliance.

Water quality monitoring has provided important data for the engineers working at the cooperative, as well as for the Regional Water Authority. Cooperative representatives never failed to highlight that the engineers they hired were spearheading the tasks of following the formalization requirements, especially those related to the environment. One miner stated, “Before we didn’t have a single professional. Today we have engineers and other professionals

that show us how to take care of the environment." Cooperative engineers provided monthly trainings and workshops to educate workers on environmental and health and safety issues. Miners stated that these workshops taught them about water management techniques, waste management, recycling, and the environmental risks from using mercury. The addition of new environmental management practices demonstrates that the process of formalization has raised miners' environmental awareness. This type of awareness, knowledge, and the ability to act is something that did not exist prior to formalization.

2.6.3 Making ASGM Legible

As discussed earlier, over the last eighteen years, the Peruvian government has created new policies aimed at the ASGM sector. However, only over the last decade has the focus shifted from obstructing ASGM activities to moving them into a more legitimate, formalized space. For government and regulatory agencies, formalization appears to represent a way to benefit from, as well as surveil the sector.

The 2002 Law of Formalization and Promotion of Small-Scale Mining and Artisanal Mining outlined the potential benefits of formalization for miners (Law 27651, Legislative Decree 1336), which included the ability to (1) freely commercialize and export gold; (2) operate in a secure, continuous, and peaceful manner; (3) receive technical support from government entities, (4) receive economic benefits, such as loans and financing; (5) avoid criminal proceedings for money laundering; and (6) access legal markets for production/mining supplies. Echoing number two in the list above, all of the government officials interviewed agreed that the most important benefit of formalization was that miners could "*trabajar tranquilamente"* or work undisturbed and not be pursued by government (Figure 2.3).

Miners (95%) overwhelmingly agreed with the government officials' responses. This response was often followed by the explanation that the ability to work peacefully and undisturbed allowed them to have a consistent income and operate in a secure, continuous manner without fearing that their machinery and equipment would be confiscated or destroyed. Various respondents recalled the government interdiction in 2012, when miners were left unemployed after their sluices were destroyed and they were not permitted to "move a single rock."

However, working undisturbed did not necessarily translate to working unnoticed. Most government officials emphasized that formalization allowed government institutions such as MINEM, the Ministry of Environment (MINAM), and the Peruvian Customs and Tax Administration (SUNAT) to exert more regulatory oversight and control of the sector, as well as gain a better understanding of the sector so future policies and regulations could be more applicable to miner's actual practices. Although this indicates that the government is working to align policy with reality, it also suggests that making ASGM *legible* allows the government to gain more control of the sector. Anthropologist James Scott (1998, p.78) argues that "an illegible state is a hindrance to any intervention," whether the intervention is welcomed (i.e., technical support) or resented (i.e., taxation). As one government official stated, "You can't improve, what you can't measure. If you don't know who it is, how many there are, and where they are, it is very difficult to design a solution for the problem." Government officials also believed that formalizing miners would allow for better traceability of gold and finances, provide MINAM with the capacity to regulate chemicals, such as mercury and cyanide, and allow SUNAT to collect taxes from the ASGM sector.

The current situation has left miners conflicted. While they generally felt that formalization allowed them to work peacefully, they also felt that formalization allowed for more government and regulatory scrutiny of their operations. One miner stated, "We are now under the government's microscope and they are waiting for us to fail or make a mistake so they can fine us, sanction us, or shut down our operations." Miners expressed that formalization provided the state with information on where and how they were operating. This coupled with the formalization requirements, including complying with environmental and labor laws and regulations, reporting gold production, providing receipts for every purchase, and filling out lengthy paperwork to commercialize and export their gold, as well as the risk of getting robbed while transporting their gold to legal markets made, in one miner's words, "going back to informality inviting".

Government officials also acknowledged the shortcomings of formalization. When we asked a government official about formalized miners feeling "under a microscope", he stated, "That is true. Instead of one feeling protected by the state to do mining activities, you feel more, we can say, pursued because you have to fulfill a series of obligations. Simply because of a lack

of knowledge, you are going to end up failing and having to pay fines or really high sanctions." This government official not only echoes some of the miners' sentiments, but he also indicates the importance of guidance, training, and assistance for newly formalized artisanal and small-scale miners.

In short, the government has not fulfilled the promise of providing support to formalized miners, as was outlined in the formalization policy of 2002. Miners shared that one reason why they became formal was so that they would not be considered "*contaminadores*" (contaminators) or "*ilegales*" (illegals), but after becoming formal they felt more pursued than miners who were not taking any steps to formalize or improve their methods. One miner stated, "All artisanal and small-scale miners, whether formal or informal, are all seen as informal miners. Government only shows our errors and accidents but does not help us fix them." This problem, in part, may be rooted in the institutional culture of the government. After many years of oppositional relationships, it appears that government officials have not changed their mindsets to work *with* artisanal and small-scale miners. Rather, they continue to see ASGM as a problem, which affects how miners are treated and portrayed. A previous government official highlighted this point:

> One key topic is the absence of a national policy that addresses and supports the ASGM sector…In general, I would say since 2012, if you look at it in only terms of budget, the emphasis has been put a lot more on the topic of interdictions against illegal gold mining than the topic of formalization. On average, the budget for ASGM formalization is 14-15 million soles (US$ 3.9-4.1 million) per year, and the illegal gold mining (interdiction) budget has gotten to 60-80 million soles (US$ 16.5-22.0 million). That's 4 times the budget that formalization receives.

As the quote indicates, cultural change within the government has been an impediment to achieving the benefits of formalization. Oppositional perspectives continue to dominate while sufficient funds are not allocated to fulfil the promises of technical support.

In addition, although formalization makes ASGM more legible to the state in some respects, there remain large gaps in understanding. For example, access to bank loans was cited by the majority (75%) of government officials to be a significant benefit for formalized miners. Although some miners (23%) stated that formalized operations were able to access bank loans and freely commercialize and export their gold, many shared that when they attempted to open a

bank account and obtain a loan, the banks denied their requests on the grounds that they did not want to get involved with the ASGM sector. During interviews with government officials, after they stated that miners could have access to banks and loans, we raised the common complaint from miners that they had not been able to secure loans from banks. All of the government officials agreed that this was the case and that they were aware that obtaining bank loans was not really possible for ASGM operators. This highlights the disparities between the perceived benefits that the government assumes miners are able to capitalize on and the actual benefits that artisanal and small-scale miners are truly receiving from formalization. This type of misunderstanding and misalignment between the state and the ASGM sector inhibits the success of formalization efforts.

Government officials also believed that miners were reluctant to spend time and money to become formal when the incentives and benefits were not experienced immediately. An ex-government official illustrated this sentiment:

> [In the long term]. . .they will be able to request loans or acquire chemicals and machinery in a formal manner because they will be working in a formal supply chain. That in a sense will be cheaper, and you are not going to have to resort to the black market. The government also indicates that miners will be able to receive technical support to switch to clean technologies. But if you notice, all of it is in the long term, there is nothing immediate besides having a formal, decent job and operating peacefully without being pursued.

With the majority of benefits coming to fruition for ASGM operators after only several years of reporting all production and costs, paying taxes, legally commercializing their gold, and complying with environmental regulations, the lack of significant short-term gains contributes to a general reluctance among miners to become formalized, as well as a lack of perceived benefits once they do become formal.

2.7 Conclusion

The results from this study highlight that formalization has had mixed results in one of the most important mining regions of Peru. There were clear improvements in health and safety practices, labor conditions, and environmental awareness. However, some of the purported benefits of formalization failed to materialize, most notably the absence of promised technical

support, and in addition, formalized miners felt burdened by new responsibilities and increased scrutiny from the state.

Although, formalization laws in the country promise technical support to miners, in Puno, this has not been the case. Both government officials and miners emphasized that there is a lack of initial and ongoing support for miners. What technical and environmental improvements have been seen instead result from ASGM miners' own initiatives to hire engineers and improve practices, without state support. Furthermore, even when miners invest the time, effort, and money to become formalized, they still perceive the government to be against them. Progress on formalization has not been enough to shift the government's attitude away from interdiction and towards supporting the ASGM sector. As a result, instead of formal artisanal miners feeling more protected, accompanied, and supported by the state, they feel more persecuted and scrutinized.

Even in what could be considered an optimal case of formalization in Peru, in which miners were able to organize into cooperatives, obtain legal titles to the concessions and mining rights, and become formal, we saw that persistent challenges may push them back, either partially or completely, toward the informal sector. Many more ASGM operations in Peru face larger obstacles, including the inability to obtain legal titles to concessions and mining rights. For these ASGM miners who struggle even more to become formalized, the realization at the end of the formalization process that government is not upholding its promises of support and instead still views them as a problem is likely to provoke even greater disillusionment and resentment. This presents a substantial risk for formalization, as both miners and government officials acknowledge that regressing to informal status might be seen as an inviting possibility.

Although Peru has made great strides to simplify the formalization process, it appears that the government's primary goal is to simply formalize the greatest number of artisanal miners possible. Reflecting the tendency to oversimplification that Scott critiques as part of the push for legibility, success is measured by the number of formalized miners and not the improvements that have been made in formal ASGM operations. In order to make formalization more fruitful for miners and government officials, it cannot simply be seen as a strategy to make ASGM more 'legible.' There needs to be an approach that takes miners' perspectives and needs into account, and that views formalization as a step within a holistic improvement process, rather than an end unto itself. If miners are not supported to remain formal and comply with legal requirements

without being sanctioned and fined, there is a high probability that they will revert back to informality, especially considering that most benefits are delayed rather than immediate.

Moving forward, governments working on formalizing ASGM activities would greatly benefit from the creation of a solid post-formalization strategy with allocated budgets and personnel focused solely on supporting formal ASGM operations. By truly prioritizing formal ASGM operations and providing technical support, this can serve as an incentive for miners to become formal and implement changes to retain their formal status. Formalization should not stop after artisanal miners receive a paper acknowledging their legal status. On the contrary, that is where the work to transform artisanal miners to responsible miners begins. Artisanal miners who have committed to becoming formal and operating in the legal sphere should be rewarded with support to enhance their operations and practices, not penalized by a bureaucracy unable to shed its oppositional mindset, unwilling to uphold its end of the bargain, or not committed to tailoring policies and incentives to the realities of ASGM.

2.8 Acknowledgements

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CHAPTER 3

VOLUNTARY GOLD CERTIFICATION PROGRAMS: A VIABLE MECHANISM FOR IMPROVING ARTISANAL AND SMALL-SCALE MINING IN PERU?

An article published in the Journal of Rural Studies[5]

Gerardo Martinez[6,7], Nicole Smith[7,8], and Marcello Veiga[9]

3.1 Abstract

Globally, artisanal and small-scale gold mining (ASGM) provides a livelihood for approximately 20 million people directly and millions more indirectly. Despite its economic contributions and job creation for rural communities, the sector continues to be overlooked in local, regional, and national sustainable development plans. Voluntary gold certification programs, created and administered by international NGOs, have emerged as one response to tackle the social and environmental issues associated with the ASGM sector. Although voluntary gold certifications are gaining more traction, their impacts remain unclear. Focusing on Peru, the country with the greatest number of certified artisanal and small-scale gold mining organizations (ASMOs), this paper examines the practical impacts when certification is achieved and identifies the shortcomings. Based on interviews with gold certification staff members and members of certified ASMOs, as well as site visits to certified mining operations, we demonstrate that gold certification programs are driving ASMOs to implement better environmental management and health and safety practices. Certified ASMOs are also benefitting from the economic incentives of selling gold internationally, and they are investing the premiums they receive from certifications into projects that benefit their workers and the mining town. Still, the reach of certification programs remains limited, with only a fraction of miners working for certified ASMOs. This article concludes that although gold certification programs have the potential to improve environmental protection and contribute to rural development, there are challenges that

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will have to be overcome for small-scale mining organizations to achieve and maintain certification status.

3.2 Introduction

Artisanal and small-scale gold mining (ASGM), generally characterized by low-tech, labor-intensive mineral extraction and processing, provides rural populations a source of income and significantly contributes to regional and national economic growth. It involves over 20 million people directly and millions more indirectly and takes place in over 70 countries producing almost 600 tonnes/a of gold (Heymann, 2020; Yoshimura et al., 2021). This accounts for approximately 20% of the global annual gold production (World Gold Council, 2022), but in some cases such as in Colombia in South America, the ASGM sector is responsible for more than 80% of the country's annual gold production (Veiga and Marshall, 2019).

Despite the ASGM sector providing a livelihood for millions of people in rural communities, the social and environmental issues associated with the sector overshadow its economic importance. ASGM is the largest source of global mercury pollution, with an estimated 2000 tonnes of mercury lost to the environment per year (UNEP, 2019). It can also contribute to deforestation (Caballero Espejo et al., 2018) and involve child labor, money laundering, and other illicit activities (Hinton, 2006; Hilson, 2010a). Furthermore, gender inequalities (Arthur-Holmes, 2021), adverse impacts on human health (Tschakert and Singha, 2007), and conflicts with owners of mineral titles (Verbrugge, 2017; Veiga and Fadina, 2020) are also fairly common among the sector. These associated social and environmental problems have raised global concern and called more attention to the need for improved governance and regulation of the sector to improve rural livelihoods and minimize environmental impacts.

Formalizing ASGM is often cited as the first step toward developing the sector (Siegel and Veiga, 2009; Maconachie and Hilson, 2011b; Hilson and Maconachie, 2020a), as the largely informal nature of the sector often precludes its inclusion in local, regional, or national sustainable development plans (Hilson, 2021; Maconachie and Conteh, 2021). However, most formalization efforts have largely targeted the legalization of ASGM activities, by focusing on making ASGM legible so governments can surveil and collect taxes from the sector, rather than building capacity and training miners—necessary components of effective formalization (Veiga

and Fadina, 2020; Martinez et al., 2021a). Without capacity building and training, governments cannot expect that miners will adopt safe and environmentally responsible practices (Marshall and Veiga, 2017).

Research in sub-Saharan Africa has highlighted that legal frameworks aimed at ASGM have not been aligned with the needs and realities of the sector and have failed to provide adequate support (Hilson et al, 2014; Hilson and Maconachie, 2020b). Therefore, formalization efforts have been inadvertently inhibited, and informality has in fact been perpetuated. Policymakers and donor agencies tend to view the sector as "homogenous" and "static" (Hilson, 2010b: p. 297), leading to oversimplifications and the failure to recognize the ASGM sector as a "platform of wealth creation" (Verbrugge, 2016, p. 109; Hilson and Hu, 2022, p. 94). Additionally, because formalization policies generally overlook the concept of mineral depletion and exhaustion, technical support to determine the extent of mineral reserves has not been provided to miners (Ofosu and Sarpong, 2022), bringing the long-term sustainability of formalization into question. Given mineral reserve depletion, a more comprehensive formalization strategy would include providing miners with opportunities and skills to diversify their livelihoods, which is vital to sustaining rural economies (Maconachie and Hilson, 2018; Chigumira, 2018).

Although Peru boasts the greatest number of formalized artisanal and small-scale gold miners in South America, formalization has failed to resolve many of the social and technical issues associated with the sector (Martinez et al., 2021b). Salo et al. (2016) argues that the Peruvian government's purpose in formalizing the sector has been to gain control of ASGM activities, generate public revenue, and implement and enforce social and environmental norms, while failing to provide clear benefits to ASGM operators. Damonte (2016, 2018) adds that the central state lacks the capacity to "read" and govern local society in Madre de Dios, thus leading to inefficient and inadequate policies which exclude miner's realities. Another study from the Peruvian Amazon, (Álvarez-Berríos et al. 2021) concluded that without adequate enforcement and interagency coordination, formalization does not resolve environmental issues, and in some cases may accelerate ecological destruction. In the Andean highlands, Martinez et al. (2021b) concluded that despite formal ASGM operations improving health and safety practices and labor conditions, formal miners felt more pursued and scrutinized than they did when they operated

informally, and they continued to face challenges obtaining technical support and accessing capital.

Given the shortcomings of ASGM formalization efforts, voluntary gold certification programs, created and administered by international NGOs, have emerged as one response to tackle the social and environmental issues associated with the ASGM sector. Unlike state-led formalization efforts which rely primarily on the threat of sanctions, voluntary gold certification programs provide market-based incentives for compliance with environmentally and socially responsible mining practices (Glasbergen, 2013; Childs, 2014b; Sippl, 2015). However, for miners to be able to enroll in certification programs, their operations must first be formalized according to national laws. Although voluntary gold certifications are gaining more traction, their contributions toward improving rural livelihoods and minimizing environmental impacts remain unclear (Fisher, 2018; Sippl, 2020). To date, there has been only one study published which evaluates the impact of the Fairmined certification program on the well-being of participating gold miners in Colombia and Peru (N. Martínez et al., 2021). This study concluded that participation in the Fairmined certification program improved miner's well-being and "might" have improved ASGM operations.

Building on N. Martínez et al.'s (2021) work, this study provides a qualitative analysis of the impact voluntary gold certification programs are having on social development and environmental protection from the perspectives of certified miners and certifying agencies. In this article, we focus on Peru, which has the most certified artisanal and small-scale mining organizations (ASMOs) in the world with three Fairtrade and three Fairmined operations. In particular, we examine the practical effects of the Fairmined gold certification program created and administered by the Alliance for Responsible Mining (ARM) in the Department of Puno. Puno is a suitable setting to examine gold certification programs, as it is home to the very first alluvial ASGM operation in the world to receive the Fairmined certification, and currently all three Fairmined certified ASMOs in Peru are in the region.

This article has multiple objectives centering on the core question of the practical impacts of certification programs. First, we examine to what extent the Fairmined certification program has achieved its objectives of improving rural livelihoods and minimizing environmental impacts

(ARM, 2015). Our key contribution is to move the debate beyond questions of how to achieve certification, to understand the outcomes of certification programs as they are experienced by ASGM operators and to identify the potential shortcomings. We argue that although gold certifications have driven some improvements in ASGM environmental and health and safety practices and have resulted in some contributions to local development, there are other environmental and development aspects that have received less attention raising questions about the longer-term viability of certification programs. Our empirical focus is on Fairmined certified operations in the Puno region of Peru; however, our findings are applicable to gold certifications more broadly, as they provide evidence of some of the ways in which certification programs may be improved to better address the challenges experienced by artisanal and small-scale mining operators.

3.3 Gold Certification Programs and ASGM

Gold certification programs have been proposed as a possible solution to fill the voids of government-led formalization efforts (Veiga and Marshall, 2019) and promote sustainable development in the ASGM sector. Through gold certification programs, miners can participate in NGO-led capacity building projects that promote the use of mercury-free processing technologies, support miners in complying with regulations, and attempt to assemble ethical gold supply chains (Sippl, 2015). To become certified, miners must be part of a formalized ASMO that has legal access to mining rights, and they must adhere to a series of standards pertaining to environmental protection and labor conditions.

Mercury is prioritized in gold certification schemes. Certified ASMOs must not directly emit mercury into the environment, and workers must use personal protective equipment when handling mercury. They are also required to demonstrate that they have in place other health and safety practices and processes and have a workplace that is free from discrimination and child labor. In return, they receive a guaranteed price for their gold, an additional premium, direct access to international markets, and technical support. Certification programs attempt to eliminate middlemen who often provide loans and other supplies (including mercury) to miners in exchange for gold at below market prices, creating a “poverty trap”, as miners become

indebted to them (Micheletti, 2003; Hilson, 2008; Spiegel, 2009b; Hilson, 2012; ARM, 2014; Wilson et al., 2015).

