Ecuador Gold Supply Chain: Analysis of Government Intervention in the Artisanal Mining Sector

by

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ABSTRACT

The government of Ecuador has been attempting to modernize the artisanal and small-scale gold mining (ASGM) sector to increase tax benefits, reduce pollution, reduce money laundering and formalize informal miners. One of the strategies to help legitimize the supply chain is a program implemented by the Central Bank of Ecuador (CBE) through its Gold Purchase Program in Sangolqui that focuses on the ASGM sector. The attraction for miners to sell gold in Sangolqui is due to the international price paid by CBE for their gold, as well as 0% deductions for service and 0% IVA. The main hurdles to expand the CBE include:1) distant location of the CBE GPP office in Sangolqui, near Quito (miners take 3 days to go by car or plane from southern Ecuador); 2) Neither local gold buyers nor CBE pay for the silver content in the *doré*; 3) Lack of security for the miners when travelling to Sangolqui with their gold; 4) Legal inadequacy, as the CBE GPP buys gold only from legal and registered sellers; 5)The CBE requests full registration of the gold sellers with ARCOM, which is a complex process; and 6) In some cases, the time lag to receive the money from the CBE GPP is too long (up to 14 days). Some suggestions to improve the CBE GPP were generated from the findings of this study, including: 1) The CBE could reinforce its presence and influence in the mining regions by establishing permanent or temporary offices near the production areas; 2) Supply a mobile purchasing unit in an armored car; 3) All of the artisanal miners in the country, formal or not, should be able to sell gold to CBE GPP after doing a simple registration; 4) Reduction of the 2% tax charged by the CBE as an additional incentive; 5) CBE and ARCOM could organize the ASGM in cooperatives, thereby creating a mechanism to buy large amounts of gold, which would reduce travel costs; 6) CBE could establish a partnership with large–scale conventional mining companies to purchase gold from ASGM.

LAY SUMMARY

This thesis explores Ecuador's artisanal and small-scale gold mining (ASGM) sector in three historically gold prominent mining districts, Nambija, Portovelo-Zaruma and Ponce Enriquez, focusing on the Central Bank of Ecuador's Gold Purchasing Program (CBE GPP). The research took place from September, 2015 to March, 2017, which investigated Ecuador's gold supply chain through a series of consultations with miners. Although the CBE program is a sound initiative, miners from the three mining districts in southern Ecuador have to travel far to sell their gold in the Sangolqui office near Quito. Only registered miners, which represent less than 1% of miners in the country, are allowed to sell the gold to CBE in Sangolqui after navigating a complex bureaucratic process. This thesis investigates different issues associated with miners' perspectives of the CBE GPP, as well as proposing changes to increase the effectiveness of the program.

PREFACE

This dissertation is the original, unpublished and independent work by the author, Maxim Jordan Thomas. The author conducted the field work described in this thesis.

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LIST OF ACRONYMS

ARCOM - Agencia de Regulación y Control Minero

ARM - Alliance for Responsible Mining

ASGM - Artisanal and Small-Scale Gold Mining

CBE - Central Bank of Ecuador

COSUDE – Swiss Agency for Cooperation and Development

ENAMI - Empresa Nacional Minera del Ecuador

GPP - Gold Purchase Program

ILO - International Labour Organization

INEMIN - Instituto Ecuatoriano de Mineria

INIGEM - Instituto Nacional de Investigación Geológico Minero Metalúrgico

IRMA - The Initiative for Responsible Mining Assurance

LSM - Large Scale Conventional Mining Companies

PRODEMINCA - Proyecto de Desarrollo Minero y Control Ambiental

OECD - Organization for Economic Cooperation and Development

RJC - Responsible Jewelry Council

UNEP - United Nations Environmental Programme

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DEDICATION

I dedicate this thesis to my late grandma, Caroline Gladys Thomas. I will forever remember your love and kindness.

My hopes and prayers are with my grandfather, Sergei Elchev, who is battling cancer. You have been a huge part of my life and I wish you a speedy recovery.

I also dedicate this thesis to the artisanal miners in Ecuador and around the world. I believe one day you will receive the fair treatment you deserve for your blood, sweat and tears in this industry.

1. INTRODUCTION

1.1. Statement of the Problem

Artisanal and small-scale gold mining (ASGM) is a socio-economic phenomenon occurring in more than 70 developing countries, involving more than 16 million people (Seccatore et al., 2014). Gold has been an important economic product for impoverished populations in rural regions of the world for decades (Hilson, 2002). Due to the highly informal characteristics of ASGM, governments do not see the economic benefits of artisanal production (Veiga, 2009) and frequently gold is illegally exported or bought by criminals as a way to launder dirty money from narco-business or other illegal transactions (Veiga and Hinton, 2002).

In the last few years, the Ecuadorian Government has been trying to formalize its large artisanal gold mining sector with over 200,000 miners (Velasquez et all., 2010), who mostly work informally. Although a series of mining legislation and regulations have been implemented, the artisanal gold mining sector in Ecuador has not been properly addressed, especially due to a lack of knowledge of the ASGM supply chain.

As actual gold output in the country has been grossly under-reported, the government ends up losing millions in tax revenue, which could be invested in much-needed social programs and infrastructure. Therefore, in order to help regulate the supply chain and better document gold production in the country, the Central Bank of Ecuador (CBE) began purchasing gold indirectly from the ASGM sector in 2014 through the national mining company ENAMI. Then, in June/2016, an office was opened up in Sangolqui to purchase gold directly from artisanal miners, as long as they completed the formalization process. However, it is important to note that the miners need to go to this office near the capital Quito to sell their gold, which is located far from ASGM areas in southern Ecuador. Therefore, the efficiency of this measure is questionable, although it is a good initial step to try and reduce illegality in the gold supply chain.

1.2. Justification of the Thesis

The research focuses on Ecuador's gold supply chain implemented by the Ecuadorian Government through analysis of the CBE's (Central Bank of Ecuador) Gold Purchase Program (GPP), which is a novel mechanism introduced by the Government to acquire and register formal gold sales from the ASGM sector. This research provides useful data to assist the Ecuadorian Government in

evaluating the success of the CBE initiative and suggests mechanisms to improve the purchasing process in order to avoid leaving the artisanal miners in the hands of unfair or illegal gold buyers. By gathering field data from the ASGM sector and government institutions, it was possible to have a clear understanding of the strengths and weaknesses of the current program, which then fostered the provision of recommendations to improve the process.

1.3. Research Questions

- What are the most efficient methods that could be applied to the artisanal gold mining sector in Ecuador to minimize losses of tax revenue, while maximizing benefits for the Government and local miners?
- Can the implementation of gold purchasing initiatives in the ASGM sector in Ecuador produce positive results if applied in a broad-based manner, or does it need to be modified based on local criteria?
- What conditions need to be in place in order to generate positive results?
- How could the CBE's GPP initiative be improved?

1.4. Research Objectives

- Gather data on artisanal gold miners regarding their perceptions on working with the Government and specifically in relation to the CBE GPP initiative
- Obtain information from stakeholders involved in Ecuador's ASGM sector; including an assessment of the gold buyers in Ecuador and current competitors to the CBE in gold commercialization
- Investigate ways to improve the CBE GPP
- Analyze the strengths and weaknesses of the CBE GPP

1.5. Applied Contribution of the Research

Research on Ecuador's gold supply chain can help to reduce the illegal gold market and contribute to improve the country's benefits from the ASGM sector. In addition, this type of study can assist the Ecuadorian Government in improving the legislation and mechanisms to deal with the ASGM sector. In addition, this research could help provide crucial information to address Ecuador's concerns with minimizing tax losses, while at the same time increasing revenues derived from the

ASGM sector. Identification of the strengths and weaknesses of this initiative can provide a model for other countries looking to utilize this strategy to purchase gold and reduce money laundering. The Central Bank of Ecuador can also directly benefit from the results of this research in their gold commercialization program by analyzing in-depth the problems identified by the field investigations and establishing a more effective system to buy gold.

1.6. Academic Contribution of the Research

Although there are numerous scholarly articles on Ecuador's ASGM sector, including studies on the environment and mercury pollution, processing techniques, and the general socio-economic situation (Tarras et al 2000, 2001, 2002; Velazquez-Lopez et al, 2010; Appleton et al, 2001; Veiga et al, 2014a; Gonçalves et al., 2017), few studies have investigated the country's gold supply chain. Existing studies of the gold supply chain (Hilson, 2002; Bugnosen, 2003; Barreto, 2012; UNEP, 2012) have not contemplated Ecuador. The present research contributes to the previous studies by strictly focusing on the supply chain, specifically in terms of the CBE's GPP initiative. The results from this thesis can help to elucidate the current situation of the country's gold supply chain in the hope of helping to improve the formalization process.

2. LITERATURE REVIEW

2.1. Artisanal and Small-Scale Mining - General Considerations

Artisanal and small-scale mining refers to individuals, families or cooperatives that engage in mineral ore extracting and processing activities using rudimentary methods that are not capital intensive (Veiga, 1997; Veiga & Baker, 2004). The InterGovernmental Forum (IGF, 2018) stressed the continuous increase in artisanal mining operations worldwide in which 40.5 million individuals are directly involved. The Artisanal and Small-scale Mining Knowledge Sharing Archive (2018) estimated that this number might even be higher, reaching 43.5 million. It is estimated that over 100 million depend on this activity for livelihood, either directly or indirectly (IIED, 2013). The number of artisanal gold miners worldwide was estimated by Seccatore et al. (2014) at 16 million individuals in more than 70 countries, producing annually between 380 and 450 tonnes of gold.

Artisanal mining received international attention in 1987, following release of the United Nations' Brundtland Report (WCED, 1987) that identified poverty as the primary driver of the world's environmental problems, including destructive artisanal mining practices. Large-scale industries and technological advances in practically every field have perpetuated excessive production and materialism, which is fueled by anthropocentric philosophies and backed-up by globalization and a growing human population. This paradigm has contributed to growing environmental problems, including land degradation, pollution, biodiversity loss, etc. (Deudney, 2000; Laos, 2013; Burchett, 2016; Kopnina et al., 2018).

Major differences exist in the definitions of small-scale mining and artisanal mining and the two terms vary in interpretation from country to country. Indeed, this is a major factor to create confusion in the mining legislation, in particular in Latin American countries (Marshall and Veiga, 2017). The size of the operation is an aspect that is usually used to define the difference between artisanal and small-scale operations. Veiga et al. (2014b) highlighted the conundrum that can be created in terms of inappropriate legislation when size is used as a method to define artisanal mining. Unfortunately, many legislations of developing countries use the size of the operation and not the rudimentary techniques to characterize artisanal miners. The opposite of artisanal mining is not necessarily large-scale, but conventional mining operations that have different sizes (Table 1). Conventional mining usually refers to the mining companies that operate on a legal basis, typically

using sophisticated technologies, adhere to the nations' mining laws and regulations, and pay taxes to the country in which they operate.