Although certifications hold some promise for promoting more legitimacy and transparency among the ASGM sector, the implementation and inspection of the certification standards are usually costly and difficult to enforce (Veiga and Marshall, 2019). Furthermore, the requirements to become certified are challenging for many ASGM operators, particularly those who are unable to secure licenses and mineral titles because of costly registration fees, complicated bureaucracies, or few available mineral titles (Hilson, 2008; Sippl, 2015; Hilson et al., 2018). This has led to the question of whether certification programs live up to their "pro-poor" narrative (McQuilken, 2016; Hilson et al., 2016, p. 236) and only target the "low-hanging fruit" or medium-scale miners who are well-organized and able to meet the stringent certification standards (Hilson, 2014; Hilson and McQuilken, 2016; Hilson et al., 2016, p. 241; Hilson et al. 2018). The transferability of these programs, particularly to countries of Africa, has also been questioned (Childs, 2008; Childs, 2014a; Hilson, 2008; Hilson et al., 2016). However, little is known as to how and to what extent voluntary gold certification programs can truly contribute to ensuring social development and environmental protection in the ASGM sector.

3.3.1 Brief History of the Fairmined Gold Certification

The Alliance for Responsible Mining (ARM) was created in 2004 with the goal of promoting responsible practices within the ASGM sector. Through the Oro Verde (Green Gold) initiative, aimed at biodiversity conservation in the Chocó Department of Colombia, ARM partnered with the artisanal mining cooperative Oro Verde to support and promote their mercury-free extracting technologies, their efforts at site restoration, and the economic benefits of selling "green gold" experienced by the Afro-Caribbean population (Sippl, 2015). In 2006, ARM developed its first standard, Standard Zero, which created a set of principles of fair-trade practices for small producers and applied them to artisanal and small-scale mining. The targeted areas included health and safety, environmental management, gender, child labor, sustainable livelihoods, governance, formalization, and marketing (Hilson et al., 2018). Through feedback from workshops, and with the input and consultation of miners' organizations and other stakeholders in Latin America, the standard was updated in 2007. In 2009, ARM entered a three-year partnership with Fairtrade International, and together launched the first gold certification

standard in 2011 under the label "Fairtrade and Fairmined Gold" (Childs, 2014b). This standard was modeled after the Fairtrade certification developed for agri-food commodities in the 1970s (e.g., bananas, coffee, tea, and cocoa). In 2013, Fairtrade Gold and Fairmined Gold were publicly released as separate interventions (Hilson and McQuilken, 2016). The stated objective of the Fairmined Gold Standard (2014, p. 4) is to:

> . . . promote the progressive organization and formalization of the ASGM sector, bringing with it improved labor rights, safer working conditions for miners, and strengthened miners' organizations with the capacity to campaign for legislation and public policies that promote their rights and enable a responsible ASGM sector.

The standard emphasizes ASGM formalization, capacity building, and improved working conditions. In Peru, over the last decade the government has attempted to simplify the formalization process for artisanal and small-scale gold miners, and there are now 10,554 formalized artisanal and small-scale gold miners (REINFO, 2022). To become certified, artisanal and small-scale miners must be operating formally and organized into an ASMO.

"An ASMO is a formal organization established for the purpose of conducting or facilitating responsible artisanal and small-scale mining and constituted according to the legal, social, cultural, and organizational reality of the local context. An ASMO has direct (held by the ASMO) or indirect (held by miners of the ASMO) legal or contractual rights and environmental permits to mine." (ARM, 2014, p. 7) [emphasis added]

Without these conditions met, artisanal and small-scale miners are not able to continue the certification process.

Fairmined certification assures that producers receive a guaranteed price, greater than or equal to 95% of the London Bullion Market Association (LBMA) fixing for gold, as well as a premium of US$ 4000 per kilogram of gold. The fixed premium was originally adopted during the creation of the certification and was 10% of the average LBMA gold fixings in December 2013 (~$40,000). Per the Fairmined Standard, ASMOs are required to invest this premium in community development projects through their "premium committee", a group of ASMO representatives that decide where and how to invest these funds (ARM, 2014). Fairmined also offers an additional premium (US$ 2000 per kilogram) to ASMOs that do not use mercury or

cyanide in mineral processing. These ASMOS are certified under the Fairmined Ecological Gold or Eco-Gold standard. For ASMOs to remain certified under either standard, they must undergo annual audits by one of three approved external third-party organizations. Each year, the requirements to renew certification become more stringent to push ASMOs to progressively improve their practices (ARM, 2014).

Currently, there are eight certified ASMOs in the world (five Fairmined and three Fairtrade). However, when examining the uptake over time, Sippl (2020) highlights that from 2013-2019, 19 ASMOs gained and maintained certification, and 7 ASMOs gained certification and then decertified. In Peru, there are three Fairmined certified ASMOs and three Fairtrade certified ASMOs. All the Fairmined certified ASGM operations are located in the Andean region of Puno, in southeastern Peru (Table 3.1), and two of the three certified Fairtrade ASMOs are also located in Puno. The Puno region presents a key region for certification programs, as it leads the entire country in the number of formalized miners (2,899 of 10,554). In this paper, we focus on the Fairmined certification because of its sole focus on gold sourced from the ASGM sector and their greater reach among the ASGM sector. Until 2020, 24 ASMOs in Colombia, Peru, Bolivia, and Mongolia worked with ARM, and 13 ASMOs in Peru, Kenya, and Uganda worked with Fairtrade (N. Martínez et al., 2021).

Table 3.1: Certified ASMOs with their certification date, type of certification obtained, location of their operation, and number of members.

Organization	Department	Number of Members	Certification Type	Certification Date
CECOMIP	Puno	200	- Fairmined - Fairmined Eco Gold	- August 2016 - January 2020
Oro Puno	Puno	20	Fairmined Eco Gold	January 2018
Cruz Pata Chaquiminas	Puno	26	Fairmined	March 2020

According to ARM, between 2011 and 2021, certified ASMOs sold more than 110 tonnes of gold. However, if we consider Heymann's (2020) estimate that the ASGM sector is producing an estimated 600 tonnes/a of gold, then in the last ten years Fairmined gold represents a very small portion (1.8%). Similarly, 246 miners in Peru are members of Fairmined Certified

operations, representing only 0.05-0.25% of the total number of miners in Peru based on De Echave's (2016) estimates of 100,000-500,000 artisanal miners. These numbers indicate that certification programs have an extremely limited reach. No less, N. Martínez et al.'s (2021) study in Colombia and Peru showed that compared to non-certified miners, miners who participated in the Fairmined certification program reported improvements in their well-being in terms of health, lifestyle, and income satisfaction.

3.4 Methods and Data Sources

This study took place in the town of Ananea, located in the Puno region at 4800 m above sea level. It is one of the most important mining districts of Peru and is home to all three Fairmined certified operations. Small-scale miners in Ananea work in large open-pit operations which resemble medium to large-scale operations in which they extract gold from alluvial deposits. The operations consist of dozens of excavators, front-end loaders, and dump trucks used to transport ore to sluice boxes. The ore is then washed down angled surfaces with carpets used to capture gold particles. After obtaining a concentrate every four hours, miners add mercury to obtain a mercury-gold amalgam which is generally burned off in an open-flame releasing mercury into the environment.

To understand the impacts of voluntary gold certification programs and their role in ensuring social development and environmental protection, we visited the three Fairmined certified ASGM operations in the Puno region from July 2018 to September 2021. We collected data on the outcomes of certification, the ways in which certified ASMOs were operating, and any changes that ASMOs had made because of certification. These data were collected through over 100 hours of on-site observations and twenty semi-structured interviews with employees from three certified ASGM operations. These employees held various ranks at the mines as miners, supervisors, accountants, lawyers, engineers, consultants, and security guards. To examine environmental practices, in particular mercury use patterns and trends, we obtained data on daily mercury use from February-December 2019 from one of the certified ASMOs.

To understand the Fairmined certification process and ARM's perspectives on and experiences with this program, we conducted semi-structured interviews with six ARM employees and compiled information from ARM's website and public documents on the number of certified miners, the certification requirements, and the investments ASMOs have made with

the premium received. In addition, we visited the ARM headquarters in Envigado, Colombia to speak with ARM employees and attended various workshops and trainings conducted by ARM employees to better understand the support being provided to certified miners. To compare the profits that certified ASMOs receive from selling their gold to international markets to those that non-certified ASMOs receive from selling their gold locally, we conducted a cost-assessment using international gold market prices as listed in kitco.com, and we obtained the costs associated with certification (e.g., export costs, audit costs, and income tax) from both certifying agencies and certified ASMOs.

3.5 Results and Discussion

During interviews and field research, several themes emerged in terms of the outcomes of certification programs in relation to social development and environmental protection. Respondents from ARM and ASMOs repeatedly referred to the costs and benefits associated with the Fairmined premium, environmental management practices associated with mercury, and community development initiatives undertaken by the ASMOs. The impacts on social development and environmental protection hinge on the economic incentives (e.g., profitability) offered by the premium which allows miners to invest into more responsible mining practices. While we acknowledge that there may be other impacts of certification programs, the ones discussed in this paper surfaced as the most relevant to both ARM staff members and artisanal and small-scale miners. Lastly, we examine some of the factors that arose in the field which may impact the sustainability and long-term success of certification programs.

3.5.1 Social Development

3.5.1.1. Profitability of Certified Operations

Certifying agencies promote the economic benefits of certifications to ASMOs, including direct access to international markets, an additional premium, and the elimination of middlemen While these benefits are enticing for miners, ARM interviewees emphasized that ASMOs must maintain a relatively high and consistent volume of gold production for certification to be economically feasible. Although they were not able to provide an exact amount, our calculations based on real numbers from one of the certified ASMOs showed that an ASMO must produce a minimum of 1.74 kg per month or 20.93 kg per year to benefit from the premium (BOX 3.1,

Example 3.1). Although an ASMO producing less than 1.74 kg of gold per month will receive a fair price based on the LBMA fixing for gold, the money received from the premium will be exhausted covering the annual audit cost, income tax, and export costs (Total Fixed Associated Costs), which amount to US$ 83,700 (see Example 3.2). This excludes many mining organizations from even entering certification programs.

Furthermore, most of the artisanal and small-scale miners in the world are actually 'micro-miners', processing less than 2 tonnes of ore per day and producing 0.1 to 0.5 g of gold per day (Veiga et al., 2014). These miners will not benefit from such programs as they generally produce only 3 to 15 grams of gold per month. It appears that gold certification programs continue to favor more medium-scale miners that can meet the requirements without much difficulty and will profit with or without the certification.[10]

The average gold production among the ASMOs we worked with, was 3 kg per month (36 kg per year). For this, they would receive an Annual Total with Premium of US$ 2.2 million (BOX 3.1, Example 3.2). Formalized miners in the Puno region do not export gold directly, rather they rely on middleman in the local market who purchase their gold at a discounted price, usually 10-15% lower than the international market price. These middlemen then sell to other gold buyers who export the gold once they have obtained a large volume. Along with the premium, according to current gold prices, certified ASMOs selling their gold to international markets can gross 19-26% (US$ 349,719 - 452,578) more than they could by selling to the local market. However, when subtracting the Total Fixed Associated Costs from the Total Premium Received, the Actual Premium Received only accounts for 42% of the total premium (BOX 3.1, Example 3.2). Factoring this new Actual Premium Received into the International Market Price, an ASMO can receive a total of US$ 2.11 million dollars. Thus, selling gold to international markets with the LBMA gold fixing and the actual premium allows ASMOs to receive 14-21% (US$ 266,019 - 368,878) more than selling to the local market. Despite miners losing more than half of the premium (58%) due to Total Fixed Associated Costs, ASMOs are still able to make

[10] In attempt to provide a solution for those excluded operators, in 2020, ARM created the CRAFT Code based on the OECD's Due Diligence Guide to target artisanal miners who were unable to pursue the Fairmined Standard. Unlike the certification program which requires miners to operate formally, obtain legal permits, and participate in annual audits, the CRAFT Code is a self-reporting program rather than a third-party certification program, thus lowering the costs for miners as audits are not necessary. See Sippl (2020) for more information on the CRAFT Code and the differences between certification programs.

more profits selling to international markets, and at the same time reduce some of the risks associated with selling their gold locally, such as being robbed while transporting gold from the mine to the nearest city. Even though certified ASMOs can benefit from a higher profit margin, there are other economic challenges for ASMOs who wish to become certified.

BOX 3.1 – *Example 3.1* calculates the minimum gold production necessary for certification to be economically feasible for ASMOs. *Example 3.2* calculates prices paid to miners based on the international market price[1] and the local market price (10-15% less than the international market price), which includes the premium received by an ASMO producing an average of 3 kg of gold per month. All currency is in USD.

Example 3.1. Minimum gold production required for certification programs to be economically feasible for ASMOs.

Annual Total Premium Received:

Total Premium Received = *X* kg * $4000/kg
Where *X* is the total annual gold produced by the ASMO.

Annual gold production (X) * Total Premium Received = Total Fixed Costs Associated with Certification (see *Example* 2)
X kg * $4000/kg = $ 83,700
X kg = $83,700 / $4000/kg = *20.93 kg gold per year (1.74 kg of gold per month)*

An ASMO must produce more than 1.74 kg gold per month to make certification economically feasible.

Example 3.2. An ASMO produces an average of 3 kg gold per month (=36 kg of gold per year).

Annual Total Received with Premium:

International Market Price: 36 kg * $ 57,144/kg = $ 2,057,184 8751.6
Premium Received: 36 kg * $ 4,000/kg = $ 144,000
Annual Total Received by ASMO with Premium = $ 2,201,184

Annual Total Fixed Costs Associated with Certification:

Audit cost = $ 4,500
Income tax (approximately 30% of the premium) = $ 43,200
Export costs = $ 36,000 for twelve exports ($ 3,000 per export)
Total Costs = $ 83,700

Annual Actual Premium Received:

Total Premium Received – Total Costs = $ 144,000 - $ 83,700 = *$ 60,300* (42% of the total premium is actually received)

Actual Total Received with Premium:

International Market Price: 36 kg * $ 57,144/kg = $ 2,057,184
Annual Actual Premium Received: $ 60,300
Actual Total Received with Premium = $ 2,117,484 (14-21% more than selling to the local market)

Local Market Price Received without Certification (10-15% less):

10% Less than International Market Price: 36 kg * $ 51,430 = *$ 1,851,465*
15% Less than International Market Price: 36 kg * $ 48,572 = *$ 1,748,606*

[1]International market price was obtained from https://www.kitco.com/charts/livegold.html on August 13, 2021.

The Fairmined Standard requires that ASMOs create an improvement plan that outlines how they will meet the standard's terms before their final certification audit. This improvement plan consists of implementing responsible environmental management practices, improving labor conditions, providing basic trainings on health, safety, and mine risks for all employees, purchasing new personal protective equipment and other supplies to enhance mining operations, and fulfilling other requirements such as tracking their purchases and sales. The implementation of the improvement plan can take anywhere from 18-36 months, and on average costs ASMOs US$ 40,000-55,000. After the certification is obtained, there are requirements that ASMOs must meet in subsequent years to remain certified, which cost them on average US$ 15,000 per year. At this point, formal miners producing less than 1.74 kg per month, those without the financial resources to cover the initial investments to become certified, as well as those that are not able to keep up with the investments for annual improvements may resort to selling their gold in the local informal market.

According to ARM staff members, many miners are not convinced of the economic benefits of becoming formalized and view paying taxes as an extra burden. In addition, miners have never had to report and show proof of their costs or production numbers. Certification requires full transparency which is a challenge for miners in rural areas where it is common for suppliers to not provide receipts for goods and services. Although ARM shared that many ASMOs reach out to their organization to pursue gold certification, they stated that many are only able to meet one or a few of the criteria, making it difficult for certifications to have broad-reaching impacts.

Lastly, it is important to highlight that for certification programs to function as theorized, there must be enough jewelers willing to pay the premium price for certified gold. ARM staff said that they have faced periods when certified ASMOs were producing more gold than jewelers were willing to purchase. Without a guaranteed buyer of certified gold, ASMOs may revert to

selling their gold back to informal markets. Another situation which was observed during the onset of the COVID-19 pandemic was that certified ASMOs were unable to export due to very high export costs (reaching up to US$ 10,000 per export). Despite being certified, ASMOs may not fully realize the economic benefits and can lose out on the higher profits from the international price, as well as the premium.

3.5.1.2. Reinvesting into Rural Livelihoods

A key component of the Fairmined certification program is that certified ASMOs must contribute to social and economic development in the area. In Puno, certified ASMOs are comprised of cooperatives with shareholders and workers who are natives to the community or neighboring towns, thus the people benefiting from certification programs are direct members of the community. One miner shared, “For every kilo we export, we receive a premium of US$ 4000; this fund is allocated for the needs of the workers, the community, and our organization. We assumed the challenge of social responsibility and sustainability over time with the development of our communities because we want to give our collaborators the level of life they deserve.” This miner highlights how important the community is for the miners, and he also emphasizes how the premium has allowed them to give back to their workers and community.

Certified ASMOs in this region have invested the premium in projects to improve their operations. One upgraded their dining facilities and installed a solar water heater so workers would have hot showers. Others invested in cleaner technologies (e.g., gravity concentrators) and personal protective equipment for miners. Certified ASMOs have also invested in projects for the community. For example, one ASMO purchased and installed a mesh screen above the elementary school playground to protect the children from the sun and another provided office furniture to the local community. Every Christmas, certified organizations donate books and gifts to local students.

Despite these efforts, the overall development in the local town of Ananea (population estimate: 32,285) remains minimal (INEI, 2015). There is no hospital and there are no doctors, the town lacks a water treatment plant, and there are teacher shortages. The town has several hotels, restaurants, hardware stores, machinery repair shops, and mechanics that serve the mining industry and its workers. Many of the miners who work at Fairmined certified operations grew-up in Ananea or neighboring communities but have purchased homes in larger cities far from

there in Juliaca (150 km) and Arequipa (256 km), citing better educational and economic opportunities for their families as the reasons why. It appears that miners themselves are investing outside of the local and in many cases, their native community. One miner stated, "I don't want my kid to be a miner, I want my kid to be a mining engineer." Although some miners are investing in their children's education which can signal a positive step toward sustainable development, the lack of miners' local investments indicate that development in the mining town of Ananea is limited.

Adding to this situation is that cooperatives in Puno are no longer accepting new shareholders. Thus, there a few people who are directly benefitting from the Fairmined certification. In Puno, there are only a total of 246 workers from three different organizations directly benefitting from the improvements at mine sites. Targeting specific groups to obtain certification and excluding impoverished, unlicensed miners carries the risk of elite capture (Hilson, 2008; Haan and Geenen, 2016). If certification programs truly aim to improving the livelihoods of miners by impacting economic growth and reducing poverty and inequality, then they will need to be more effective at capturing the majority of workers who truly need the support.

3.5.2 Environmental Protection

Both ARM and ASMOs highlighted that the most significant changes driven by certification programs were improved environmental management practices. A past president of a certified ASMO stated,

> The Fairmined certification allowed us to become aware of caring for the environment and carry out mining tasks with a responsible approach. To keep our certification and premium, each year we must comply with new environmental management requirements. This allowed us to optimize our resources, become more conscious of environmental protection, and in turn eliminate the use of mercury completely in the [recovery] process.

Throughout the certification process, miners are taught about the importance of environmental protection and are incentivized for implementing better environmental management practices. Because the certification is aligned with the Minamata Convention on

Mercury, it specifically targets mercury and puts in place a process to support ASMOs to progressively minimize its use.

The Environmental Protection section of the standard, Section 2.1 (Management of Toxic Substances) is solely dedicated to progressively reducing mercury use and eliminating cyanide leaching of amalgamated tailings with new requirements at years 0, 3, 6 and 9. However, other topics such as tailings management and water quality management are very briefly mentioned, and air quality is completely omitted. ARM staff members agreed that this was a shortcoming of the certification program and stated that their goal was to expand the focus to encompass other environmental issues. They expressed concern, however, that if the environmental standards were too stringent then this could decrease the number of miners able to pursue certification.

3.5.2.1. Minimizing and Eliminating Mercury Use

ASMOs certified under Fairmined are allowed to use mercury as their preferred gold recovery method, but they must demonstrate that they are capturing the vapors using retorts. Eco-gold certified ASMOs do not use any chemicals (mercury and/or cyanide) in mineral processing. During site visits in 2018, there was only one operation in Puno that was Eco-Gold certified and one that was Fairmined certified and was using a retort to capture mercury during their amalgamation burning process. Even so, from February-October (2019), this Fairmined certified ASMO used a total of 34,178 g of mercury, recovered 24,359 g (71%), and released over a quarter (29%; 9,819 g) of it into the environment (e.g., tailings, atmosphere), amounting to an average of 608 grams of mercury lost during recovery per month (Figure 3.1).

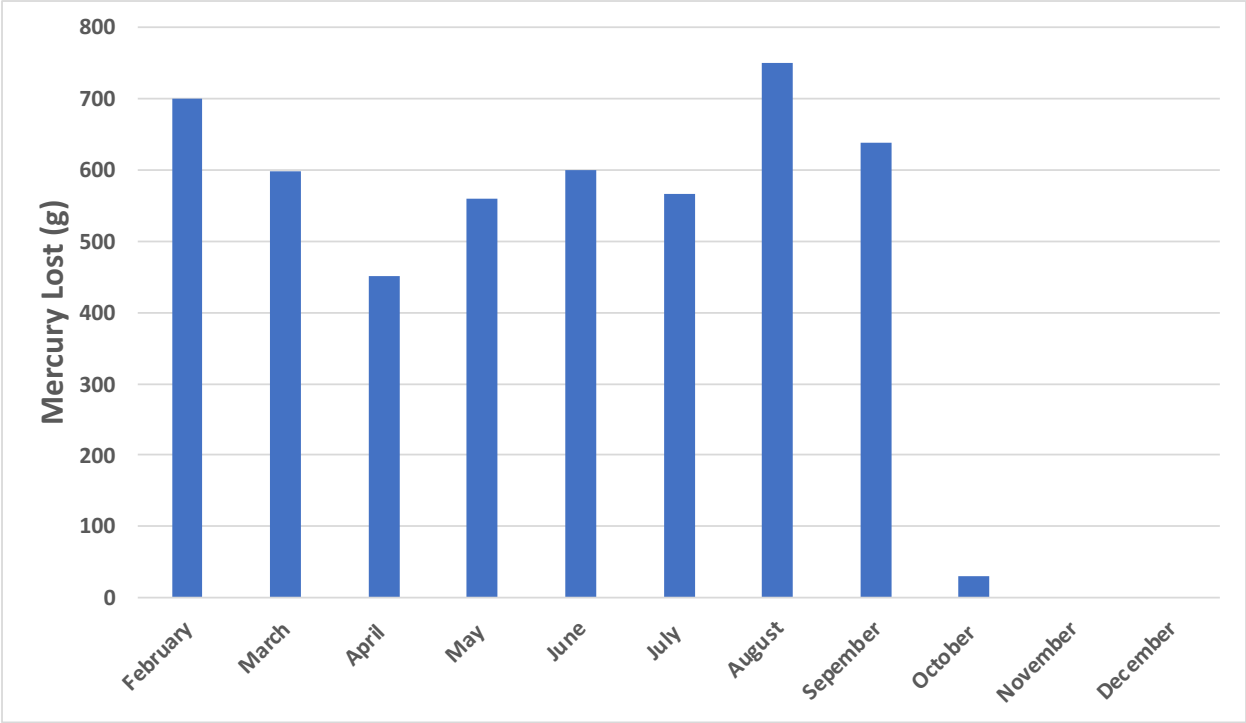

Figure 3.1: Total mercury lost in grams per month from February-December 2019 by a certified ASMO. In October 2019, gravity methods were introduced to replace mercury amalgamation.

By the end of 2019, this operation eliminated mercury from their gold recovery process. They implemented a shaking table to further concentrate their pre-concentrate obtained from the sluices and then directly smelted with borax to extract the gold from the concentrate (Figure 3.2). In 2020, four years after becoming certified, the ASMO passed the Eco-Gold audits and became the second ASMO in the Puno region and all of Peru to obtain the Eco-Gold certification. Miners from this ASMO highlighted that the two most important reasons why they chose to become Eco-Gold certified were to receive a higher premium and to eliminate negative impacts to human health and the environment. Given that this ASMO is the second largest in the Ananea mining district in Puno, this elimination of mercury is significant. But it is important to note that these methods are not universal. The shaking tables worked efficiently at this site because most of the gold was liberated (Veiga and Gunson, 2020), and the borax was effective because of the high grade of gold in the concentrate. The same would not necessarily be true for a primary rock or other type of ore, such as a colluvial ore.

Figure 3.2: In September 2019, one Fairmined cooperative implemented a shaking table to further concentrate their pre-concentrates obtained from the sluices and remove the use of mercury. After a small high-grade gold concentrate is obtained, the cooperative uses borax to recover gold.

ASMO representatives agreed that better environmental management and chemical control and handling were positive aspects of becoming certified, but they advocated for equal emphasis to be placed on providing them with support on how to improve their gold recovery. They were aware that gravity recovery methods were not the most efficient because they were able to recover more gold when they reprocessed their tailings. There was a consensus that they needed more technical support to avoid having to reprocess their tailings multiple times and advocated for information and training on improved recovery methods to be included as part of certification programs. The miners' sentiments also raised the question of whether the complete elimination of chemicals (e.g., mercury and cyanide) is truly a viable option for all types of artisanal and small-scale miners (e.g., alluvial versus hard rock).

3.5.3 Looking to the Future

Despite some of the positive contributions that certification programs are having on improving miner's livelihoods and minimizing environmental impacts, there is future uncertainty. Of the three certified ASMOs included in this study, one of them is currently the longest certified organization globally, in year six of Fairmined's ten-year plan. The other two

certified ASMOs are in years two and four. Currently, the Fairmined Standard does not have any additional requirements past year nine for certified ASMOs. However, ARM staff members shared that the goal is for these certified ASMOs to grow as organizations and perhaps pursue a different certification for medium to large-scale operations (e.g., Responsible Jewelry Council). To date, only one ASMO (Minera SOTRAMI S.A.) was able to move from the Fairmined certification to the more stringent Responsible Jewelry Council certification.

One challenge that remains for ASMOs is the lack of geological data on the viability of the ore deposits. Miners echoed this uncertainty by estimating that the life of mine would last anywhere from 5-30 years, but in general they were optimistic. One miner stated, "Ooooo this mine is going to outlive me. I'm going to be gone and my kid's kids will still be working here. This mine isn't going anywhere." The priority for miners and certifying agencies is to maintain or increase annual gold production and continue operating, exporting their gold, and receiving a premium. Yet, as reserves are depleted, annual gold production will inevitably decrease, raising questions of whether the costs of maintaining certification outweigh the benefits. Certifying organizations, as well as government could play a role in eliminating some of this uncertainty by supporting miners in obtaining geological data

A further challenge is that there must be consumer and market demand for "responsible" gold and a relatively stable or increasing international price of gold. If demand and the price of gold decrease, ASMOs may abandon their operations with even greater environmental and human health impacts. In the Puno region, as miners operate in large open-pit mines, abandoning mine sites has major implications for future livelihoods as this ecologically degraded land will take decades to regenerate. In addition, heavy metals present in abandoned tailings also present long-term ecological and human health risks for downstream communities and future generations.

The abandonment of mines is another pressing long-term issue, along with mine closure and remediation. As mentioned, all the certified ASMOs in operation have been certified for under six years, but there are several ASMOs who have lost their certification (Sippl, 2020). Therefore, the question of whether and how certified ASMO will successfully close their mine operations and remediate environmental issues remains unanswered. The Fairmined Standard does not include any specific guidance or detailed information on mine closure or remediation,

rather the only requirements are that impacted areas must be rehabilitated through topographic restoration (year 3) and must be revegetated as appropriate for the ecosystem or intended uses (ARM, 2014). To our knowledge there does not exist an ASGM operation that has successfully undergone mine closure and remediation. If certification programs are truly targeting long-term social development and environmental protection, there must be a stronger emphasis on mine closure for the future generations.

Some of the recommendations to improve miner's practices as well as the sustainability of gold certification programs, require more government support and greater NGO capacity. ARM staff members reflected on this and described how issues such as mine closure and remediation have often been sidelined by governments and funding agencies who have primarily focused their attention on mercury. They discussed how they have tried to increase their capacity by intentionally focusing their work in two regions (Arequipa and Puno) that together, account for almost half of the formalized artisanal miners in Peru (44%) (REINFO, 2022). They stated that they prefer to work in regions where they can provide capacity-building workshops and technical assistance to multiple ASMOs at once and refer to these locations with multiple certified ASMOs as "clusters". They also highlighted that non-certified ASMOs are more likely to trust their organization if they have a positive track-record of working in the area, and they are also more likely to pursue certification if they see certified ASMOs benefitting.

3.6 Conclusion

The complexity and variety of challenges associated with ASGM preclude simple solutions. Formalization alone does not resolve all the social and environmental issues associated with the ASGM sector, and NGOs and certification programs are providing miners with incentives and capacity-building opportunities to implement responsible mining practices. In some ways, certifications are proving profitable to ASMOs, driving safer and more responsible environmental practices, safeguarding human health and safety, and making contributions to local communities. Certifications also legitimize artisanal and small-scale mining activities to international stakeholders.

Gold certification programs have the potential to positively enhance ASGM formalization efforts by contributing to social development and minimizing environmental impacts. For ASMOs that have become certified, retained their certification, and continued to produce a

constant volume of gold, the economic incentives have proven to be greater than selling to middlemen in the local market for suboptimal prices. These economic returns have allowed ASMOs to invest in improving their mining operations and provide their workers with decent jobs and consistent pay. However, as we demonstrate, miners must have constant, reliable gold production for the price of gold and the premium to outweigh the export and audit costs and taxes. Because of this, the uptake of gold certification programs is quite low and continues to exclude the majority of miners who are unable to meet the entry requirements. Ultimately, if the requirements were less strict and a greater percentage of miners were able to become certified, the success of certification programs is still not guaranteed because there must be consumer and market demand for "responsible" gold. If too many organizations become certified and there are not enough consumers and market demand, it could lead certified miners to rely more on informal markets.

Although gold certification programs are driving ASMOs to implement better environmental management practices, such as the reduction and elimination of mercury, this does not necessarily increase gold production. All conventional mining companies in the world use cyanide because the gold recovery is far higher than the use of gravity and direct smelting. Future research must determine whether eliminating chemicals entirely is the best course of action for artisanal and small-scale gold miners.

Certified ASMOs have invested the premium into development projects that benefit their workers and the local mining town of Ananea. Perhaps the most valuable investments include improving working conditions at the mine site and investing in cleaner technologies, but it appears that ASMOs' investments in community development resemble philanthropic donations that rarely lead to longer term social development. As miners' profits are generally invested elsewhere and cooperatives in Puno are closed to new shareholders, the risk of elite capture may undermine sustainable development efforts in Ananea.

Ultimately, certified ASMOs are benefitting from certification program's capacity building initiatives and the economic incentives that allow miners to improve their practices and livelihoods. However, the reach of certification programs remains limited. This year, ARM plans to publish the third version of the Fairmined Standard, with new updates for certified and non-certified ASMOs. Future research should examine how these new updates will impact all

ASMOs. Lastly, governments and civil society organizations should strongly consider providing artisanal and small-scale miners with permanent technical and economic assistance for the entire mine life cycle to improve rural livelihoods and environmental protection, specifically mine closure and remediation to prevent miners from abandoning mine sites and leaving environmental and human health liabilities for future generations.

3.7 Acknowledgements

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CHAPTER 4

THE MYTH OF GRAVITY CONCENTRATION TO ELIMINATE MERCURY USE IN ARTISANAL GOLD MINING

An article published in the Journal of Extractives Industries and Society[11]

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4.1 Abstract

Artisanal and small-scale gold mining (ASGM) continues to expand rapidly due to the increasing global price of gold and the economic impacts of Covid-19. This expansion of ASGM has raised concerns about mercury use and increased the number of projects designed to reduce or eliminate the use of mercury in ASGM in many developing countries. Unfortunately, to date, these projects focusing on substituting mercury with gravity separation or concentration have been relatively unsuccessful due to a lack of continuous support, guidance, and capital. Through a critical examination of the gravity separation and concentration interventions that have been globally implemented in ASGM, the shortcomings and challenges for artisanal miners are addressed. This article highlights how gravity concentration can reduce the amount of material to be amalgamated or treated thermally or chemically to extract gold from concentrates. However, it also acknowledges that this process has the potential to eliminate the use of mercury in very rare, specific cases. Ultimately, this article concludes that gravity concentration is not the final solution to eliminate mercury use in artisanal gold mining, but it can drastically reduce the use of mercury and its release into the environment.

4.2 Introduction

The number of artisanal gold miners is increasing exponentially in many developing countries due to the recent increase of gold prices from around US$1500/oz in March 2020 to more than US$1800/oz in December 2020 (Kitco, 2020). The COVID-19 pandemic, which eliminated millions of jobs, alongside this substantial increase in gold prices, has caused more

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individuals around the world to search and mine for gold in an artisanal manner (Calvimontes et al., 2020; Laing, 2020; Hilson et al., 2021a). The dramatic impact to the global economy, in particular to small businesses, has inspired new gold rushes and increased the number of artisanal and small-scale gold miners to over 20 million people (Heyman, 2020). Worldwide, half of the estimated 43 million artisanal miners (IGF, 2017) are directly involved in artisanal and small-scale gold mining (ASGM). Estimates suggest that gold production from the ASGM sector has increased from 450 tonnes/a (Seccatore et al., 2014) to almost 600 tonnes/a (Heyman, 2020). Considering the price of gold in December 2020, approximately US$60 per gram, the gold produced by the ASGM sector is worth an estimated US$36 billion. Consequently, the amount of mercury emitted and released into the environment is increasing proportionally, reaching levels as high as 2000 tonnes/a (UNEP, 2020, ArtisanalMining.org, 2018).

Despite the ASGM sector providing direct employment to millions of people, ASGM continues to be overlooked in regional economic and development plans for rural, developing communities. The vast majority of ASGM activities operate informally and without licensure, thus leading the economic importance of the sector to go overlooked (Hilson et al., 2018; Hilson, 2020a). Studies have highlighted that ASGM fosters a socio-economic differentiation, leading miners to either invest their revenues into improving their mining activities, investing into agricultural activities, or diversifying their livelihoods (Brugger and Zanetti, 2020; Libassi, 2020, Ofosu et al., 2020). There is an emerging consensus that formalization of the ASGM sector would require enhancements beyond technical improvements and land allocation (Marshall and Veiga, 2017). In addition, the complex governmental regulations from countries impacted by artisanal mining are not facilitating the assimilation of this group of unprivileged miners into the formal mining sector (Hilson and Maconachie, 2017; Hilson et al., 2017; Hilson, 2020a).

Despite the large number of technical, social, economic and legal problems related to ASGM, mercury pollution is still the most prevailing issue discussed by researchers, authorities, and sponsoring agencies. The number of initiatives designed to eliminate the use of mercury in ASGM is increasing in many developing countries. The Global Environmental Facility (GEF), through its PlanetGold (2020) initiative, has dedicated efforts to improve the lives of ASGM communities in nine countries (Burkina Faso, Colombia, Ecuador, Guyana, Indonesia, Kenya, Mongolia, Peru, and Philippines). From 2014 to 2018, the GEF invested US$141 million on

projects aimed at "*reducing over 600 metric tons of mercury per year from key sectors including ASGM and the production of vinyl chloride monomer"* and providing *"support to 110 countries to conduct Minamata Initial Assessments and to 32 countries to conduct ASGM National Action Plans*" (GEF, 2020). Following the guidelines of the *Minamata Convention on Mercury*, a global treaty created to reduce global emissions of mercury, the GEF's projects intended to encourage elimination of whole ore amalgamation and open burning of amalgam or processed amalgam in residential areas. These measures have been well-designed to reduce the use of mercury but not necessarily eliminate it. For the period of 2018-2022, the GEF increased the funding of projects to US$206 million, expecting to remove 1,163 tonnes of mercury from the market. In spite of the GEF's well-intended actions, mercury has not been reduced by this magnitude in ASGM operations, as many of the projects are still in their infancy.

By analyzing a large number of projects implemented in the last 40 years by different agencies to eliminate mercury use in artisanal mining, the following main reasons for inefficiency can be listed:

- Projects do not consult stakeholders to understand the challenges and successes of previous projects; consequently, they frequently repeat the same mistakes (Miserendino et al., 2013; Smits et al., 2020).
- Projects are usually short-term and do not have continuity; artisanal miners are not provided with long-term, permanent technical assistance (Zolnikov and Ortiz, 2018; Smith, 2019).
- Projects are designed without proper consultation of the needs, motivations (to keep mining), and aptitudes of the artisanal miners to learn "new" techniques (Stocklin-Weinberg et al., 2019).
- The majority of the projects have been focused on assessing environmental and health impacts of mercury with less focus on identifying solutions to reduce or eliminate it (Hinton et al., 2003; Hilson, 2006; Hilson et al., 2007).
- Large amounts of funds were dedicated to convincing governments to change their complex legislations instead of facilitating formalization of artisanal miners (Hilson and Banchirigah, 2009; Marshall and Veiga, 2018; Holley et al., 2020; Hilson, 2020b).

- Few interventionists have sufficient knowledge about the mineralogy of the ores to suggest technical solutions and they believe that one gold recovery process is applicable for all types of ores (Veiga et al., 2014b).
- There is a widespread perception that gravity concentration can eliminate the use of mercury in all types of ores (Vieira, 2006; Appel and Na-Oy, 2011; Esdaile and Chalker, 2018; USEPA, 2018).
- Many projects have focused on demonstrating gravity concentration methods to micro-miners, those processing fewer than 2 tonnes of ore per day. However, they are not the main mercury polluters (Veiga et al., 2014a).
- Techniques to completely eliminate amalgamation and transform artisanal miners into small, responsible miners often require significant amounts of capital (Veiga et al., 2018).

As a result, the attempts to reduce or eliminate mercury in ASGM operations worldwide have not reached any significant outcome, as has been witnessed in the field in many countries. Processing centers, usually the main mercury polluters (Veiga et al., 2014a), are typically neither approached nor interested in collaborating with mercury-reduction projects. For these rudimentary processing centers, the less gold they recover for their clients (i.e., artisanal miners) by amalgamation, the more profits they make. Artisanal miners leave their rich amalgamation tailings as a form of payment for utilizing the processing centers. The owners of the processing centers then process these tailings with cyanide to extract the gold not trapped by mercury. This gold typically constitutes more than 70 percent of the gold in the ore. In this process, mercury-cyanide complexes are formed in the final waste stream and dumped into local drainage areas (Esdaile and Chalker, 2018). These complexes are very toxic, as they accumulate in the kidneys of the aquatic biota (Marshall et al., 2020)

Following the adoption of the *Minamata Convention*, many countries introduced laws prohibiting the use of mercury in ASGM. However, artisanal miners continued to secretly use mercury. In some cases, artisanal miners have been observed burning amalgams in their homes. The official imports and exports of mercury by countries are currently not correctly reported in the UN COMTRADE (2020), a UN database. In 2018, Colombia and Peru, countries with hundreds of thousands of artisanal gold miners, only reported imports of 2 tonnes and 34 kg of

mercury, respectively. Rather than the *Minamata Convention* eliminating the trade of mercury among countries, it has reduced the transparency of mercury trading, which predominantly benefits mercury smugglers. Subsequently, mercury prices in the field increased with middlemen controlling the sales of gold and mercury. Meanwhile, more projects in the field are bringing additional demonstrations of gravity concentration processes to artisanal miners with the goal that this will lead to the elimination of mercury use (Veiga and Fadina, 2020).