The level of production has no correlation with the sophistication of the process. If the developing countries adopted this simple concept, it would be much simpler to establish boundaries between artisanal and conventional mines. While the definition of artisanal and conventional mining should be based on the level of sophistication of the operations, regulations usually do not consider this basic tenet (Marshall and Veiga, 2017). Solutions suggested to resolve problems associated with pollution, invasions of concessions, formalization, social impacts, etc. caused by artisanal miners have always revolved around treating the miners as micro miners, i.e. those processing less than 2 tonnes per day of ore (Barreto, 2012; Veiga et al., 2018).

Table 1. Differences between artisanal and conventional mining operations.
(Source: Veiga et al., 2014).

Type of Mining	Size	Legal Situation	Mechanization
Artisanal (Rudimentary)	• Micro • Small • Medium • Large	• Illegal • Informal • Legal	• Manual • Semi-mechanized • Mechanized
Conventional	• Small • Medium • Large	• Legal	• Mechanized

Veiga et al. (2014) described artisanal as being operations and activities that use rudimentary and simplistic techniques, lack permits and financial capital, as well as being generally devoid of the specific know-how and capacity that is inherent in medium-scale or large-scale mining companies. However, as seen in Table 1, artisanal mining could either be: micro, small, medium or large in size; manual, semi-mechanized or mechanized; and informal, illegal or legal.

The social and environmental impacts of the large-scale mining and oil industries has been the target of many NGOs and media, as well as being blamed for changing the climate of the planet (Lal, 2004). Although the impacts of the artisanal mining sector are frequently mentioned in the scientific literature and press (Veiga et al., 2014b), little is said about the importance of this sector in poverty alleviation of rural communities in developing countries (Hentschel et al., 2002; Hilson

and Hilson, 2015). Schumacher (1973) made the argument that the modern paradigm is based around anthropocentric beliefs and is plagued with the obsession of excess and materialism. He further argued that small-scale technology is the only way to keep progressing in a sustainable manner. Schumacher's philosophy is relevant to the discussion about ASGM, as it magnifies the necessity about introducing sustainable practices in this sector. The framework provided by Schumacher can be very beneficial for developing countries, as long as it is well-planned, organized and can contribute to alleviating poverty, thereby mitigating environmental impacts (Hilson, 2002).

For the sake of this thesis, the term artisanal and small-scale gold mining (ASGM) has been used to simplify the polemic terminology and to be in frequency with the term widely used in the literature and governments documents.

2.2. Artisanal and Small-scale Gold Mining (ASGM) in Ecuador

The history of gold mining in Ecuador started with the activities in the southern part of the country. There are indications that gold mining activities in the region of Portovelo-Zaruma began in the 1550s (Lane, 2004). However, only in 1880 did a British company establish a conventional mining operation in Portovelo. In 1896, this company was sold to a conventional American mining company, SADCO (South American Development Co.) that used cyanidation as the main gold extraction process (Astudillo, 2007). In the 1950s, the operation passed to the hands of an Ecuadorian company, CIMA (Compañia Industrial Minera Asociada) that operated until 1978, when bad management ended forced the end of CIMA operations (Murillo, 2000). At that point, artisanal miners began re-establishing a strong foothold in the region, with thousands of men flocking to the region to look for gold.

It is not precisely known when the processing centers started their operations in Portovelo-Zaruma region providing processing services for the artisanal miners, but it is believed that this occurred at the beginning of the 1990s (Velasquez et al., 2010). In Portovelo-Zaruma, Ecuador, a solid rapport exists between the miners and their community. Gonçalves et al (2017) estimated that gold production in Portovelo-Zaruma was between 7-8 tonnes/annum, which included the production from 87 processing centers using a combination of amalgamation and cyanidation to process the ores.

Ecuador is still in its initial stages of formalization and has a large artisanal gold mining sector, due to the high gold price and the fact that most artisanal gold miners are driven by poverty. It is crucial that the country develops a viable, legal system for taxing this sector and regulating its activities in order to enforce environmental legislation and pay for mitigation of environmental degradation, health impacts on mining communities, child labor, money laundering, etc. (Sandoval, 2002, ILO-IPEC, 2003, Velasquez, 2010).

The large ASGM sector in Ecuador does not have accurate inventories of people involved, gold production, equipment used, etc. It was estimated that over 200,000 miners are directly involved in this sector (Velasquez et all., 2010), in which the large majority work informally. Other estimates indicate that only 90,000 Ecuadorians are directly employed within the ASGM sector, with a total of 400,000 directly and indirectly dependent on this activity for this livelihood (UNEP, 2012). Most ASGM activities occur in the southern part of the country.

At the beginning of the 2000s, Ecuador's artisanal mining sector was estimated to account for close to 85% of the total gold production in the country (Sandoval 2001). ARCOM, which is the Ecuadorian Agency of Mining Regulation and Control, estimated that the official gold production in the country was around 7 tonnes in 2017 (CBE, 2018). This seems to be a gross underestimation, since as mentioned previously since in 2015 it was estimated that the ASGM sector in Portovelo-Zaruma region alone produced 7 to 8 tonnes of gold in 2015 (Gonçalves et al., 2017).