This article highlights how gravity concentration can reduce the amount of material to be amalgamated or treated thermally or chemically to extract gold from concentrates. Additionally, in very rare, specific cases, this can be a solution to eliminate the use of mercury. This article uses simple language in order to reach non-technical audiences with the argument that gravity concentration can definitely reduce, but not completely eliminate, mercury use in ASGM.

4.3 Concepts of Mineral Liberation

Most interventions in ASGM sites do not pay attention to assessing the gold recovery of the process. Generally, artisanal miners are thrilled when they see yellow concentrates. This is a common misconception that leads artisanal miners to believe that they are making more money by recovering more gold. The concepts of gold grade and gold recovery must be carefully explained to artisanal miners. Gold grade is obtained by chemical analysis of a sample. Dividing the mass of gold found in a sample by the mass of the whole sample, the gold grade is obtained.

The gold recovery in a mineral separation process, i.e., the percentage of gold recovered from the original amount of gold in the ore, is expressed by:

$$R_{Au}\ (\%)\ = \frac{Y_c * M_c * 100}{Y_i * M_i}$$

where:
R_{Au} = percent of gold recovered
Y_c = grade of gold in the concentrate
Y_i= initial grade of gold (feed) in the ore being processed
M_c = mass of the concentrate
M_i = initial mass of the feed (ore)

In order to obtain the gold grades of the ore (feed) sample and concentrate, it is advisable to analyze the gold in the feed and tailings as the concentrates are usually not homogeneous with regard to gold content, creating the “nugget effect” (Clark, 2010). Then, the gold recovery and grade in a concentrate is obtained by the difference (Veiga and Gunson, 2020).

In the equation above, it is clear that the gold recovery can increase with a higher gold grade and/or greater mass in the concentrate. The latter is not desired, as it will reduce the gold grade in the concentrate. In an ideal gold separation process, operators should strive to have a smaller mass of concentrate and a high recovery of gold. However, this is very uncommon.

The gold recovery depends on many factors including the economic implications. Since gold recovery serves as an antagonist to the concentrate grade, it is important to determine how to obtain a small mass of high-grade concentrate with little harm to the recovery. Knowledge about the mineralogy of the ore is critical in obtaining a high-grade concentrate with a high recovery. If the ore has heavy minerals that can be concentrated with gold, the grade will be reduced. The liberation of gold particles from the other minerals, called gangue minerals (commercially worthless minerals), can also affect the quality of the concentrate. However, particles with unliberated gold can generate sufficient weight to the gangue particles to be concentrated. This is an important fact that is usually overlooked by interventionists demonstrating concentration techniques to artisanal miners. Gold concentrates can be rich, with 3,000 to 10,000 g Au/tonne (or ppm), but the gold particles are not necessarily liberated. The grinding process liberates the mineral particles of interest from the rest, the gangue. Since unliberated particles can also be concentrated, it is inadequate to target full gold liberation by grinding to produce a high-grade concentrate. Grinding is the most expensive process in mineral concentration, as it consumes large amounts of energy and is therefore not feasible in economically-challenged communities. Naturally liberated gold particles are only observed in alluvial (placer) deposits where minerals have been transported and grinded by streams for thousands of years, thus freeing gold particles. However, it is important to note that not all alluvial deposits have fully liberated particles, but this is frequently observed.

In alluvial (placer) gold deposits, when gold is fairly liberated and the grain sizes are quite uniform, gold recovery can reach levels above 90 percent with a simple sluice box (Teschner et al., 2017).

When analyzing gold in screened tailings from primary ores, it is frequently observed that the majority of gold lost in gravity concentration processes used by artisanal miners is in the coarse and fine-grain-sized fractions (Andrade-Lima et al., 2008). Gold in the coarse fractions represents the unliberated gold, while gold in the fine fractions represents the fine gold particles

that are not efficiently recovered by rudimentary gravity methods (Veiga et al., 2014b). The first case can be resolved with adequate grinding and size classification after the grinding, which is known as "closed-circuit grinding" (Wills and Finch, 2016). After size classification, the coarse fractions return to the mill. The gold particles do not need to be 100 percent liberated from the gangue to be concentrated but some degree of liberation[16] is expected (Figure 4.1). Most industrial gold processing plants aim to obtain about 70 to 80 percent of gold degree of liberation during the grinding process. The calculation of the degree of liberation for gold is not a trivial task, as the gold particles are not numerous in sieved fractions and are hard to quantify in a microscope (Petruk, 1994, Veiga et al., 2006, Bargawa and Hardiyanto, 2017). The majority of artisanal miners do not use any classification method (e.g., sieves), as they typically operate an open-circuit grinding process. As a result, artisanal miners lose the highest percentage of gold in the coarse fractions. When the gold is liberated but finer than 200 mesh (0.074 mm), it is difficult to concentrate with the most common gravity separation techniques. Industrially, fine gold is usually recovered by flotation or directly leached with cyanide.

[16] Degree of liberation is the percentage of gold attached to a mineral particle.

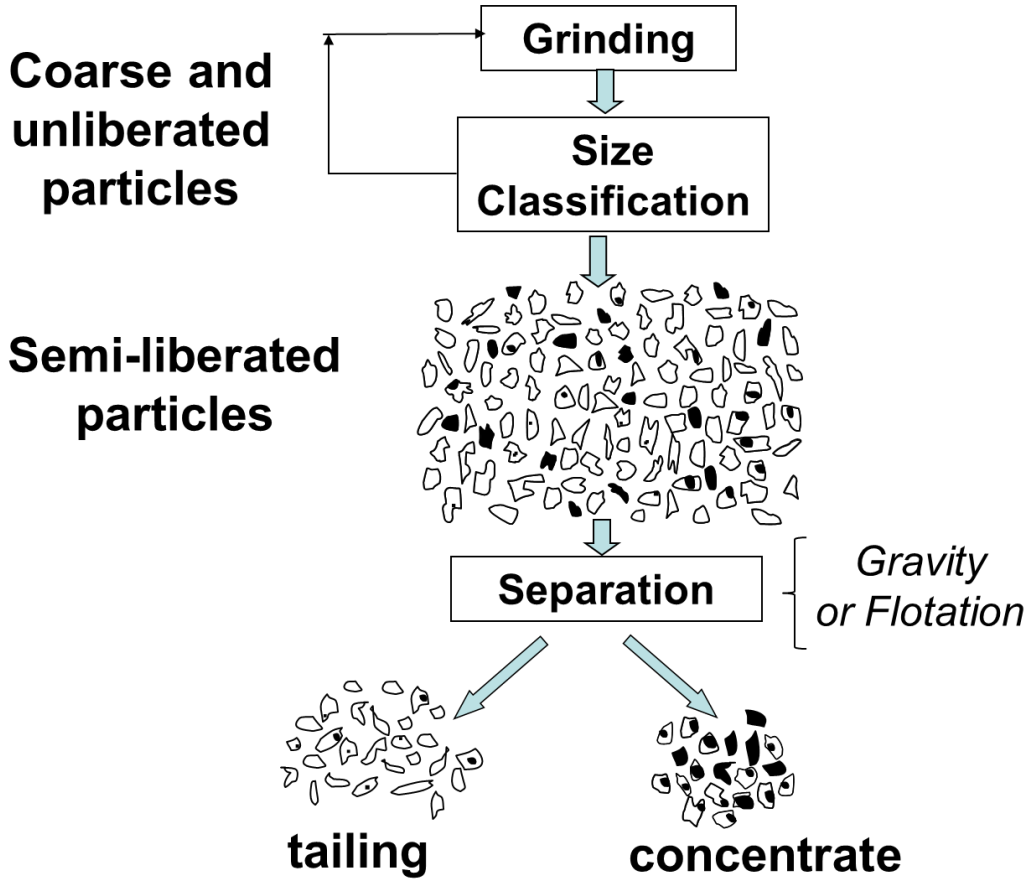

Figure 4.1: Classification after grinding allows for a more efficient gold concentration. Note: Gold is represented by dark dots.

4.4 Gravity concentration

Due to the difference between the specific gravity of gold (SG = 19.3) and its common associate minerals, usually silicates like quartz (SG = 2.65), the most traditional method to separate gold from the gangue is to use the difference in the weights of the particles. The gravity separation occurs due to the difference in weights between particles, but there are many variables that should be considered. These include the type of minerals accompanying the gold, the degree of liberation of the gold particles from other minerals, the shape of gold particles, the percentage of solids in the pulp being processed, the viscosity of the pulp, and the grain size of the gold particles. The latter variable is usually recognized by most practitioners as critically important. In a simplified and theoretical way, using Stokes' Law (BOX 4.1) it is possible to estimate that a particle of quartz of 0.25 mm has the same terminal velocity - velocity in which a particle sinks in a fluid- in a gravity separation as a 0.075 mm particle of gold (Tourtelot, 1968, Albrecht,

2017). Therefore, they cannot be separated. The separation of larger particles is easier, as the difference in terminal velocity between particles increases. In short, the size classification is important to improve the efficiency of the separation. Unfortunately, artisanal miners do not use any size classification, such as screens or hydrocyclones, after the grinding process or before the gravity concentration process.

BOX 4.1 – Calculation of the terminal velocity of a 0.25 mm quartz particle and a 0.075 mm gold particle using Stoke's Law

Terminal velocity using Stokes' Law:

$$V_T = \frac{2}{9}\frac{r^2 g(\rho_b - \rho_f)}{\eta}$$

Where:
V_T = terminal velocity of particle [cm/sec]
r = radius of particle [cm]
g = gravitational force [cm/sec^2]
ρ_b = density of particle [g/cm^3]
ρ_f = density of fluid [g/cm^3]
η = viscosity of fluid [g/cm*sec]

For a quartz particle with a diameter of 0.025 cm:

$$V_{Quartz} = \frac{2}{9}\frac{(0.0125\ cm)^2(980\frac{cm}{sec^2})(\frac{2.65g}{cm^3}-\frac{1g}{cm^3})}{0.01\frac{g}{cm*sec}} = 5.61 \text{ cm/sec}$$

For a gold particle with a diameter of 0.0075 cm:

$$V_{Gold} = \frac{2}{9}\frac{(0.00375\ cm)^2(980\frac{cm}{sec^2})(\frac{19.3g}{cm^3}-\frac{1g}{cm^3})}{0.01\frac{g}{cm*sec}} = 5.61 \text{ cm/sec}$$

4.4.1. Sluice Box

Globally, artisanal miners have used many types of gravity separation equipment. The most commonly employed is an antique equipment known as the sluice box. Sluices boxes are the preferred process used by artisanal gold miners as they are simple and can be locally built. Sluices use water to wash ore down angled surfaces or platforms. As water washes ore down the sluice, the friction of the flat surface of the sluice causes gold particles to sink and become captured. There is a large number of parameters that must be assessed in order to have an efficient operation, including particle size, width, riffles, type of carpets to increase friction, discharge time to remove the concentrate, pulp density (usually between 10-20 percent of solids),

angle of the sluice, and water source, among others. The angle of inclination of sluices varies a great deal from site to site, ranging from low angles as low as 5°, to moderate angles of 15°, to large angles greater than 20° (Veiga and Gunson, 2020). Sluices with low angles, as observed in Ecuador, accumulate a great deal of concentrate and require hourly cleanups to remove concentrate. Sluices with moderate angles are common in countries such as Colombia, Peru, and Brazil. These sluices allow for less frequent cleanups that can take place after eight hours of operation. Sluices with large angles are not efficient in capturing fine particles as the slurry flow is too fast and does not allow the particles to settle. Some dredges in Brazil, Venezuela, and Guyana, clean the carpets after 10 to 15 days of operation. It is important to understand that the more frequently the concentrates are discharged, the higher the gold recovery will be. This is true for any non-continuous process. However, the gold grade will be lower because a higher mass of concentrate is obtained. The opposite is also true. If the equipment operates for long periods of time, more mass of ore will pass through the sluice. Therefore, the gold grade will be high, but the recovery will be low. Miners do not realize that a yellow concentrate translates to a high-grade concentrate. However, a large amount of gold is lost to obtain this concentrate leading to a low-recovery situation.

In some artisanal mining operations, miners construct sluice boxes that are too long. In Brazil, Sudan, and Indonesia, sluices with lengths up to 40 m were observed. Artisanal miners believe that these long sluices will provide a greater distance and area for the fine gold particles to settle. However, this is a common error and misconception, because the fine particles must settle in the sluice region with lower water speed, which is usually at the beginning of the sluice. Studies have shown that the majority of gold is recovered in the first meter of a sluice. Therefore, sluices longer than 2 m do not provide any additional benefits (Burt, 1984, Litvintsev et al., 2012). It is better to disrupt the speed of the water flow using two or three decks of sluices in zigzag orientation than to build a longer sluice. By disrupting the velocity of the slurry traveling from sluice to sluice, an increase in gold recovery can be achieved.

Carpets are commonly used to increase the friction between gold particles flowing in sluice boxes. Many artisanal miners have also added riffles in their sluices to break the flow of water and retain the gold particles. However, this creates more turbulence and affects the settling process of fine gold particles. Artisanal miners use a wide variety of carpets to concentrate gold,

ranging from wool rags to 3M Nomad loop vinyl, which is used to clean shoes at doorsteps. Despite the efficiency of the vinyl loop carpets, the gold becomes trapped in the loops and is very difficult to remove during the cleaning process. This has led some miners to burn the carpets in order to extract the gold trapped in the small loops. However, the company Gold Dog (2016) sells vinyl carpets without underlayers that allow for the trapping and easy removal of gold particles.

4.4.2. Shaking Table

Shaking tables have been promoted to artisanal miners as an efficient way to concentrate gold in a continuous manner. Shaking tables do not require miners to stop the operation to discharge concentrates, as is necessary with sluices and centrifuges. These shaking tables have inclined decks with riffles placed perpendicular to the pulp flow (usually with 20-30 percent of solids) that block the progress of heavier particles, sending them to the lateral part of the table, where they are collected. The light fractions, which consist of less-dense minerals and small grains, pass over the horizontal riffles and are discharged at the front of the table. These shaking tables have low processing capacity rates, usually around 1-2 tonnes of ore/h. Several conventional gold mining companies use shaking tables after size classification and primary concentration (e.g., using centrifuges) processes to remove coarse gold particles that will delay the cyanidation process. These tables are used to upgrade the concentrates from the centrifuge to prepare them to be melted with borax. Tables are efficient to concentrate liberated gold as fine as 200 mesh (0.074 mm), but the efficiency depends on the shape of the gold particles and the uniformity of the grain size fraction. As gold is relatively hydrophobic, flaky gold particles are not efficiently concentrated in any laminar concentration system like sluices or tables.

Shaking tables are very sensitive to the grain size of the material being separated. Therefore, a size classification is usually needed before the process to create a narrow grain size range. The fast speed of the horizontal movement of the table is useful for fine grain sizes of gold (Wills and Finch, 2016). Shaking tables have two slopes, ranging from 0 to 6^{o}, one lateral or parallel to the riffles that controls the production rate, and another longitudinal or frontal that controls the particle size being concentrated. Large frontal slopes may allow heavier particles to surpass the riffles, which can lead to gold specks being lost in the process (Sampaio and Tavares, 2005). The slopes must be investigated and appropriately designed depending on the type of ore

and grain sizes being processed (Silva, 1986). It is frequently observed that artisanal miners use shaking tables without any prior knowledge of the ore mineralogy. Artisanal miners also use only one shaking table after the discharge of a mill without any classification. Rather they should be using two or three different tables (rougher, cleaner, and scavenger) aimed at capturing more gold and generating a higher-grade (cleaner) concentrate. Miners believe they have a high recovery when they see yellow strips of gold coming out of the table. This is usually the liberated and semi-liberated gold particles being separated at the top of the table. However, this does not necessarily indicate anything about gold recovery.

4.4.3. Jig

Jigs are not commonly used by artisanal miners, but some operators in Colombia and Brazil use them for continuous gravity concentration. The heavy particles are separated from the lighter particles by a pulsating flow of water. The pumping and suctioning water movement fluidizes the particles allowing the heavy particles to sink and pass through a bed of steel balls. The smaller and lighter particles are pumped out from the jig, while the heavier and larger particles settle faster. Jigs operate better with narrow grain size ranges and usually perform better separating particles of gold coarser than 100 mesh (0.15 mm). Jigs can process up to 1000 tonnes of ore/h with pulps of 10-30 percent solids (Wills and Finch, 2016). In Colombia, there are many operations using 8”x12”, 1 HP jigs with the capacity to process 0.3-1.45 tonnes/h. They are placed before the shaking tables as a size classification tool, to remove the coarse fractions. Many artisanal miners do not prefer this configuration. As a result, they have decommissioned the jigs and feed the 2 mm ground ore directly to the shaking tables without any size classification.

4.4.4. Centrifuge

In terms of gravity separation equipment, centrifuges outperform all other equipment, as they are adequate to separate coarse and fine gold particles. The centrifugal force exerted on the particles substantially increases the difference of terminal settling velocities between the gold and the gangue minerals (Sampaio and Tavares, 2005). For example, as seen above in BOX 4.1, in a natural settling process using only the gravitational force (G), a gold particle of 0.075 mm has the same terminal velocity as a quartz particle of 0.25 mm. Therefore, these two particles cannot be separated. However, when a centrifugal force of 60 to 350 times larger than the

gravitational force is applied, the difference in terminal velocity greatly increases. This makes the particle separation easier. There are two leading international manufacturers of centrifuges with counter flow water pressure: (1) Knelson concentrators (G = 60-120) and (2) Falcon (Sepro) centrifuges (G = up to 200). These centrifuges are also available in sizes for artisanal operations that can process from 0.7 up to 15 tonnes of ore/h. These machines operate with riffles where the heavier particles are retained. Also, a counter flow of water jets expel the lighter particles from the riffles, allowing the concentration of the heavier particles.

In some cases, artisanal miners set up two or three centrifuges in series to process the tailings from the previous centrifuge. This setup has proved to significantly increase the gold recovery when operating in an open circuit grinding process, thus justifying the extra investment. However, when operating in a closed-circuit grinding process, the ground material can be concentrated in only one centrifuge. The tailings are classified in a hydrocyclone with the underflow (UF) returning to the mill and the overflow (OF), comprised of fine particles, being either concentrated by flotation or leached with cyanide (Figure 4.2). This is typically observed in conventional gold processing plants. Although more expensive centrifuges with automatic discharge of concentrates exist, the most common ones operate in batches where operators are frequently discharging the concentrates. The cleanup process also respects the rule of gold grade versus recovery. When the centrifuge is discharged every 20 minutes, the recovery will be high, but the grade of the concentrate will be low. Conversely, if the centrifuge is discharged every two hours, the grade will be high, but the recovery will decrease. In order to operate centrifuges with water pressure, the counter flow water needed to expel the gangue minerals from the riffles must be clean. This poses an issue for artisanal miners who work with turbid waters. The main parameters that must be carefully studied and considered include percent of solids in the feed, grain sizes of particles in the feed, water pressure, discharge time, and rotational speed. Some centrifuges, such as GoldKatcha and Knudsen, do not use counter flow water and their rotational speeds are much lower than the Knelson and Falcon centrifuges. In general, centrifuges are not easy-to-use pieces of equipment, such as jigs. As observed in many sites in Brazil, Ecuador, Colombia and Peru, many artisanal operators become frustrated after acquiring these centrifuges due to their complexity and lack of technical assistance.

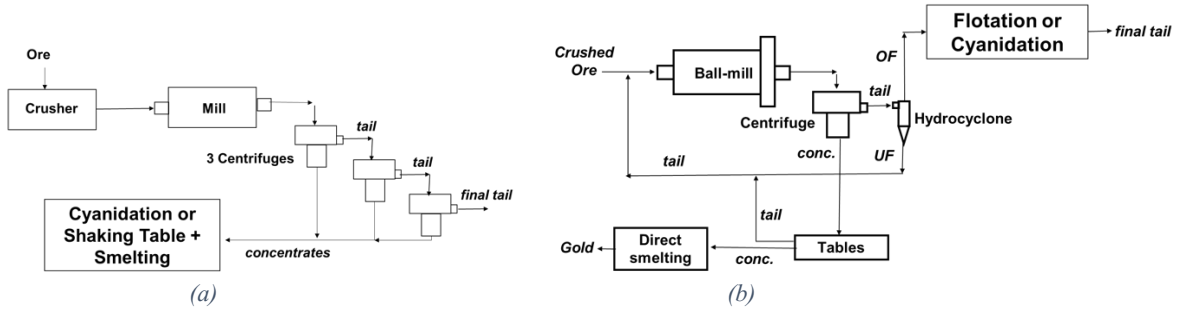

Figure 4.2: Use of centrifuges in an (a) open-circuit and a (b) closed-circuit grinding process.

4.5 Extracting Gold from Concentrates

After gold is concentrated by a gravity separation process, a small mass of concentrate must be processed to obtain the gold. There are three common, basic methods used by artisanal miners:

1. Amalgamation
2. Direct smelting
3. Leaching

4.5.1. Amalgamation

Gravity concentration separates free and unliberated gold particles usually generating a mass smaller than 10 percent of the original processed ore. In some processes, like a sluice and centrifuge, the mass of concentrate can be as low as 0.01 percent of the feeding ore mass. Amalgamation is simple and effective in trapping gold particles that are coarser than 0.074 mm, but it cannot collect unliberated gold particles. Mercury forms an amalgam with almost all metals except platinum and iron (Veiga and Baker, 2004). Usually amalgams from artisanal miners are obtained by removing the excess mercury using a piece of fabric. This rudimentary filtration ends with the operator manually squeezing the amalgam to obtain a final paste with 40-50 percent mercury and 50-60 percent gold and other metals. "*The wetting of gold by mercury is not alloying, but a phenomenon of moderately deep sorption, involving some interpenetration of the two elements*" (Pryor, 1965). In other words, the more the miners squeeze the amalgam, the less mercury will be present in the amalgam. Taking this into consideration, centrifuging the amalgam is a way to remove more mercury, producing an amalgam with 80 percent gold and 20 percent mercury (Veiga et al., 2006).

Gold can combine with mercury to form a wide range of compounds from $AuHg_2$ to Au_8Hg. The three principal gold amalgams are: $AuHg_2$, Au_2Hg, and Au_3Hg (Taggart, 1945). Amalgamation of gravity concentrates causes significantly less mercury losses than the amalgamation of the whole ore in copper plates or small ball mills called *cocos* in Colombia, *chanchas* in Peru and Ecuador, and *tromols* in Indonesia. These methods can lose up to 15 parts of mercury for each part of gold produced as mercury pulverizes in the grinding process (Cordy et al., 2011). If only gravity concentrates are amalgamated, mercury use and loss are substantially reduced as a smaller mass is amalgamated. Some concentrates can be difficult to be amalgamated, particularly those with very fine gold particles or those with high grades of sulfides present that contribute to mercury "flouring"[17] (Beard, 1987). Artisanal miners use unconventional reagents during the amalgamation to reduce flouring. These include lemon juice, bicarbonate, quicklime, guava leaves, Coca-Cola, brown sugar, toothpaste, urea, detergents, and others. The effect of these reagents on improving mercury coalescence is not well understood. There are some electrolytic processes to avoid mercury flouring by forming sodium or potassium-amalgams that are actually more efficient in amalgamating finer gold particles (Pantoja and Alvarez, 2000). In most artisanal mining operations, the amount of gold recovered by amalgamation of concentrates or whole ore is rarely higher than 30 percent (Veiga et al., 2014b).

In the South American operations, artisanal miners are currently thrilled by the use of what they call "mercurio rojo" (red mercury), which according to artisanal miners combines much better with gold than the ordinary mercury. This mercury is sold on the internet for approximately US$100/kg (Mercado Libre, 2020). It is identified as the "German Red Mercury" and is definitely not the same infamous and very expensive red mercury with uranium, plutonium and other substance alleged used to manufacture nuclear weapons (Wallenius et al., 2007). The "German Red Mercury" vendors do not reveal its composition, but this might be mercury with antimony oxide ($Hg_2Sb_2O_7$) known as "cherry red" (Edwards, 1995). The amalgamation and coalescence properties of this mercury seems to be better than the pure mercury and this is the new hoax in the ASGM sector.

[17] Flouring is a phenomenon that forms many mercury droplets, with no coalescence due to oxidation of mercury surface.

4.5.2. Direct Smelting

Gravity concentrates can be directly melted with borax. For centuries, borax ($Na_2B_4O_7.10H_2O$) has been used as a flux in gold smelting by conventional and artisanal miners. If the concentrate has a high grade of gold, for instance 30,000 g Au/tonne (or 3% Au) or above, the yellow concentrate can be directly smelted (Appel and Na-Oy, 2011). If the concentrate does not have a high grade, the particles of gold will not coalesce during the smelting process to create enough weight to sink in the molten bath. This leads to a significant amount of gold being lost in the slag (Veiga et al., 2014b). This process is used by industrial companies to melt the gold recovered by the gravity circuit. This is the small amount of gold removed before the flotation or cyanidation process. The main drawback of this method is that in order to obtain a very rich concentrate, the recovery is low.

4.5.3. Leaching

Almost all conventional gold processing companies use cyanide to extract gold from concentrates or from the whole ore. Artisanal operations have also been using cyanide for a long time, in particular in the rudimentary processing centers, where the operators leach the amalgamation tailings left behind by artisanal miners (Veiga et al., 2014a). These centers offer their amalgamation services to miners for free, but the gold-rich tailings must stay in the centers where they are leached with cyanide. In this process the residual mercury in the tailings forms complexes with cyanide that are not completely recovered in the activated carbon or zinc precipitation process used to obtain gold from the cyanide solutions (Velasquez et al., 2011). Artisanal cyanidation operations use vat leaching or, less frequently, agitation tanks. Artisanal processing centers are rarely observed leaching gravity concentrates. Instead, they leach tailings, in particular amalgamation tailings. Cyanidation plants, even the most rudimentary ones, require some chemistry knowledge. Tailings must be carefully managed, which is not frequently observed. Similar to industrial plants, artisanal operators must also remove and melt the coarse gold particles prior to cyanidation of gravity concentrates, as coarse particles take too long to be dissolved. For example, a 0.150 mm (100 mesh) particle of pure gold takes 44 hours to be dissolved in normal cyanidation conditions (Hedley and Tabachnick, 1968). When leaching concentrates, operators must consider that concentrates usually have heavy minerals that consume cyanide. Therefore, high levels of cyanide around 5-10 g/L are needed. The main

variable that increases the cyanidation kinetics is the level of oxygen in the solution. Therefore, for satisfactory results, a well-aerated pulp, usually an agitated tank with 30 percent of solids, is required.

Other lixiviants that are less toxic and more effective than cyanide have been developed to leach gold. However, these lixiviants either have considerably high operating costs or they use undisclosed proprietary reagents. Therefore, their application in commercial, large-scale conventional processing plants is limited. None of these alternative chemicals have been observed being used in artisanal processing plants.

4.6 Discussion

Gravity concentration, as universally used, is an efficient method to separate gold particles -usually above 0.074 mm or 200 mesh- from the rest of the gangue minerals. Gravity separation in conventional gold processing plants is used to remove relatively coarse gold particles before entering the flotation or cyanidation circuit. While testing a synthetic gold ore in the lab, Lins and Adamian (1993) demonstrated that gold grains up to 0.71 mm can be floated if the turbulence and the pulp density are low. These authors showed that under normal flotation conditions with 33 percent of solids and high aeration, particles above 0.16 mm are not well recovered. In a more recent study, Ran et al. (2019) tested flotation of a copper-gold-lead ore and reported that fractions above 0.1 mm had poor gold recovery with the maximum gold recovery obtained in the fractions - 0.043 + 0.02 mm.

As discussed previously, cyanidation takes too long to dissolve relatively coarse particles. In addition, amalgamation usually is not efficient for fine gold particles. Mitchell et al. (1997) highlighted that the recovery of free gold particles by amalgamation can drop to 65 percent for particles finer than 200 mesh (0.074mm). Virtually, no conventional industrial plant uses solely gravity concentration methods to obtain a gold bar, except in alluvial operations. Rather, conventional processing plants remove the coarse grains, when present, using gravity separation processes or leach the whole ground ore with cyanide when the gold is fine and exposed. Generally, conventional companies use flotation to obtain a gold concentrate that is then leached with cyanide. When only the concentrates are leached with cyanide, this leads to a smaller mass of cyanide-contaminated tailings being produced which then needs to be treated by a costly

process in order to destroy the residual cyanide. However, some companies leach the whole ore when they do not achieve a satisfactory recovery of fine gold through flotation.

Therefore, the promotion of gravity concentration to eliminate the use of mercury does not offer any effective solution to artisanal miners in terms of what to do with the gravity concentrates. It is not possible to melt concentrates with borax when the grades are below 30,000 g Au/tonne, as highlighted by Appel and Na-Oy (2011), as the majority of gold will be lost to the slags (Veiga et al., 2014b). If a concentrate with a high grade of gold is the target of the gravity concentration, then a large amount of gold will be lost with tailings in the process. It is difficult to convince artisanal miners to eliminate mercury and use a concentration process in which they will lose the majority of the gold present in the ore in order to have a rich concentrate to melt with borax (Veiga and Fadina, 2020). It may be to melt low-grade concentrates with borax by adding more gold or silver into the molten bath, creating a quartering process. The added precious metal will collect the spread grains of gold and bring them to the bottom of the crucible during the smelting process. It seems unrealistic to convince artisanal miners to use their gold bars as a collector, but it can be a solution.

Cyanidation of gravity concentrates with relatively coarse gold specks is possible, if a highly aerated system is applied. Commercially, there are some companies offering intensive cyanidation for gravity concentrates. The oxygen in highly aerated systems speeds up the leaching process. Artisanal miners can use oxidants such as ozone, hydrogen peroxide, or domestic detergents that contain sodium percarbonate (16–21 percent of H_2O_2) can be used to speed up the process. The small ball mills used for amalgamation of the whole ore can be converted into a cyanidation tank (Veiga et al., 2009, Veiga et al., 2014b). These measures require some capital and knowledge. The process is known as “intensive cyanidation,” as highly aerated solutions also consume free cyanide. Therefore, high concentrations of sodium cyanide are used in the process.

Unfortunately, when promoting gravity concentration to artisanal miners, there have not been any alternatives to extract gold from the concentrates other than smelting of the rich concentrates with borax. If a miner wants to increase their gold recovery, then they need to produce a larger mass of concentrates using large crucibles to melt them or repeat the gold pouring process throughout the day. If this is the only solution suggested by the interventionists,

sooner or later artisanal miners will realize that the amalgamation of the whole ore produces better gold recoveries with little or even no investment and no operating costs when conducted in processing centers. Without knowing the percentage of gold being recovered by artisanal miners using their processes, there is no way to convince them to adopt cleaner practices. It has been suggested to compare the amalgamation of the whole ore with another alternative method such as a gravity concentration. The best approach is to extract gold from their tailings to show the artisanal miners that they are losing gold and there are ways to recover it (Restrepo-Baena et al., 2020).

For an efficient gold concentration, the gravity separation equipment must be coadjutant of the flotation and cyanidation processes. Then, the operating and capital costs must be considered. For a complete processing plant, the capital cost (CAPEX) is around US$20,000 to 30,000 per tonne of ore daily processed (tpd) for 100 and 200 tpd production rate plants. This includes crushing, grinding, size classification, gravity separation with centrifuges, flotation cells, and cyanidation circuit with activated carbon adsorption, elution, electrowinning, gold smelting, infrastructure, tailing dams, and all necessary accessories. The annual operating cost (OPEX/a) for these two plants is US$5,641 and 4,272 respectively (Table 4.1). The economies of scale is obvious, as larger plants have lower CAPEX and OPEX per tonne of ore processed. This table was obtained using new equipment by buying the cheapest pieces in the local and international markets and delivered to Colombia.

Table 4.1: CAPEX and OPEX for small gold processing plants

Production Rate (tpd)	CAPEX	OPEX/a
10	653,986	141,708
25	1,133,267	245,560
50	1,717,712	372,200
100	2,603,565	564,150
200	3,946,266	855,091

Note: tpd = tonnes per day of ore processed

In South Africa, the research center MINTEK developed a method called the iGoli process to replace amalgamation in ASGM sites. The method employs hypochlorite and hydrochloric acid to dissolve gold from gravity concentrates followed by gold precipitation with metabisulfate. This useful process was demonstrated to African and some Latin American

miners, but the procedure was never fully adopted by ASGM due to the relatively complex chemistry, accessibility to reagents and cost. Ultimately, any process that is presented to artisanal miners has to consider the complexity of the process as well as the associated costs with switching technologies and operational costs.

4.7 Conclusion

From the technical viewpoint, it seems clear that gravity concentration is not the final solution to eliminate mercury use in artisanal gold mining, but it can drastically reduce the use and losses of mercury. Gravity concentrators working in discontinuous cycles, such as sluices and centrifuges, can reduce the mass of concentrate to less than 0.1 percent of the original mass. This reduces the amount of material to be amalgamated or leached.

Centrifuges with counter-flow water can efficiently and simultaneously concentrate coarse and fine gold particles. They allow more throughput of ore than any other gravity separation equipment used in ASGM and provide better gold recoveries than other concentrators. Centrifuges have a higher capital cost compared to other simple concentrators used in ASGM, and they require clean water as well as some knowledge on the part of the operators. It is common to observe centrifuges not being used in ASGM sites, as artisanal miners affirm, “they are too complicated to use”. Training and permanent technical assistance for artisanal miners are critical.

A cleaner and efficient gold processing plant is the main capital cost for artisanal miners. These processing plants, with all the accessories and environmentally safe conditions, would have a CAPEX ranging from US$20,000/tpd (for 200 tonnes/day of ore processed) to US$65,000/tpd (for 10 tonnes/day). The operating costs will be a heavy burden for artisanal miners. Without an efficient process to extract gold from gravity concentrates, it is most advisable for artisanal miners to sell their ores directly to the mineral processing plants instead of paying for rudimentary amalgamation techniques in processing centers that extract less than 30-40 percent of the gold from the ore (Veiga et al., 2014a). Creative homemade gravity concentration plants have been promoted (Veiga et al., 2018) for small producers (<2 tonnes/day) but these are palliative solutions, largely due to the fact that the major mercury polluters are the processing centers. These centers provide impoverished artisanal miners with grinding and amalgamation services for a nominal fee.

CHAPTER 5
"I AM FORMAL, WHAT COMES NEXT?" A PROPOSED FRAMEWORK FOR ACHIEVING SUSTAINABLE ARTISANAL AND SMALL-SCALE MINING FORMALIZATION IN PERU

5.1 Abstract

Artisanal and small-scale gold mining (ASGM) continues to exponentially increase in developing countries. However, the majority (70-80%) of ASGM operations around the world continue to operate informally without any permits or licenses. In recent years, Peru has seen relative success in its ASGM formalization efforts based on the number of formalized miners (10,554 as of May 2022). However, aside from the number of formalized miners, analyses of the persistent socio-technical issues present among formalized ASGM operations are nonexistent. The article draws on four years of field-based research analyzing formalized ASGM operations in three of the most important ASGM regions in Peru (Arequipa, Puno, and Madre de Dios), which account for almost half (46%) of all formalized miners in the country. This article proposes a framework for post-formalization needs, focusing on three-pillars that can support formalized ASGM operations to remain in compliance and improve their practices. The three pillars we develop within the framework are Mining Operations, Business Development, and Partnerships and Collaborations. This research underscores the importance of post-formalization strategies and provides a starting point for host governments including specific elements that should be considered in the development of these plans.

5.2 Introduction

Over the last three decades, artisanal and small-scale gold mining (ASGM) has continued to increase rapidly in developing countries. Globally, the ASGM sector directly employs over 20 million miners who produce 15-20% of the total annual gold production (Heymann, 2020). Despite the many social and environmental issues associated with the sector, governments, donors, NGOs, and researchers have concluded that ASGM cannot be eliminated especially due to the lack of alternative opportunities for rural and developing communities as well as the increasing, high international price of gold. Experts have identified that formalization is one part of the solution is to improve the governance and regulation of ASGM activities (Salo et al.,

2016; Hilson et al., 2019). As several donors including the World Bank and United Nations are now pressuring governments to incorporate ASGM into their development strategies, "the push to formalize ASGM has never been greater" (Hilson and Maconachie, 2017, p.443).

Despite the increase in formalization efforts, the majority (70-80%) of ASGM operations around the world continue to operate informally without any permits or licenses (IGF, 2017). Researchers have highlighted that recurrent top-down ASGM formalization policies exclude the most vulnerable artisanal and small-scale miners (Persaud et al., 2017; Hook, 2019). Furthermore, formalization policies and initiatives are not tailored to the ASGM sector, as they often require informal, small-scale operators to comply with the same regulations as large-scale, mechanized, foreign-financed operations (Hilson and McQuilken, 2014).

Peru has seen relative success in its ASGM formalization efforts based on the number of formalized miners. It currently leads Latin America with 1,761 formalized ASGM operations, representing 10,554 miners (REINFO, 2022). Of these mining operations, approximately 14% are titleholders of the mining rights, while the remaining 86% possess exploitation contracts from titleholders. Although formalization remains a challenge in Peru and elsewhere, these signs of progress and the emergence of a core cohort of formalized ASGM highlight the need to think about what comes next.

In this article, we advocate for a shift beyond the traditional short-term focus on formalizing miners. Experience has shown that formalization, while necessary, is not sufficient to fix technical, social, economic, and environmental problems associated with the sector (Veiga and Marshall, 2019; Álvarez-Berríos et al., 2021). Concrete improvements on the ground require a shift beyond the exclusive emphasis on formalizing the greatest number of miners, to a recognition that formalization is "just the beginning" (Martinez et al., 2021b). There is a clear need to focus more on post-formalization and outline steps beyond formalization itself that can help transform the ASGM sector into a more sustainable livelihood.

This article proposes a framework for post-formalization needs, focusing on three-pillars that can support formalized ASGM operations to remain in compliance and improve their practices. The post-formalization framework should help ASGM operations prosper while also realizing environmental and social gains that formalization alone has failed to achieve. The three pillars we develop within the framework are Mining Operations, Business Development, and

Partnerships and Collaborations. This research underscores the importance of post-formalization strategies and provides a starting point for host governments including specific elements that should be considered in the development of these plans.

The article draws on four years of field-based research analyzing formalized ASGM operations in three of the most important ASGM regions in Peru (Arequipa, Puno, and Madre de Dios), which account for almost half (46%) of all formalized miners in the country (REINFO, 2022).

5.3 Why is a Framework for Sustainable Formalization necessary?

Globally, formalization of ASGM has been identified by policymakers, governments, and donors as the first step towards transforming the sector into a sustainable livelihood (Siegel and Veiga, 2009; Geenen, 2012; Zvarivadza, 2018). However, depending on the approach taken by governments, formalization of the ASGM sector can be a vehicle for sustainable development or for sustaining inequalities (UNITAR & UN Environment, 2018). In sub-Saharan Africa, Hilson and Maconachie (2020a) concluded that a formalized and supported ASGM sector has the potential to contribute towards the United Nations Sustainable Development Goals. However, most academic analyses of ASGM formalization policy have highlighted that the top-down bureaucratic processes generally place a strong emphasis on mineral tenure and property rights, thus excluding the majority of artisanal miners and favoring elite groups (Maconachie and Hilson, 2011b; Fold et al., 2014; Hilson et al., 2021b).