Although some ASGM miners in Ecuador have organized themselves into cooperatives in recent decades, becoming somewhat successful at collectively generating small profits for their operations, there has been little improvement with neither socio-economic nor environmental problems associated with ASGM activities (Gonçalves et al., 2017). While environmental issues persist and few taxes have been collected, a small group of wealthy entrepreneurs continues to take advantage of the lack of technical capacity and financial investment of the vast majority of artisanal miners. While processing centers are the major source of environmental pollution in the ASGM sector, the impoverished artisanal miners are forced to deal with these centers to process their ores (Veiga et al., 2014a) and to sell their gold to local buyers at low prices. Furthermore, instead of Ecuador reaping benefits from the high gold production and commercialization, which

could help diminish economic disparity among underprivileged segments of the population, black-market transactions only end up making certain individuals richer.

In another vein, artisanal mining is often reported as small-scale mining, which is mainly due to financial limitations and lack of proper permits (Veiga and Marshall, 2018). In Article 138, Chapter 2 of the Ecuadorian Mining Law of 2009, it states that small-scale mining has the capacity to exploit and process up to 300 tonnes per day of ore or 800 m^3/day for non-metallic material, while any entity above 300 tonnes per day is subject to a higher tax bracket (Lexis, 2009). Although artisanal miners are considered individuals, families or cooperatives that mine for subsistence purposes, they fall in the same category as small-scale miners. The Ecuadorian Government developed official definitions for small-scale mining and artisanal mining in order to distinguish the two activities. The main highlight of this definition is that the small-scale miner pays a 3% royalty and the artisanal miner is exempt, due to artisanal mining being classified as a subsistence activity, in which it is considered that the miners would not have the financial ability to pay taxes. All of these definitions in the Ecuadorian legislation become loopholes for companies to avoid or reduce taxes. For example, although some companies in Ecuador have the capacity to mine and process 2000 tonnes/day of ore, they often split their operations in many small-scale subsidiaries in order to pay only 3% royalty tax.

2.2.1. Gold Amalgamation

Gold amalgamation is one of the oldest gold extraction methods, dating back to the middle of the 16th century, and is the most popular method for gold extraction in the ASGM sector (Hilson and Vieira. 2007). Amalgamation involves mixing mercury (Hg) with the ore that contains gold and silver, resulting in the formation of a metal paste of mercury and gold particles with a small amount of gold dissolving in the liquid mercury (Taggart, 1945). This paste is then wrapped up in a cloth and squeezed, and the amalgam usually contains 40 - 50% mercury, which is then burnt off using a gas torch. After the majority of the mercury is burnt off, usually 2-5% of it is left with the gold and a gold *doré* is produced by raising the temperature above the melting point of gold (Hinton and Veiga, 2002). The effectiveness of the burning process and the heat source used is a significant factor that determines the percentage of residual mercury in the *doré*. In African countries, as the lack of resources does not allow for the use of gas or propane torches, bonfires are utilized as a heat source, which results in up to 20% of residual mercury in the *doré* (Veiga, 2006).

Artisanal gold miners rely heavily on amalgamation as their key processing method, which results in the loss of almost 1400 tonnes/a of metallic mercury worldwide from AGM activity (UNEP ASGM Partnership, 2017) This technique dates back centuries and is very popular due to its simplicity, speed and effectiveness in trapping the gold particles to produce the metal compound. However, due to a lack of financial support and technological knowledge on how to improve their gold extraction process, artisanal miners become habituated in using such a primitive and inefficient method like amalgamation (Hilson and Pardie, 2006).

There are two methods used for gold amalgamation by artisanal miners: 1) amalgamation of a gravity concentrate 2) amalgamation of the whole ore. Amalgamation of the whole ore is very inefficient at gold recovery, managing usually only 30% of the total gold with over 40% of the Hg being lost (Garcia et al., 2015). This is usually conducted in small ball mills that are called "chanchas" in Ecuador, "cocos" in Colombia, and "tromols" in Indonesia (Veiga et al., 2014a). As observed in Ecuador and Colombia, approximately 50% of the mercury introduced into the small ball mill is lost with the tailings (Velasquez et al., 2010, Garcia et al., 2015).

It is important to point out that a correlation exists between the price of gold and the price of mercury. As the price of gold increases, the price of mercury also rises concurrently (Veiga et al., 2006). In 2013, the international price of mercury was $95 a kilogram, which was 40% higher than 2012. Latin American countries such as Colombia, Brazil, Peru, Ecuador and Venezuela are amongst the world's top ten largest consumers of mercury (Cordy et al., 2011).

Telmer and Veiga (2008) discussed the reasons behind the popularity of mercury and its use amongst artisanal miners. The reasons mentioned by the authors were that mercury is easy to use, usually very accessible, and relatively cheap. Although some miners may be somewhat aware of the hazards of using mercury, most miners often do not have any other alternatives and they simply follow what they know to sustain their livelihoods on a day-to-day basis.

2.2.2. Processing Centers

The majority of individuals involved in the ASGM sector lack the financial capacity to purchase their own equipment for ore beneficiation. Processing centers owned by third parties have emerged to address this issue and have become a lucrative entity. The centers began by only using gold amalgamation techniques to recover gold, but have evolved to include cyanidation as well, either using Carbon-in-Pulp (CIP) or Merrill-Crowe processes (Velasquez et al., 2010).

Tarras-Wahlberg et al (2003) identified the main processing techniques used by the processing centers in Nambija, Portovelo-Zaruma and Ponce Enriquez, which included gravity concentration; pan washing; amalgamation, and cyanidation.

The processing centers in the region of Portovelo receive ores from miners who work for 2-3 weeks before trucking sacks of ore to the centers. Miners pay no to low cost if they leave their tailings at the processing centers as payment after using amalgamation with either Chilean mills or "chanchas". After amalgamation, the owners of processing centers then re-process the tailings with cyanide. It has been estimated that the miners recover only around 30% of the gold from the ore when the processing centers use amalgamation. The residual 70% of the gold is left in the Hg-contaminated tailings, which is then extracted using cyanidation (Veiga et al., 2014a).

The region of Portovelo-Zaruma currently has 87 processing centers, which utilize either one of the two processing methods: 1) Chilean mills and sluice boxes; or 2) "chanchas" (small ball mill) processing (Gonçalves et al., 2017). The Chilean mill centers grind the ore, concentrate and amalgamate the concentrates, whereas "chancha" centers amalgamate the whole ore during grinding. The "chanchas" were shown to be inefficient in the use of mercury, as an average of 27.5% of the total mercury introduced ends up in the tailings when the whole ore is amalgamated (Velasquez et al., 2010). These tailings are then leached with cyanide and typically discharged into local waterways (Marshall et al., 2018).

The processing centers either provide a place for the miners to evaporate the mercury from amalgams in an open pan or ask the miners to burn the amalgams at home. The atmospheric releases of mercury in the twin towns of Portovelo and Zaruma by the gold-shops is a matter of public health, since this pollution occurs in the urban core (Velasquez et al., 2010).

In the last 10 to 15 years, the use of cyanide in gold processing centers in Portovelo-Zaruma has increased significantly, due to the understanding that gold recovery with cyanidation is usually above 80% (Veiga et al., 2014b). All Ecuadorian processing centers can easily purchase sodium cyanide (NaCN) without the need for a permit, which has greatly increased accessibility. Cyanide destruction can be performed naturally by leaving tailings in the ponds and exposing them to sunlight. For small quantities of cyanide-contaminated tailings, chlorine bleach has been used. These methods are the simplest ways to get rid of cyanide and can be utilized by miners who know little about cyanide destruction. Hydrogen peroxide is a more dangerous method that can be used

to destroy cyanide, especially if there are large amounts of sulphides, whereby the hydrogen peroxide can require large quantities as it oxidizes other compounds other than the cyanide that is targeted. Although complex, the most effective method to dispose of cyanide is using sulfur dioxide/air. For this process, there requires a strong agitated reactor and constant flow of air, at which point sodium sulphite is added to the solution. However, it is extremely important to control the pH to avoid the formation and liberation of hydrogen cyanide gas, which is deadly. Lime is an effective agent that is used to control the pH and keep the hydrogen cyanide from forming.

The unequal division of profits between artisanal miners and processing center owners has been discussed in many meetings with miners and authorities in Ecuador. The main problem is that a significant amount of capital is required to build and operate a processing center. Approximately US $10,000 per tonne of ore being processed per day is needed to establish and run a clean and profitable processing facility, which does not include the cost of any necessary improvements (Veiga et al., 2014b). For a small operation processing 2 tonnes of ore per day using gravity concentration, flotation and cyanidation in “chanchas”, Veiga et al. (2018) estimated that the capital cost would reach US $10,500 or US $5250/t. If artisanal miners want to operate their own gold processing facility, they must be able to achieve at least 50% gold recovery, as they already receive approximately 30% at the processing centers with amalgamation and pay nothing or very little. When using the processing centers, miners do not pay for the depreciation of the capital cost and in many cases do not pay for the operating costs either, as long as they leave the tailings behind.

2.3. Environmental and Health Impacts of ASGM

ASGM activities expose artisanal miners and other community members to chemical hazards such as dust, cyanide, mercury and other heavy metals and chemicals. Frequently, tailings are discharged in the rivers without any treatment, which cause contamination of surface waters and sediments and possible pollution of aquatic life Other safety hazards related to the mining process itself include noise, vibration, heat, lack of oxygen, confined spaces, as well as the potential risk of slips, falls, flooding, fires, over-exhaustion, and psychological stress to workers (Mayala et al., 2016). .

In 1994, the Ecuadorian government, funded by the World Bank, began a project called PRODEMINCA that conducted environmental monitoring of the water systems in the four main

mining districts: Portovelo-Zaruma, Nambija, Ponce Enriquez and Santa Rosa. In 1999, the study concluded that the most severe environmental impacts were caused by the country's poor management of waste products derived from the ASGM sector. The drainages downstream of Portovelo-Zaruma were found to have high concentrations of cyanide, lead, cadmium and copper, while water bodies in close proximity to Ponce Enriquez had large amounts of cyanide, copper and arsenic. Therefore, due to these significant environmental impacts and the lack of clean sustainable practices, Tarras-Wahlberg (2000) has argued that ASGM is less desirable than large-scale mining.