For policymakers, governments, and donors, formalization is seen as the end goal. These stakeholders are commonly under the impression that the social and environmental issues associated with the sector largely stem from ASGM operating outside the legal sphere and being predominantly unregulated (Maconachie and Hilson, 2011b). Researchers have highlighted that it is fundamental to consider that formalization refers to a process for growth and development, and thus formalization should not be considered the end result (Siegel and Veiga, 2009). Instead of treating formalization as "just the beginning" (Martinez et al., 2021b), providing continuous support for miners who have achieved formalization and are committed to operating responsibly in the legal sphere, artisanal miners are left without any further support and are faced with complying with all the regulations and requirements of being formal. Without long-term support, there is a danger that formal miners will go back to their old informal practices, particularly if

they struggle to meet formal requirements while other miners around them have remained informal and continue operating as they always have without consequence.

On the other hand, many critics note that formalization often allows miners to continue existing practices, even when environmentally or socially harmful. For example, in Madre de Dios, Peru, Álvarez-Berríos et al (2021) observed that artisanal and small-scale mining activities taking place in titled areas did not result in compliance with environmental regulations, and at times were worse than practices by informal miners. The basic idea is sometimes lost, that formalization is only valuable if mining practices in the field are improving. As Veiga and Marshall (2019) note, when formalization only focuses on the legal aspect, governments end up legalizing irresponsible practices rather than achieving improvements on the ground. Formalization without education and training is not sustainable and can inadvertently perpetuate inefficient mining and processing methods, including the widespread use of mercury (Veiga and Marshall, 2019).

These basic flaws in typical formalization approaches underscore the need for a shift to focus more on post-formalization now, rather than waiting to begin after more miners have formalized. Indeed, a stronger post-formalization support model could bring more benefits for formalized miners, for the environment, and for society, which in turn could motivate more informal miners to complete formalization processes.

5.4 Formalization in Peru – a grey area

Prior to 2002, artisanal and small-scale gold miners were not legally recognized in Peru, as the government had a strong focus on facilitating large-scale, foreign financed operations in the country. However, in 2002, the Peruvian government passed Law 27651, *Law of Formalization and Promotion of Small-Scale Mining and Artisanal Mining*, which created a legal framework to formalize ASGM activities. Although the goal of this law was to facilitate the formalization of artisanal and small-scale gold miners, it was mostly ineffective as artisanal miners had to abide and comply with the same laws, regulations, and requirements as large-scale, multinational financed operations.

Due to the law's ineffectiveness, in 2012, Congress of the Republic of Peru passed Legislative Decree 1105 which created a simplified procedure called the 'exceptional process'.

Under this process, artisanal and small-scale gold miners could complete five steps to become formalized rather than following the full process that applies to larger companies: (1) obtain property or authorization of surface rights; (2) obtain title to mining concession or exploitation contract; (3) have an approved simplified environmental impact assessment; (4) submit a sworn statement declaring the absence of archaeological remains; and (5) prepare a technical mine plan. To facilitate this process, the Ministry of Energy and Mines created the General Directorate of Mining Formalization (DGFM) in 2013 to promote the formalization of the ASGM sector, propose improvements to the regulatory frameworks, and provide support to regional governments which oversee the formalization of artisanal and small-scale gold miners in their respective region.

While the simplified process sought to facilitate ASGM formalization, during the 2002-2016 period the Peruvian government also put a strong priority on combatting illegal gold mining (Legislative Decrees 1100-1107). During this time of contradictory approaches to informal mining, only 112 artisanal and small-scale miners achieved formalization throughout the entire country. This shortcoming led to the passing of Legislative Decree 1293 in 2016 which declared the formalization of the ASGM sector a national interest. This decree created the Integral Registry of Mining Formalization (REINFO) and required artisanal and small-scale miners to enroll in the registry to declare their commitment to the formalization process. Today, there are a total of 88,153 inscriptions in the REINFO, and 10,554 (12%) are formalized. Although this percentage seems high, when considering estimates of artisanal and small-scale gold miners in Peru ranging from 100,000 to 500,000 (De Echave, 2016), the percentage of formal miners drastically decreases to less than 2%. The model has also created a large and problematic grey area, as the tens of thousands of miners officially in the process of formalization are often treated as de facto formal. Many ASGM operations registered in the REINFO seem content to remain "in process" indefinitely and show few signs of progress toward full formalization. In fact, many treat the opening step of registration as if it were the whole formalization process (Cano and Kunz, 2022).

It is important to note that the REINFO is no longer open to new enrollment, but those currently enrolled in the registry have until December 31st, 2024, to complete all the mandatory

steps to become formalized. After this deadline, miners enrolled in the REINFO who did not complete the mandatory steps will be classified as “illegal” miners.

As countries continue to focus their efforts on formalizing the greatest number of artisanal and small-scale miners, there will come a point in time when the number of new formalized miners will begin to decrease. In Peru, the number of newly formalized artisanal and small-scale miners has experienced a negative trend over the last five years (Figure 5.1). The trend suggests that the “low hanging fruit” has all been harvested, meaning that the artisanal miners most interested and able to formalize have done so, and that further gains in formalization will be more difficult to achieve.

While it is important to continue advancing formalization, the slowing trend could be interpreted as a signal to shift priorities, placing more emphasis on supporting the success and compliance of those already formalized. As Martinez et al. (2021b) highlighted, the number of formal artisanal miners can diminish if miners do not receive sufficient support or incentives to avoid reverting to informality. Thus, the next step of the formalization process, which has received very little attention, is to retain formal miners in the legal sphere and help transform their operations to more responsible, sustainable livelihoods.

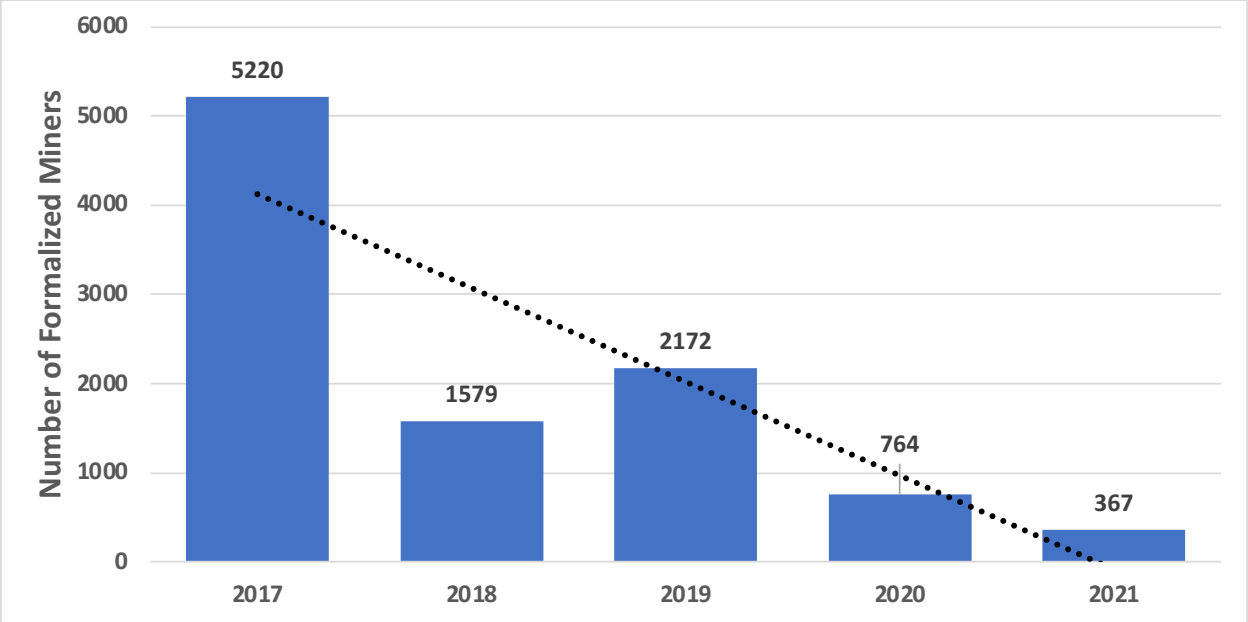

Figure 5.1: Number of newly formalized artisanal and small-scale gold miners in Peru each year, 2017 to 2021.

5.5 Methodology

This paper is a synthesis of ideas that emerged over the course of four years of research on ASGM in Peru (2018-2021). Our fieldwork included 56 semi-structured interviews, eight focus groups with artisanal and small-scale miners (n=33), non-governmental organization (NGO) representatives who work in these regions (n=10), and current and past government officials from the Ministry of Energy and Mines (n=13). We collected data from the Peruvian Customs and Tax Administration on the companies and businesses registered in the REINFO which have obtained legal authorization to purchase and utilize mercury. We also obtained national gold export data from the Peruvian National Bank and Peruvian Customs and Tax Administration to estimate the percentage of unreported gold exports associated with the ASGM sector. Finally, we conducted participant observation at more than twenty ASGM operations in three of the most important ASGM mining regions of Peru—Arequipa, Puno, and Madre de Dios.

These regions are included among the top six regions in Peru in terms of the greatest number of artisanal and small-scale miners formalized (4,656 of 10,554, 44%), the largest number of miners in the formalization process (38,894 of 88,153, 44%), and the highest quantities of artisanal and small-scale gold production. The study sites also represent three key examples of different ASGM contexts: 1) Alluvial mining in the rainforests of the Amazon basin (Madre de Dios); 2) Open pit mining of alluvial deposits in the Andean highlands (Puno); and 3) Hard-rock underground mining in the arid coastal plateaus (Arequipa).

5.6 A Three-Pillar approach to achieve Sustainable Formalization

The framework presented here provides a big-picture view of formalization and makes recommendations of how to make formalization sustainable in multiple senses: ASGM operations remaining formalized and in compliance, remaining profitable and sustaining employment, and improving environmental and social practices for sustainability. The approach consists of three pillars: a) Mining Operations; b) Business Development; and c) Partnerships & Collaborations (Figure 5.2). The model is designed to be generic, applicable in different regions in Peru and beyond, though given the heterogeneity across ASGM sites, any initiative to promote sustainable formalization must be customized and adapted to consider the particular social, economic, and political contexts of the site or country. No less, this analysis of formalized

ASGM operations provides overarching themes related to the socio-technical issues that persist among the study regions and may be relevant to other ASGM regions globally. We recognize that there is a constant interplay between the pillars, and our analysis demonstrates this. However, we suggest that conceptualizing formalization as encompassing these three pillars is a start for moving toward more sustainable formalization efforts.

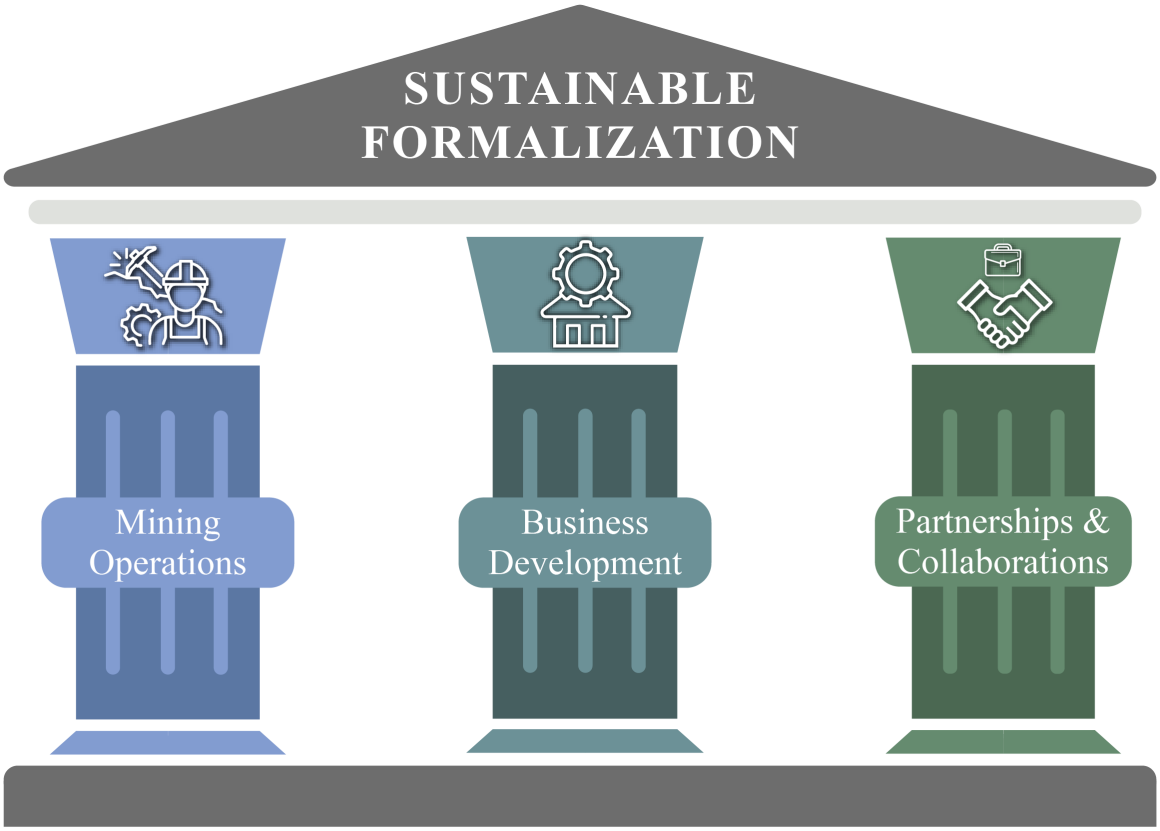

Figure 5.2: Proposed pillars to achieve Sustainable Formalization: (i) Mining Operations; (ii) Organizational Structure; and (iii) Partnerships and Collaborations.

5.6.1 Pillar I: Mining Operations

The first pillar for sustainable formalization is improved mining operations. As noted above, single-minded focus on getting as many people formalized as possible leads to insufficient emphasis on improved practices, often meaning that little changes on the ground when miners become formalized. If environmental problems and poor working conditions persist, formalization only succeeds in legalizing bad practices (Marshall and Veiga, 2017; Álvarez-Berríos et al., 2021). Improving ASGM operations is critical if formalization is to be truly sustainable.

Our previous work showed that government formalization programs did little to change realities on the ground for formalized miners in Puno (Martinez et al., 2021b). Despite achieving formalization, the miners lacked initial and ongoing technical support from government agencies to improve their operations. Miners pointed to the need for increased capacity and technical support to shift away from traditional mining practices, the ability to legally purchase supplies required for their operations, and capacity building initiatives to move past legalization. These needs (and constraints) shape the choices miners make in their operations and often result in environmental, social, and economic problems that hinder the sustainability of formalization. Three key areas for improvement of mining operations emerged during our research: mercury use and gold recovery, access to and handling of explosives, and tailings management. All of these areas fundamentally impact environmental responsibility and human health and safety.

5.6.1.1 Mercury Use and Gold Recovery

Although mercury use in ASGM has been referred to as the "tip of the iceberg" of problems associated with the sector (Veiga and Fadina, 2020: p. 1135), it continues to be a focal point for governments, donors, and civil society organizations. Peru signed the United Nations *Minamata Convention on Mercury* in 2014, ratified it in 2016, and it went into effect in 2017. The *Minamata Convention* was designed to protect human and environmental health from releases of mercury and mercury compounds, and it requires signatory countries to develop and implement a National Action Plan. However, Peru has yet to release the National Action Plan required by the convention, outlining how they intend to reduce or eliminate mercury use and its emissions and releases to the environment from the ASGM sector. Without an adequate plan, the mercury problem will not be eliminated by the formalization or legalization of ASGM activities.

The lack of clarity around national mercury reduction goals translates to confusion and inefficient practices on the ground. For example, formalized ASGM miners highlighted that when regional government officials conducted inspections, their two concerns were: (i) whether mercury was purchased legally, and (ii) if miners were using retorts to capture mercury. There was no emphasis on mercury reduction, improved efficiency of mercury use, or alternatives to mercury. This limited focus and lack of support for miners to improve their practices leads them to continue using mercury amalgamation with traditional equipment and processes which negatively impact human and environmental health.

In a recent study conducted by the United Nations Development Programme (UNDP) in three regions of Peru (Puno, Arequipa, and Piura), 94% of artisanal miners surveyed (n=502) indicated that mercury is the chemical most used to process their ore (UNDP, 2021). In line with these results, during our visits to various ASGM operations in Puno, Arequipa, and Madre de Dios, we found that regardless of formalization status, mercury amalgamation continues to be miners' preferred gold recovery method.

According to records from the Peruvian Tax Administration, only 3,808 of the total 88,153 inscriptions (~4%) in the REINFO have legal authorization to purchase mercury, logically meaning that most are purchasing mercury from the black market, regardless of formalization status. More alarmingly, in the field we observed that even miners with authorization to buy mercury legally were resorting to purchasing mercury in the informal markets, citing that the insufficient number of legal suppliers. This example underscores the reality that formalization in and of itself is not sufficient to tackle the complex problems around ASGM, when miners of all statuses depend on black market mercury for day-to-day operations.

There is also a need to improve mercury reduction programs and technical support. As a starting point, it is important to recall that gold recovery rates in ASGM using mercury amalgamation are generally less than 40% (Miserendino et al., 2013; Spiegel et al., 2018). Mercury amalgamation is effective in trapping liberated gold particles coarser than 0.074 mm, but it is unable to recover unliberated gold particles (Martinez et al., 2021a). However, there is no one-size-fits-all solution, and processing methods need to be tailored to the characteristics of the ore body and the mining methods (Veiga et al., 2014a, 2014b). Unfortunately, government and NGO programs over-emphasize gravity processing methods, focusing on mercury reduction goals rather than explicitly targeting improved recovery for ASGM operations. However, prior to suggesting mercury-free technologies, there is a strong need for projects and programs to conduct ore characterization and geometallurgical studies to properly determine what kinds of alternative processing methods might be technically viable. After this initial step, processing methods could be narrowed down based on miner perceptions and community needs. Finally, miners can then be trained on how to improve their gold extraction methods according to their respective site-specific or regional studies.

Another important trend we identified, which has been noted elsewhere as well (Thomas et al., 2019), is that artisanal and small-scale miners' default response to economic challenges is to increase production. To do this, many miners worked longer hours and/or purchased more heavy machinery and expanded facilities to process more ore – all using their established processing methods. Without improvements in processing and gold recovery, increased production only leads to greater environmental impacts, with more waste, more tailings, and greater water consumption. This is a missed opportunity to upgrade the processes that ASGM operations. Better gold recovery could make ASGM operations more economically *and* environmentally sustainable. Gold balance studies that demonstrate the amount of gold miners are losing with their current practices are a first step to encouraging miners to consider alternative methods for improved gold recovery that will facilitate more economically viable ASGM activities while also reducing environmental impacts (Restrepo-Baena et al., 2020).

5.6.1.2 Explosives

During ore extraction, all the hard rock ASGM operations visited in Peru (Arequipa and Puno) obtain their explosives through informal markets. One miner from the Arequipa region stated, "My organization completed the entire formalization process, yet we still rely on the black market for all of our explosives. Nobody has helped us legally acquire explosives or trained us how to use them properly." Government officials echoed this sentiment by highlighting that although some regions have stores where explosives are legally sold, artisanal and small-scale miners continue to purchase explosives through informal markets. The National Coordinator of the Peruvian Small-Scale Miners Confederation, a civil society organization comprised of artisanal and small-scale miners from all mining regions that advocates for the sector, shared that the organization is pushing a proposal to the Ministry of Energy and Mines to provide artisanal and small-scale miners with opportunities to attend workshops, participate in field trainings, and receive technical assistance from professionals on how to safely handle explosives and use appropriate drilling and blasting methods.