The study of the Puyango-Tumbes river basin by Tarras-Wahlberg et al. (2001) confirmed the PRODEMINCA findings, showing that poor tailings management of the ASGM sector in Portovelo-Zaruma was contaminating the watershed. In addition to contamination of water, sediment and soils downstream from the processing centers in Portovelo-Zaruma, elevated concentrations of methylmercury were also found in carnivorous fish species along the main channel of the Puyango-Tumbes. As environmental regulations and technical solutions were unlikely to solve the environmental problems in the region, community-based solutions were recommended, despite the high investment and broad-based level of participation required (Tarras-Wahlberg, 2001). It was clear that micro-miners who use amalgamation in small batches were not the main problem, as the continuous discharge of tailings from processing centers in Portovelo-Zaruma was causing the most significant environmental impacts.

Studies investigating the environmental impacts caused by ASGM operations in southern Ecuador have strongly focused on mercury pollution. Despite the large atmospheric Hg emissions released when amalgams are burned, either by miners or gold shop owners, the main environmental problem is caused when the processing centers leach Hg-contaminated tailings left by the miners with cyanide. The simultaneous use of mercury and cyanide by the Ecuadorian processing centers has been a subject of extreme concern for the Ecuadorian and Peruvian authorities.

Tarras-Wahlberg et al (2000), Veiga et al (2009) and Drace et al. (2016) discussed the practice of mixing mercury and cyanide in gold processing, which includes the still unknown bioavailability of mercury cyanide in fluvial drainages downriver from processing centers. The residual mercury left in tailings, when leached with cyanide, has a dissolution kinetics slower than gold. Therefore, the tailings, dumped into the river, contain usually 50% of the mercury that was in the tailings (Velasquez et al., 2011). Furthermore, part of this mercury has already been transformed into

mercury cyanide. Although the toxicity of the mercury-cyanide complexes has not been well studied, there are indications that this compound is highly toxic for aquatic biota.

Tarras-Wahlberg et al (2001) and Guimarães et al. (2011) analyzed the effects of cyanide, mercury and other heavy metals in the Puyango-Tumbes River downstream from Portovelo-Zaruma in El Oro Province, including biodiversity loss and bioaccumulation of metals in aquatic organisms. Further research by Betancourt et al (2005) confirmed environmental problems associated with mercury and cyanide release into the environment. In addition, Couture et al (2002) provided evidence of health problems in children exposed to atmospheric mercury emissions in this region.

Recently, Marshall et al. (2018), in a study sponsored by the United Nations Industrial Development Organization (UNIDO), concluded that mercury dumped with tailings into the Puyango-Tumbes River by processing centers in Portovelo has been traced to sedimentary Hg 160 km downriver in the Tumbes delta in Peru. Mercury isotopes revealed that the signature in downstream sediments was consistently similar to the Hg signature observed in tailings discharged by processing centers in Portovelo (Schudel et al., 2018).

This problem of mercury pollution, specifically when processing centers use cyanide to leach Hg-contaminated tailings, is a significant environmental impact found in more than 30 developing countries where gold processing centers are known to be proliferating (Veiga et al., 2014a). For example, Veiga (2010) identified Antioquia, Colombia, as the region most contaminated with mercury per capita in the world, which was attributed to amalgamation of the whole ore in “cocos” (small ball mills similar to *chanchas*) and to burning amalgams in gold-shops (Cordy et al., 2011).

The study by Velásquez et al. (2010) in Ecuador established that the annual production of 10 tonnes of gold in 2009 by the processing centers in Portovelo-Zaruma was accompanied by the release of 1.5 tonnes of mercury - 71% of which is discharged into the atmosphere and 29% into the tailings. Recently, Gonçalves et al. (2017) estimated that the 87 processing centers in this region produced approximately 7 to 8 tonnes of gold in 2015 and released 1.9 million tonnes/a of tailings into the river, which contained 2033 tonnes/a of cyanide and 222 kg/a of mercury. In the same year, these authors However, a 60% reduction in the use of mercury by the processing centers was observed from 2013 to 2015, while the use of cyanidation processes increased 30% over the same time period. Although the mercury reduction was partially attributed to increased enforcement of environmental regulations, it also appeared that miners were realizing that they

could increase gold recovery using a combination of effective gravity concentration and cyanidation processes, while at the same time not having to purchase mercury, which was becoming more expensive.

In terms of health concerns for artisanal miners, the most serious impact occurs when amalgams are burned, as the mercury vapor is directly inhaled. Although safety protection and retorts for mercury capture are available, most miners either do not have access to these technologies or do not feel that they are necessary. Unfortunately, the miners often burn the amalgams at home or in populated areas, which exposes entire families to the toxic fumes. This also occurs in gold-shops, where amalgams are burned using only a fume hood, which sends the mercury vapors out into the communities.

The environmental and health impacts of mercury vapor on artisanal miners and local populations in Zaruma-Portovelo have been investigated. UNIDO (2016) reported high mercury concentrations in the atmosphere on the streets of Zaruma outside of gold-shops, where Hg concentrations exceeded 79,000 ng/m^3 (close to schools and a local hospital), with maximum spikes being over 1,000,000 ng/m^3. It is worth highlighting that the World Health Organization has recommended a maximum level of 1000 ng of Hg/m^3 in air (annual average) for public exposure (WHO, 2003).

Inside a gold-shop Hg atmospheric concentrations averaged 210,000 ng/m^3, with a maximum concentration of over 2,000,000 ng/m^3 immediately after burning an amalgam (UNIDO, 2016), which can be fatal if the operators spend hours continuously inhaling this contaminated air (Veiga and Baker, 2004). Inside the processing centers, when miners were amalgamating the whole ore in “chachas”, mercury concentrations were also above 200,000 ng/m^3, with maximum levels of 2,000,000 ng/m3 registered by a LUMEX atomic absorption analyzer 15 m away from an amalgam being burned.

Schutzmeier et al. (2017), analyzing 865 urine samples from miners operating in Portovelo-Zaruma, reported that 5.9% of miners exceeded the 25 μg/L limit and showed high probability of intoxication symptoms. Approximately 5% (44 individuals) of the miners had urine mercury levels above 15 μg/L, while 78.3% had levels below 7 μg/L, with no risk of intoxication. Drasch et al. (2002) established 5 μg of total Hg/g of creatinine as the alert level, which is the same as approximately 7 μg/L (Veiga and Baker, 2004).

In 2013, the Ecuadorian Ministry of Environment implemented the “Zero Mercury” policy, where the use of mercury was prohibited in any mining operations. Then, in 2015, the Law was implemented and miners in Portovelo were arrested in the midst of decomposing amalgams (Veiga and Marshall, 2017). As a result, this prohibition is forcing miners to burn amalgams at home, where all family members are now exposed to the harmful vapors (UNIDO, 2016).

Adler-Miserendino et al. (2013) noted that exposure to toxic metals and chemicals can significantly contribute to the mortality of local people within the mining communities, especially for miners and their families. These authors reviewed the challenges to measuring, monitoring and addressing environmental impacts caused by the ASGM sector in Ecuador. They suggested that solutions need to “involve broad, systematic regulatory and social change driven through non-traditional policy tools”. There need to be efforts from the government, regional or international bodies and the scientific community, including new management strategies to address issues over temporal, spatial and jurisdictional scales, information-based strategies, and cross-scale and cross-level policy mitigation methods. They argue that success is dependent on the participation of stakeholders to promote a better understanding of the ASGM sector and the technological mechanisms required for implementation of clean practices.

Veiga et al (2014a), in a review of the methods used in processing centers in several developing countries, found that the main pollution problems were caused by the following: lack of cyanide management; amalgamation of the whole ore in ball mills; use of cyanide in recovering residual gold from mercury-contaminated tailings; the indiscriminate discharge of effluents contaminated with cyanide, mercury and other heavy metals; and the burning of amalgams without the use of mercury capture systems.

The health effects caused by mercury releases and emissions from ASGM operations has been well-documented by Gibb and O’Leary (2014) and Kessler (2013). However, these authors also claimed that implementation of the Minamata Convention would play an important role in reducing the pollution, as the Convention is a global treaty aimed at protecting the environment and human health from the adverse effects of mercury. The international accord was signed by 128 countries in October, 2013 and has since been ratified by 102 countries. The Convention entered into force on August 16, 2017 for the first block of parties that both signed and ratified the accord. The main focus of the Minamata Convention is to: 1) ban new mercury mines; 2) phase out

existing mercury mines; 3) cut down mercury use in products and processes; 4) control measures on emissions to air and releases to the environment; and 5) regulate the informal sector of ASGM. At the same time, most of the countries that have ratified the Convention has also implemented National Action Plans to address deficiencies in regards to mercury controls and ways to reduce and eliminate Hg from artisanal and small-scale mining in those jurisdictions. Although on paper it looks like this strong international agreement will make a significant difference in curtailing mercury use, it takes a very committed presence and enormous investment in education and training at grassroots levels to really create a positive impact.

This type of top-down approach to deal with mercury use and pollution has been tried many times before by a multitude of different projects in ASGM regions around the world. This usual approach to address problems with mining communities, in particular with ASGM, has been criticized by Spiegel et al. (2014), Veiga and Tucker (2015) and Stocklin-Weinberg et al. (2019). Without strong involvement by the ASGM community in the search for solutions, the projects are likely to be unsuccessful over the long term or result in lasting changes on the ground.

Despite the recent restrictions placed on mercury exports and imports by the European Union and other willing countries, due to implementation of the UNEP Minamata Convention, mercury is still easily accessible to artisanal miners through black-market means, who are able to purchase it without any sort of documentation. Although Ecuador ratified the Minamata Convention on July 29th, 2016, law enforcement measures by the Ecuadorian Government against miners using mercury has led to disastrous consequences. While afraid of being arrested for burning amalgams outside, more miners are burning amalgams at home, even closing the windows to reduce visibility of their illegal act, which only contaminates themselves and family members, including children, even more (Veiga and Marshall, 2017).

Implementation of the Minamata Convention in developing countries with ASGM has been heavily criticized, as most government personnel in charge of conducting mercury inventories and creating National Action Plans do not have the technical capacity to deal with the problem (Hilson et al., 2018). Spiegel et al. (2014) urged governments to rectify the inadequacies in mining policy that have prioritized the importance of large-scale conventional mining over ASGM activities, which have created even more informality and disrespect for environmental protection regulations. In fact, little has been done through the Minamata Convention umbrella to create sustainable

training facilities for artisanal miners in order to introduce cleaner practices, as advocated by Veiga et al., (2014b).

2.4. Ecuador Mining Laws and Legislation

Artisanal mining is characterized by its informal and decentralized nature and does not adhere to a single and consistent definition. It is very region/country specific and can often be branded as an illegal activity. The lack of precise definition and contrast between small-scale conventional mining and artisanal mining in mining legislations and mineral policies has significantly hindered the formalization process. This is always associated with government authorities' poor understanding of the problems and challenges facing artisanal mining, as well as finding solutions and offering opportunities for rural communities (Hilson, 2002, Hilson, 2006, Marshall and Veiga, 2017).