Obtaining explosives from the informal markets drastically erodes artisanal and small-scale miners' profitability. We coordinated with a small-scale mining operation in Arequipa to obtain quotes from both a legal supplier and an informal supplier for a standard order of one box of "fully assembled" explosives (3,750 kg of explosives with safety fuses and detonators). The

informal market price was more than double the legal supplier's quote (taxes included) for the same explosives (US$70,140 vs. $32,444). Interviews in other settings suggested some artisanal and small-scale miners pay even higher black-market markups.

While the cost penalty is significant, other factors push miners to resort to informal channels to obtain explosives. Miners highlighted that the most significant constraint was the time spent on acquiring all the necessary permits and authorizations to legally purchase, transport, store, and handle explosives. The permitting process for explosives is the same for all mining operations regardless of size (artisanal, small, medium, and large-scale). Therefore, artisanal and small-scale miners face a difficult time meeting the requirements set forth by National Office of the Superintendent for Security Services, Firearms, Ammunition and Explosives Control for Civilian Use (SUCAMEC). Aside from the permitting process, regulating storage, transportation, cargo clearance (importing) and verification of explosives operators, government does not have a role in controlling sales of explosives. Generally, medium to large-scale mining companies have no difficulty acquiring these permits prior to construction and operations, as they have the necessary knowledge and expertise. On the contrary, artisanal and small-scale miners lack guidance and technical support in handling explosives and acquiring the permits. One miner stated, "Who knows, by the time they approve all my permits, this mine will be done, and I'll be working at another mine. But for now, I have to eat." This statement highlights the miner's feelings towards the lengthy permitting process as well as the risk he is willing to take by continuing to use explosives purchased from informal markets.

Ultimately, the cost and challenge for artisanal and small-scale miners to complete the lengthy explosive permitting process and maintain certification could offset the savings from legally purchasing explosives. Similarly, even with miners acquiring all explosives permits, there is no assurance that this will improve miner's health and safety and reduce fatal accidents in underground mines. The most recent publicized incident occurred on March 31st, 2022, with three fatalities and the disappearance of seven workers (miners and engineers) after the blast and collapse of a mine in Nasca (Diario La Opinión, 2022). Prior to this event, two miners lost their lives inside of a mine in Puno on January 12th, 2022, from carbon monoxide asphyxiation after blasting (La República, 2022). Similarly, in October 2021, four miners died inside of a mine in Puno from carbon monoxide asphyxiation after blasting (La República, 2021). However, when

speaking with miners and government officials, they both asserted that such accidents are very common and most go unreported. To our knowledge, there are only records of one explosives training project in Peru (Veiga et al., 2015) that took place in the Piura region in 2013-2014 and trained 15 artisanal miners on: (a) explosives handling; (b) underground ventilation; (c) scaling and falling rocks; and (d) operational safety. If the aims of formalization are to improve artisanal and small-scale miner's practices, educational trainings and support such as these should be more frequent and widespread throughout all mining regions.

5.6.1.3 Tailings Management

Aside from the issues associated with ore extraction and mineral processing, a reoccurring issue that was observed among all formal ASGM operations is poor tailings management practices which pose both human and environmental risks. The main environmental issues associated with poor tailings management practices at formal operations align with those that have been observed in previous studies (Velásquez-López et al., 2011; Miserendino et al., 2013), such as: (1) dumping tailings with mercury and other heavy metals into natural drainages; (2) using cyanide to extract gold from mercury-rich tailings; (3) a lack of geomembrane liners to decrease permeability beneath the tailings and prevent seepage into ground and surface water. In many settings, we observed that ASGM mining operations built simple tailings impoundments; however, there was no monitoring or geotechnical and geochemical expertise involved in the design and construction. This poses a great risk for mining communities as well as downstream communities due to the potential consequences of dam failure even for small tailings storage facilities.

Due to a lack of reporting, accurate numbers of tailings dam failures in the ASGM sector do not exist. However, anecdotal information from miners and site visits revealed that tailings dam failures are quite common and have resulted in the destruction of property, contamination of waterways, and fatalities. For example, we were informed of a tailings dam failure in 2019 that claimed the life of a community member who was driving on the road during the failure and was buried and suffocated by the tailings. In November 2021, another tailings dam failure occurred in the same mining district at another formal ASGM operation (Figure 5.3). When speaking with small-scale miners in Puno, they repeatedly stated, "We are running out of space, we don't know what to do or where to put our tailings anymore. These accidents will continue to happen if we

continue to use the same practices." This issue is further complicated by mine leaders' expectation that they could reprocess their tailings in the future if the price of gold continues to increase, influencing their tailings storage and disposal decisions.

Regardless of whether ASGM operations were formalized, none of the sites we visited employed or consulted with qualified technical professionals specialized in tailings dam design, tailings dam monitoring, or mine waste management. In addition, formal miners mentioned that they had never received any training on how to adequately design, construct, or maintain their tailings storage facilities. Miners continue to use the same methods that were used prior to formalization including depositing tailings into the same ponds but topping off the surrounding walls, to try to minimize the release of tailings into the environment. It is apparent that formal miners require increased support to implement responsible tailings and waste management practices to protect humans and the environment.

Figure 5.3: Photos taken after a tailings dam failure occurred at a formalized ASGM operation in the Puno region in November 2021. The photo on the left (A) shows the road being destroyed due to a tailings dam bursting under the road and flowing from circle 1 to circle 2. The photo on the right (B), downstream from photo (A), shows one of the trucks that was dragged by the flow of tailings into an embankment.

5.6.2 Pillar II: Business Development

A key component that is necessary for successful and sustainable formalization programs which has not received a great deal of attention is business development for ASGM organizations. The ASGM sector has been largely associated with a gold rush mentality where miners operate until the resource is depleted, leading miners to abandon their workings and migrate to other mines (Mkodzongi and Spiegel, 2020). However, for miners who have invested time and capital into fulfilling all the formalization requirements, this is not generally the case. Instead, miners have identified that the greatest incentive of becoming formalized is the ability to work undisturbed (Martinez et al., 2021b). Bearing this in mind, through our investigation and analysis of formal operations, we observed that one of the greatest shortcomings was the lack of support being provided to help miners grow as entrepreneurs. Rather than assuming miners already possess the necessary business acumen to assure long-term sustainability, formalization efforts need to provide additional support to transform miners into enterprising businesspeople. Through our investigation and analysis of formal operations, three aspects that emerged and are critical to business development and the long-term sustainability of ASGM organizations were corporate governance, access to banks and loans, and gold commercialization and exporting.

5.6.2.1 Corporate Governance

As top-down formalization strategies focus on the legalization of ASGM activities and view formalization as the end goal, the long-term sustainability and profitability of formal ASGM operations is uncertain. Government officials we interviewed shared that two of the greatest struggles for newly formalized miners are: (i) remaining in compliance with the laws and regulations, and (ii) reinvesting their profits to improve their operations and practices. Although government officials recognize these shortcomings and challenges, they have been unable to address the problems adequately. The first of these struggles is strongly associated with miners being unaware of their new responsibilities, while the latter is largely due to miners believing that their current practices are adequate, otherwise, they would not have been able to become formal.

An ex-president of a mining cooperative in the Puno region shared that during his term as president he tried to implement more efficient gold recovery methods to eliminate mercury use and increase profits. However, he faced a great deal of resistance as the majority of the members

of his cooperative did not perceive the investment to be worthwhile, since they were able to obtain profit by using mercury amalgamation methods for gold recovery. Similar experiences were shared by other organizations. A current president of another mining organization in Arequipa added that sometimes the leadership within mining organizations is risk averse and resists changes, as they do not want to "gamble away their profits" switching to methods with which they are unfamiliar. These examples demonstrate the importance of understanding the internal dynamics of ASGM operations and how they influence sustainability.

ASGM formalization policy must not only target mining operations and practices; it must also target educating miners about corporate governance. Miners cannot simply be told to improve their practices. They need practical education on how to manage their own organizations to achieve improvements. For example, many formal ASGM organizations we visited had organizational structures in place that mimicked positions in conventional mining companies, such as accountants, logistics coordinators, marketing and commercialization professionals, operations advisors, and strategic planners. Creating these organizational structures helped the miners achieve formalization, but most of the changes were only on paper. The people filling these newly created roles were members of the organization who did not possess the necessary training and knowledge that the titles implied. These situations underscore that even when miners try to do things correctly and comply, they fall short as they do not have the capacity and education to fulfill these roles and actions.

For formalization efforts to be sustainable in a sector dealing with non-renewable materials, such as mining, formal operations and their leaders need to be educated and well-versed in running and operating a business to boost their environmental and economic sustainability. Organizational structures are critical for miners to achieve formalization, but without orientation on the importance of balancing their worker's immediate needs (salary, wages, health insurance, etc.) with the company's mid to long-term sustainability efforts then there is no assurance that formalization will lead mining organizations to grow as entrepreneurs and continue to increase their profits.

5.6.2.2 Access to Banks and Loans

A constant hurdle preventing miners from implementing better technologies, equipment, and practices is the lack of access to financial resources. In 1972, the Peruvian Mining Bank was

established to provide credits to miners, purchase their gold, and provide technical support (Cortés-McPherson, 2019). However, in 1992 the Peruvian Mining Bank was disassembled, and large-scale foreign financed projects were promoted instead of national small and medium-scale projects. In 2017, Legislative Decree 1336 stated that a Mining Fund would be created with financial resources allocated by the Ministry of Economy and Finance. This Mining Fund was slated to provide loans to both formal miners and miners in the process of formalization; however, the Ministry of Economy and Finance never allocated money into the fund, leaving artisanal miners without the support from any federal financial institution.

The lack of financial support from the government is compounded by the reluctance of private financial institutions to provide services to formal small-scale miners. A common misconception among private lenders is that all ASGM activities are *informal* and thus, carry legal, environmental, and economic risks (UNDP, 2021). In terms of legal risks, financial institutions fear being investigated for financing illicit activities or money laundering, since miners are often unable to provide receipts for all their purchases. As highlighted in the previous section, a high percentage of formal miners continue purchasing mercury and explosives from informal markets, which would be problematic for financial institutions to justify. Due to the negative publicity around ASGM in Peru focusing on cases of drastic environmental contamination, deforestation, and vice, financial institutions do not want to be associated with ASGM.

In addition to reputational concerns, banks are wary of ASGM's risk profile. The improvised nature of much ASGM could create greater risk of loan default. Unlike conventional mining companies which provide banks with geologic studies and reserve projections as evidence that they will be able to repay loans, nearly all artisanal and small-scale miners lack information on geology or reserves. This geologic uncertainty is a major risk factor for miners themselves, who rely on intuition and experience to decide where to mine and how to develop their operations. This uncertainty and risk would in turn affect banks who loan to ASGM. In addition, under current conditions, artisanal and small-scale miners usually attempt to obtain personal loans or small business loans, rather than following practices of larger mining companies that seek business loans tied to a specific project. The trend towards personal loans presents a significant challenge for miners who lack financial education and commonly have bad

credit or no credit history. These miners do not fit the customer profile that banks are used, and no ASGM-specific programs exist to support their access to credit. Lastly, as banks do not have employees specialized in the ASGM sector, there is also a lack of experience on behalf of financial institutions working directly with artisanal miners and lack of familiarity with the laws associated with the sector. Many banks decide to avoid ASGM, rather than investing the time and effort to learn how to deal with the sector.

Access to financing and credit support is a key prerequisite to achieving sustainable formalization and financial development. If miners are provided with access to financial resources, they may invest in improving their operations through the purchase of more efficient technologies and equipment that allows them to increase their productivity. Miners are encouraged to become formal, yet they are not included in the formal financial system, which prevents their growth and financial development. It has been estimated that Peruvian artisanal and small-scale miners need a total of USD 344 million in financing to increase their production and generate development (UNDP 2021). In many cases, the amount of credit needed or desired by individual ASGM operation is small. According to the UNDP (2021), the average personal loan needed by formal miners to improve their operations is USD 14,180. Given this reality, even a micro-credit program could support many artisanal miners and limit risk for financial institutions, although past studies reveal some challenges for the model (Siegel and Veiga, 2009; McDaniels et al., 2010).

5.6.2.3 Gold Commercialization and Exporting

In Peru, 10,554 miners have become formalized; however, government officials shared that there is virtually no data on how many of these miners are directly commercializing and exporting their gold. Most sell to local middlemen, who are commonly tied to informal markets. We asked formalized miners why they were not directly exporting their gold. The four most common responses were: (1) the lengthy Peruvian Customs paperwork; (2) the costs associated with exporting (~USD $4000/per shipment regardless of gold mass); (3) the lack of connections to a secure, legitimate gold buyer; and (4) the lack of trust in Peruvian Customs, as they have a history of confiscating legal gold from artisanal and small-scale miners even when they have all the necessary permits. Ultimately, miners lack of trust and knowledge leads them to sell their gold to local buyers so that someone else can assume the risks of exporting.

Artisanal and small-scale miners continue to strongly rely on local market middlemen who purchase their gold at suboptimal prices. These local gold buyers purchase gold and then sell it to larger gold buyers or aggregators who are able to cover the export costs and logistics, because they are exporting larger volumes of gold. According to our interviews, government officials are aware of two types of formalized miners who directly commercialize and export their gold: (1) gold processing plants, and (2) miners who have achieved gold certification. Of the 10,554 formalized miners, these two groups only account for a very small number of miners: 23 processing plants and five certified gold mining organizations. Overall, these two groups account for less than 1% of all formalized miners in the country, who are directly commercializing and exporting their gold to international markets.

Formal miners continuing to rely on informal markets has been observed as a shortcoming of ASGM formalization by government officials, as one of the goals of formalization is for artisanal and small-scale miners to legally commercialize and export their gold allowing the government to collect taxes from the sector. According to data from the National Bank of Peru (BCRP) and the Peruvian Tax Administration (SUNAT), on average, almost half (44%) of monthly exports in 2021 were Unregistered Gold Exports coming from the ASGM sector (Figure 5.4). These Unregistered Gold Exports are largely associated with artisanal and small-scale gold miners who are either informal or those who are formal but are not directly commercializing their own gold.

Even formalized ASGM miners face barriers to legally commercialize their gold, so it is difficult for them to benefit from the international price of gold. Given challenges around scale and logistics, perhaps the solution is not to have all artisanal miners aspire to directly export. Alternative models could be explored to provide formalized miners with fair and responsible intermediaries, such as the prior model of the Peruvian Mining Bank. Under such a model, it would be important to establish gold purchasing centers near the most prolific mining regions so miners could avoid the high costs and robbery risk associated with traveling to major cities to sell gold. Reducing reliance on informal buyers is essential for formal miners to receive a fair price for their gold. Members of the mining community stated that they would like to see the Mining Bank return to purchasing their gold to eliminate middlemen. Perhaps this can be revisited, however future research is necessary to develop an adequate gold buying program for formalized artisanal and small-scale miners that allows them to benefit from fair gold prices and

prevents them from resorting to local, informal buyers. Possible models to emulate include ENAMI in Chile (Castro and Sánchez, 2003; Hilson, 2020a), and government gold buying programs such as Ecuador or Mozambique (Dondeyne and Ndunguru, 2014; Thomas et al., 2019). Some of the key considerations are: funding, location/mobility, security, payment, and strategies to avoid middlemen controlling these markets. Previously, host governments have funded these programs with the support of donors. However, the location, mobility, and security of such programs has largely excluded the most vulnerable mining communities. In both Ecuador and Mozambique, middlemen have been able to control these markets as miners are unable to travel to major cities, and governments have placed a maximum volume of gold that artisanal miners can sell without having to pay royalties. If these considerations are not addressed, gold buying programs will fail and miners will continue to rely on informal gold buyers.

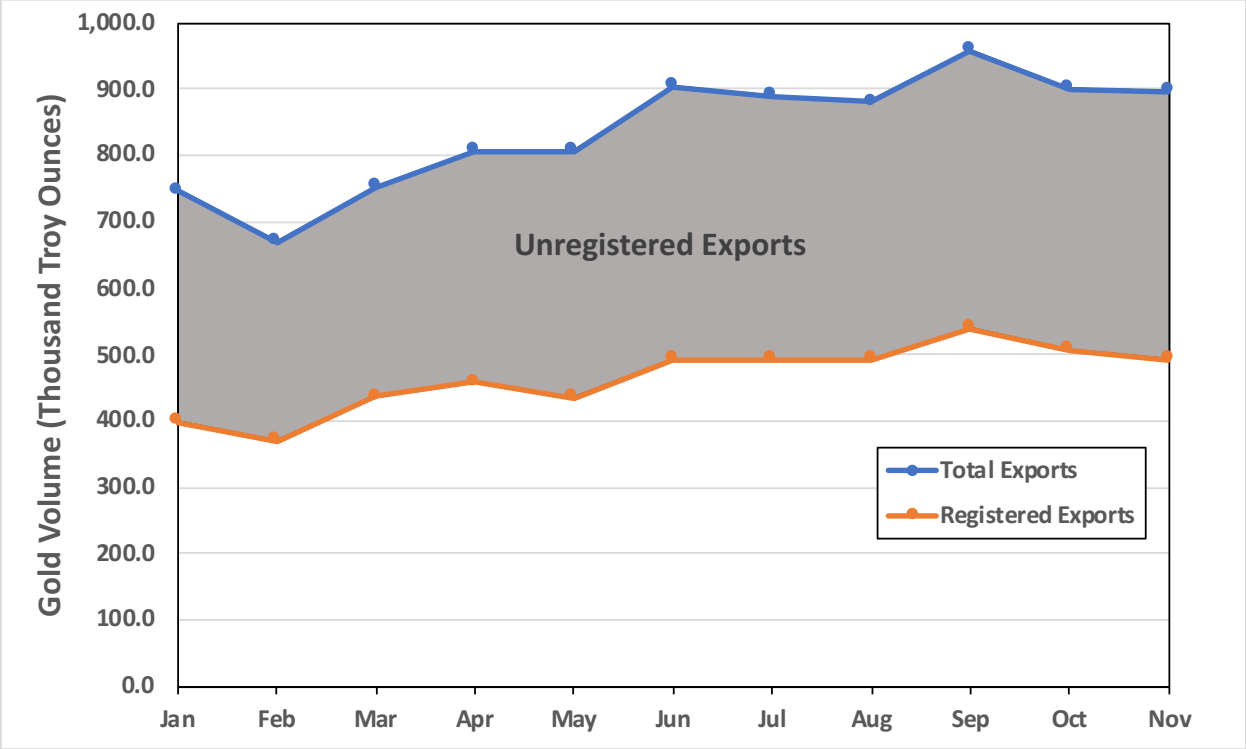

Figure 5.4: Plot of the Total Monthly Gold Exports (blue) with Registered Monthly Gold Exports (orange) for 2021 (data obtained from the Peruvian National Bank and Peruvian Tax Administration). The grey area is the estimated Unregistered Monthly Gold Exports.

5.6.3 Pillar III: Partnerships and Collaborations

The last pillar in the proposed approach towards achieving sustainable formalization is partnerships and collaborations. After analyzing some of the ongoing challenges for formal miners in the previous sections, it is safe to conclude that there is not a single entity that can tackle all the shortcomings of formalization. Therefore, it is imperative that government entities, donors, NGOs, and private sector work together in supporting formal artisanal and small-scale miners in accessing the tools, knowledge, and resources needed to improve their operations. If formal miners lack information and guidance on how to remain in compliance, implement responsible mining practices, and grow as entrepreneurs, then becoming formal will have marginal (if any) impacts. Evidence from the field suggests that partnerships can create valuable opportunities for artisanal and small-scale miners to improve their operations. In the next sections we discuss some of the partnerships and collaborations observed in the field and their impact as well as possible considerations.

5.6.3.1 Government/State Support

There is a lack of partnership between artisanal and small-scale miners and the specific government entities aimed at supporting formalized ASGM operations. Most formal miners highlighted that they had not received any support on how they should improve their operations. Rather, the government's focus has largely been associated with complying with laws and regulations. However, during interviews, government officials from the General Directorate of Mining Formalization (DGFM), highlighted that public-private partnerships (PPPs) had been formed to provide formal miners with technical support to improve their operations and implement more responsible practices. Some of DGFM's partners include the Artisanal Gold Council, Better Gold Initiative, Planet Gold, and USAID. In 2020, a total of 595 miners in five regions of Peru received trainings at workshops on best mining practices with a focus on clean technologies, occupational health and safety, and gold commercialization. Although this is a positive step, the number of formal miners participating in these workshops was less than 6% of all formalized miners, and less than 1% of all miners registered in REINFO.

Another necessary but absent form of collaboration is intragovernmental cooperation among the different Peruvian ministries. In Peru there has been a strong disconnect in terms of approaches to ASGM formalization among different government entities. In December 2021, the

Peruvian government voted to extend the ASGM formalization process two more years allowing miners to continue operating while fulfilling all the requirements and acquiring the necessary permits to become formalized. This decision was favorably viewed by the Ministry of Energy and Mines because it allowed them to continue working towards legalizing ASGM activities. However, this decision was met with strong resistance from environmental NGOs and the Ministry of Environment, as these organizations believe that miners enrolled in the formalization process simply use their inscription as protection against government interventions and continue operating and polluting without completing the entire process (Actualidad Ambiental, 2022). In terms of achieving sustainable formalization that moves past empty promises and formalization just "on paper", the lack of political will among distinct government entities to openly support and improve the ASGM sector will continue to discourage miners from operating in a legal sphere.

5.6.3.2 Civil Society Actors

In Peru, the most common partnerships observed in the field, as well as the most cited and praised by government officials, were international NGOs working with artisanal and small-scale miners through their voluntary gold certification programs (e.g., Fairmined and FairTrade). Peru currently has five responsible gold certified mining operations, which is the most of any country with ASGM operations. These certification programs provide miners with a fair price for their gold and an additional incentive for implementing responsible mining practices and improving traceability. However, there are various barriers to entry, including requirements that most artisanal and small-scale miners are unable to meet to obtain and retain gold certifications. For example, to become Fairmined certified, ASGM organizations must have completed the entire formalization process and must have a minimum monthly production of 1.74 kg of gold for the certification program to prove economically feasible (Martinez et al., 2022). Although these programs were initially developed for the ASGM sector, it has been argued that these programs only target the "low-hanging fruit" or medium-scale miners who are well-organized and able to meet the stringent certification standards (Hilson, 2014; Hilson and McQuilken, 2016; Hilson et al., 2016, p. 241; Hilson et al., 2018). Other studies have highlighted that certification programs have the potential to improve miner's well-being and contribute to reducing environmental impacts and ensuring social development (N. Martínez et al., 2021;

Martinez et al., 2022); however, the reach of these programs remains limited with only 246 miners directly benefitting from the Fairmined certification in Peru. Ultimately, even if the requirements were lessened to allow for greater participation by ASGM operators, if there is not a market and consumer demand for 'responsible' gold then these programs will not function as theorized. During the COVID-19 pandemic, certified miners experienced numerous challenges when attempting to export their gold, due to exorbitant export prices as well as a decrease in demand for certified gold (Fairmined, 2020).

5.6.3.3 Private Sector

The private sector in Peru has taken an approach distinct from that of government entities and NGOs to help miners achieve formalization. Some medium-scale mining companies in southern Peru have signed exploitation contracts with artisanal and small-scale miners working on their concessions and have assumed an intermediary role between artisanal miners and government entities (Solidaridad, 2022). Artisanal miners are generally demonized by government entities, which has strongly fueled their lack of trust and opposition towards government. However, this type of model allows miners to continue operating without having to undergo the entire formalization process on their own (Holley et al., 2022). They report to the company, instead of the government, while abiding by mutually negotiated agreements.

Generally, in these arrangements, artisanal and small-scale miners extract ore from their specific workings, turn over their ore to the company, the company then sends the ore to a lab where the gold grade is analyzed, and after obtaining the lab results, the company pays the miners a set percentage of the gold content in the ore (e.g., 30%). Under this model, artisanal and small-scale miners do not need to worry about mineral processing with mercury, gold recovery, tailings management, or commercializing their gold. Rather, the company's business focus is on mineral processing and commercialization. This type of arrangement allows miners to focus on mining, while the company handles all the ore-processing, permitting, and legal issues. Researchers have identified that co-existence models conducted with full transparency and trust have the potential to be the most effective solution to eliminate mercury use and pollution, as the companies are not processing ore with amalgamation (Veiga and Fadina, 2020). However, if miners are operating in an area where the private sector is not present, which is very common in

Peru, then this is not an option. This model has potential, but also faces important challenges, which are beyond the scope of this paper (see Malone and Martinez, forthcoming).

5.7 Conclusion

The ASGM sector has proven challenging for governments, NGOs, or international actors to influence. Substantial emphasis on mercury reduction has yielded only modest results (Veiga and Fadina, 2020), and formalization programs have similarly struggled in many cases (Persaud et al., 2017; Zolnikov and Ortiz, 2018; Prescott et al., 2022). Peru's relative success – though still partial by any standard – demonstrates the importance of strengthening post-formalization planning now, even as formalization itself proceeds more slowly than hoped. Early indications from Peru show that formalization without ongoing support or adequate infrastructure can result in backsliding and reversion to informality (Martinez et al., 2021b).

The sustainable formalization framework presented in this paper provides a guide for a more holistic approach with a longer-term orientation. The model's three pillars, a) Mining Operations; b) Business Development; and c) Partnerships & Collaborations, cover key areas where many ASGM operations struggle. The framework pillars are designed to be generalizable, though we emphasize that there are no one-size-fits-all solutions for a sector as diverse as ASGM. Thus, the specifics of each pillar can and should be adjusted for different contexts, taking into account field data and adapting the post-formalization framework to particular regions and jurisdictions.

Another key motivation for focusing on a post-formalization framework is the observation that formalization often merely legalizes ASGM operations without leading to improved practices or substantial changes on the ground (Van Bockstael, 2014; Verbrugge and Besmanos, 2016; Robles et al., 2022). In this regard, have a plan that bridges from formalization into post-formalization with a longer-term focus and holistic approach is of paramount importance. Governments and policymakers should not wait until most miners are formalized to create a sustainable formalization plan. A plan or strategy should be developed as formalization continues, or even from the start of formalization efforts, to ensure that formalization creates needed improvements in environmental, labor, and social areas, and strengthens ASGM operations. Changes of this type are needed if ASGM is to reach its identified potential as a driver of development and shed its most problematic elements.

5.8 Acknowledgements

We would like to thank all the interviewees for taking time out of their busy schedules to participate in the research, and the miners for allowing us to visit their operations.

CHAPTER 6
POTENTIAL APPLICATIONS AND RECOMMENDATIONS FOR FUTURE WORK

6.1 Conclusions and Potential Applications

This research demonstrates that the formalization of ASGM activities is a fundamental step towards transforming the sector into a more sustainable livelihood. However, formalization alone has had mixed results and does not solve all the issues associated with the ASGM sector. NGOs and their voluntary gold certification programs have the potential to enhance formalization efforts by providing miners with capacity-building opportunities and market-based incentives to implement responsible mining practices. This dissertation supports the argument that in order for formalization to be sustainable, governments cannot expect formalization to be the end goal. Rather governments and policymakers must develop and implement post-formalization plans to support and better incorporate formal miner's new challenges after becoming formal. This section summarizes the conclusions of each of the dissertation's research questions.

What are the outcomes of ASGM formalization and are state-led efforts sustainable?

The case study of formalized ASGM operations in the Puno region of Peru revealed that formalization has yielded mixed results. On the one hand, formalization has led ASGM operators to improve health and safety practices and labor conditions at the mine. Formal miners also improved their environmental practices and believe that environmental awareness among employees has increased. However, the technical and environmental improvements that miners have implemented are a direct result of miner's initiatives and their capacity to hire professionals and improve practices, without state support.

Despite formalization laws promising technical support to formal miners, this purported benefit never materialized. In addition, formalized miners felt burdened by new responsibilities, increased scrutiny, and lack of guidance from the state. This study concludes that even in what can be considered the optimal case of formalization in which miners were able to organize themselves, obtain legal titles and mining rights, and become formal, there are persistent challenges which may push miners back towards the informal sector. Instead of miners feeling

more protected, accompanied, and supported by the state, they feel more persecuted and scrutinized than when they operated informally.

Ultimately, state-led formalization of ASGM activities continue to resemble legalization of ASGM operations rather than capacity-building, which is necessary for adequate formalization. In order for formalization efforts to prove more fruitful and sustainable for miners and government officials, it cannot be seen as an end goal or a strategy to make ASGM more legible. Governments working on formalizing ASGM activities would greatly benefit from the creation of a post-formalization strategy with allocated budgets and personnel focused solely on educating and supporting formal ASGM operations.

Are voluntary gold certification programs a viable mechanism to enhance ASGM formalization efforts and improve the sector?

The case study of gold certified ASGM organizations in Chapter 3 presents a critical examination of the practical impacts when certification is achieved. The chapter found that voluntary gold certification programs are providing miners with incentives and capacity-building opportunities that are driving ASGM organizations to implement better environmental management practices and health and safety practices. Voluntary gold certifications also legitimize artisanal and small-scale mining activities and connect operators with international stakeholders. This has allowed certified ASGM organizations to strongly benefit from the economic incentives of selling their gold internationally, and they are investing premiums into projects that benefit their workers, operations, and mining town. These findings suggest that voluntary gold certification programs are filling voids that top-down ASGM formalization strategies are not fulfilling.

This study concludes that although gold certification programs have the potential to positively impact the three dimensions of sustainability— economic, environmental, and social—there are challenges that will have to be overcome for small-scale mining organizations to achieve and maintain certification status and contribute to sustainable development in and around the communities where they operate. The study identifies a set of longer-term issues that can affect the sustainability of voluntary gold certification programs. Some of these include: (i) lack of geological data; (ii) abandonment of mines due to resource depletion; and (iii) mine closure and remediation. The findings suggest that in order to target longer-term sustainable

development, governments, donors, civil society actors, and funding agencies should focus on sidelined issues as well instead of primarily focusing their attention on mercury.

What are the prevailing issues after becoming formalized and how to overcome them to achieve sustainable ASGM formalization?

The proposed three-pillar approach in Chapter 5 suggests a framework for identifying the support formalized miners require to achieve sustainable formalization. This chapter highlights that regardless of the geographical mining region (high Andes, coastal, and Amazonian) and time elapsed operating in the legal sphere, there are common challenges among miners which formalization does not resolve. This study finds that the prevailing issues which formal miners continue to struggle with fall into three categories: (i) Mining Operations; (ii) Business Development; and (iii) Partnerships and Collaborations. This study examines each category in depth and provides insights on how to support miners and prevent formalization efforts to be unsustainable.

This study suggests that governments should allocate significant resources to addressing formal miner's concerns and challenges and thereby achieving measurable changes and improvements at mine sites. Moreover, these findings suggest that formalization policy should encompass all aspects of the mining life cycle as well as business and managerial aspects associated with operating a mining organization/company. Lastly, this research highlights that although formal miners in different regions continue to struggle with similar issues, there are some issues which cannot be overgeneralized, and thus post-formalization support must be site-specific.

Collectively, these three studies conclude that formalization policy and efforts end once miners meet all the formalization requirements. The dissertation calls on governments, policymakers, donors, NGOs, and IGOs to place a greater emphasis on what comes after miners become formalized. Formalization efforts are unsustainable if the end goal is simply to formalize the greatest number of miners possible. NGOs and their voluntary gold certification programs have the potential to enhance formalization efforts by targeting economic, social, and environmental issues. However, these types of support need to be more widespread and readily available for formalized miners. It recommends that host governments engage their formal

miners to obtain more nuanced understandings of the new challenges that formalization brings for artisanal miners operating in the legal sphere.

6.2 Recommendations for Future Work

This research raised several questions that the author was unable to pursue. This section discusses the most potentially impactful opportunities for future work.

6.2.1 Continued Examination of Formalization and Formalized Operations in Peru

Peru remains compelling as a case of ASGM formalization. The Peruvian Directorate of Mining Formalization has potential to be the most proactive government entity in South America to deal with formalization of artisanal and small-scale gold miners. There are currently over 10,000 miners formalized throughout the country, yet data on these operations is extremely limited. The present case study analyzed the impacts of formalization at an ASGM operation in one of the most important mining districts in the Puno region. It identified that formalization had mixed results and rather than miners feeling protected and receiving support from government, they felt more pursued. However, there remains significant potential to examine more formal operations and evaluate a wider selection of variables (e.g., gold recovery methods, gold production, mercury use, heavy machinery, water consumption, etc.). With greater examination of formalized operations, this can help guide policymakers, governments, donors, and NGOs, obtain a clearer picture of the most pressing issues, and provide more useful support and capacity-building initiatives.

In December 2021, the Peruvian government decided to extend the formalization process and provide miners with two more years to obtain all the legal permits and complete all the formalization requirements. However, despite this extension it is unclear how this will affect the ASGM sector in Peru.

Some questions that need to be further studied include:

- How will the recent formalization process extension affect miner's decisions to become formalized? Will the number of formalized miners continue to decline, or will this extension reverse the trend? What is the future of formalization in Peru?

- How many formal ASGM operations remain in compliance with all the laws and regulations? How many formalized operations have lost their formalization status?
- Are formal operations safer than informal operations? Are accidents and fatalities less likely to occur at formal operations? Are formal operations contributing the same amount of mercury into the environment than informal operations?

Throughout the study, the case of Chile's copper formalization process was cited by various individuals as a successful case of top-down formalization in which artisanal and small-scale copper miners can receive financial resources and technical support to sustain their operations. After ore extraction and mineral processing, the government purchases copper from miners and handles exporting procedures. A comparative study could address some of these questions:

- Why are the apparent outcomes of formalization of artisanal miners so different in neighboring countries? What are the key differences between formalization strategies?
- How do the attitudes and perspectives of government officials from each country differ towards formalization miners? How do the attitudes and perspectives of miners vary towards government officials?

6.2.2 The Future of Gold Certified Operations and Evolution of Certification Programs

The case study of gold certified operations presented in Chapter 3 fills a gap in the certification literature and provides fundamental data on the outcomes and shortcomings of voluntary gold certification programs. This study identified that NGOs and their certification programs have the potential to impact the three dimensions of sustainability. However, voluntary gold certification programs were originally developed to support miners through a ten-year program. To date, there does not exist any ASGM organization that has reached the final stage of the program, therefore it is very important to analyze whether this will come to fruition. As scholars begin to better understand the impacts of voluntary gold certification programs, some questions include:

- What will be the future of certified ASGM organizations in Peru? Will organizations be able to reach the end of their current certification programs and pursue a more complicated gold certification program (e.g., Responsible Jewellery Council)? If so, will

these impacts motivate additional organizations to pursue certifications? Or, will organizations continue to decertify leading miners to lose interest in voluntary gold certification programs?

- Over the course of this study, there was an increase in Authorized Suppliers (e.g., refiners, traders, manufacturers, and casters that are authorized to trade Fairmined gold) and Licensed Brands (e.g., affiliated brands authorized to sell final consumer products made of Fairmined metals), however, volume of certified gold purchased from ASGM organizations has declined. Further investigation is necessary to discover the underlying reasons and explanations for these conditions and the impact it has on certified operations.
- What percentage of Authorized Suppliers and Licensed Brands purchase gold from ASGM organizations? At what rate and quantity? Are there trends among Authorized Suppliers and Licensed Brands? Are these stakeholders willing to continue purchasing gold at smaller volumes and higher prices?
- The Alliance for Responsible Mining recently developed a less stringent, feeder program (CRAFT Code) to the Fairmined certification which targets miners who have yet to fulfill all the formalization requirements. The idea behind the code was to create a program readily available for the majority of miners regardless of formalization status. However, further research is necessary to understand whether these types of codes are stringent enough to create change in the field.

6.2.3 Mercury Reduction and Elimination Efforts

Chapter 4 critically examines the most common gravity separation and concentration interventions which have been implemented in the ASGM sector. This work is critical in guiding governments, policymakers, donors, civil society actors, and researchers, to avoid reinventing the wheel and making the same mistakes. The research highlights that gravity separation and concentration is not the final solution to eliminate mercury use in ASGM, but it can reduce the use of mercury and its release into the environment. One critical line of research that is necessary moving forward to convince miners to adopt cleaner practices is to conduct gold balance studies to examine the percentage of gold being recovered with artisanal miner's current processes. In

addition, interventions aimed at reducing mercury must extract gold from miner's tailings to show miners that they are losing gold. These programs should train miners how to recover this gold in the tailings and educate miners on which methods could be used to avoid these losses. Lastly, it is imperative that mercury reduction and elimination interventions are not created with a one-size-fits-all perspective.

6.2.4 Improving and Refining the Proposed Pillars

The proposed pillars to achieve sustainable formalization presented in Chapter 6 is a newly suggested tool to help guide governments, policymakers, civil society actors, donors, and researchers on determining post-formalization issues and how to resolve them. Research has highlighted that "formalization cannot exist without education" (Marshall and Veiga, 2017). Through our study it was observed that the Directorate of Mining Formalization identified various formal ASGM organizations to provide them with trainings and workshops to enhance formalization efforts. However, the outcomes of these efforts are questionable as the trainings and support provided to formal miners was not permanent.

As the framework pillars are designed to be generalizable, future research should be conducted to adjust the pillars for different contexts. It is emphasized that there is no one-size-fits-all solution for a heterogeneous sector as ASGM, but the pillars can be refined based on field data including miner's needs, motivations, and capacity. Some future questions to be explored are:

- If post-formalization efforts took into account miner's preferences and realities (bottom-up approach), would this lead to safer and more responsible practices?
- What are the persistent informalities among formal ASGM operations?
- What support do state actors require to help improve their strategies in fulfilling a sustainable ASGM formalization?

6.3 Final Thoughts/Concluding Remarks

In order for formalization to be sustainable for all stakeholders involved, there needs to be a long-term vision and support from all stakeholders. If governments lack the political will to acknowledge and openly support the ASGM sector, then formalization efforts will prove unfruitful and unsustainable. Although this seems straightforward, after spending years working

with the ASGM sector, there is constant opposition and resistance to support artisanal and small-scale miners from different government entities and officials. As with most research in developing countries, corruption and high government official turnover rate are two uncontrollable issues that plague host governments and in turn affects their governance strategies.

Throughout my dissertation, there will be some people who disagree with my interpretations and conclusions. The heterogeneity throughout the ASGM sector within countries and around the world makes it very difficult to capture all perspectives and realities. One thing we can all agree on is that there is no silver-bullet solution that will resolve all the issues associated with the ASGM sector. However, I am hopeful that despite disagreement, people will see the honest attempt in capturing the reality of ASGM in Peru. I also expect some readers to feel that some details regarding illicit activities were omitted, and to be completely transparent, that is an accurate assumption. As I wrote these chapters, the goal of my research was not to incriminate any group of miners or mining operations, rather the goal was to focus on the overarching objectives and their ongoing struggles. I am hopeful that my work contributes to the increased support of miners by highlighting ASGM operators who are committed and open to transforming their practices into more responsible, sustainable livelihoods. I am also hopeful that this work will urge governments and policymakers to prioritize formal miners and consider their site-specific realities when developing educational and capacity-building programs.

This work aims to uncover some of the mystery associated with formalized ASGM operations. I am hopeful that this work convinces some people that not all artisanal miners should be demonized and considered *illegal* miners. Although a silver-bullet solution does not exist, there are some bad practices that can be eliminated through site-specific, longitudinal technical support and capacity-building initiatives. I am hopeful that if nothing else, the reader can come away with an appreciation and understanding of the challenges associated with the ASGM sector, the complexity of solving these issues, and the importance of solving these issues for our global society and future generations.

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