As mentioned by Veiga et al. (2014), both education and organization must be in place in order for formalization to have a successful outcome. Regardless, many developing countries, without considering the importance of following these first steps, simply implement formalization initiatives hoping that it will solve all their problems related to the ASGM sector, while alsoincreasing tax revenues at the same time. It is estimated that less than 1% of the artisanal miners in Latin America are in fact legal. i.e. formalized through the Ministry of Mines and Ministry of Environment and keeping their mineral titles in good shape (Marshall and Veiga, 2017).

The problem with the legislation concerning formalization is that there is a lack of understanding and confusion regarding the definitions of "artisanal" and "small-scale", as they often get grouped together into the same category. This is problematic, as the miners who use advanced machinery and processing techniques get taxed the same way as miners who are still using rudimentary tools and methods, which creates an unbalanced taxation system and discourages actual artisanal miners from participating with the government.

Bugnosen (2003) reviewed the legislation addressing artisanal and small-scale mining of several developing countries, with the intent of gaining knowledge and insight for governments interested in following the trend of legalization and formalization of the sector. He suggested several strategies for improving the effectiveness of ASGM laws and legislation, which included: choking

the supply chain of illegal gold into the black market; addressing the environmental degradation stemming from artisanal mining in order to generate employment opportunities; generate foreign exchange earnings; bolster entrepreneurship of small-scale activities; and provide mechanisms for government revenue collection.

The Mine Promotion Law of 1974 was Ecuador's first attempt to recognize, formalize, and promote artisanal mining. The law confirmed the State's dominion over metallic and non-metallic natural resources, excluding alluvial gold deposits (Sandoval, 2001). Although the law succeeded in producing definitions for small-scale mining and formalization, it created an ineffective, complicated and expensive legal obstacle for formalization (UNEP, 2012). Artisanal mining was defined as mines that do not exceed the production threshold of 1,500 tonnes per month. Furthermore, the formation of cooperatives among artisanal mining individuals was encouraged under Articles 39 and 40. The technical and administrative supervision of the sector, as stated in Article 41, falls under the Director General of Mines and Geology of the Ministry of Natural Resources and Energy. Within the law, a clause exists for "independent washers", who fall under Article 46 of the Law and Article 16 of Regulation, who do not need a permit to mine within zones of free exploitation (Sandoval., 2001).

In 1985, a revised mining law was introduced that re-confirmed the State control of mining activities. The law succeeded in facilitating the granting of permits and reducing prerequisites in order to achieve administrative and financial autonomy through a subordinate public entity called the Ecuadorian Institute of Mining (INEMIN). The "independent washers" status was not altered, and ASGM activity was still generally classified as a marginal activity, despite increasing numbers of people entering the sector (Sandoval, 2001).

With implementation of the Mining Law of 1991, Ecuador created a Mining Code with the help of the World Bank. The Code facilitated the application process for mining concessions and reduced the quantity of taxes. Article 142 characterized artisanal miners as individuals or families mining for sustenance "by the use of rudimentary instruments, manual devices or simple portable machines," with the activity limited to riverbeds, beaches or land without mining rights (PbP, 2014). Although this law defined artisanal mining as an activity that sustains economic livelihood, it hindered the legal recognition of miners who began their mining activities prior to 1991. Although a few miners managed to formalize through concessions made by the government for

newly formed operations, they still had to operate under a mining title that applied to both small and large-scale operations. This made it difficult for operators without financial or technical capacity to meet the legal threshold of operation, pay royalties and produce technical and environmental reports, without which they would lose their title (Sandoval, 2001).

The Law for Promotion of Investment and Citizen Participation of 2000 altered the law to recognize artisanal mining based on a maximum concession area, ore extracted per day, maximum investment and technical conditions (UNEP, 2012). In 2001, the Mining Law was modified, including a more nationalistic view of the country's mineral assets and incorporation of important aspects related to environmental protection. In 2008, the new Constitution cancelled the licenses of many mineral concessions with no economic compensation offered, alleging that Environmental Impact Assessments for those concessions had not been issued. In 2009, the Mining Law was once again amended, which was then followed by General Regulations to the Mining Law, the Environmental Mining Regulations and the Regulations for Small-Scale Mining. The amendment tried to organize the mineral titles in the country and curtail all operations that can have deleterious impacts on the environment (PBP, 2014). This new set of regulations focused on ensuring that the majority of the revenue derived from the extraction of natural resources stays within the country, using taxation as the primary vehicle. The tax scheme applies to medium and large-scale operations, with the following attributes: 5% royalty tax on all sales; 25% income tax; 12% tax on all profits; 70% windfall tax; and 12% VAT (Adler-Miserendino, 2013).

This legislation has been criticized for its lack of clarity on how and to whom the taxation applies, resulting in a lack of incentive, participation and transparency from the mining sectors that are on the border-line between artisanal and conventional mining. Inherently, the idea that artisanal and small-scale miners can become more organized and create formal business enterprises is hindered by this law. In order to avoid a definition that would require greater commitments and responsibilities, including higher taxes and environmental protection, artisanal miners do not want to declare themselves as operating above the threshold of the artisanal sector. There is little incentive for artisanal mining to organize into entrepreneurial entities or business enterprises when such a "lack of clarity of the tax policy" continues to exist. The result is a loss of tax revenue for the government and communities and reinforcement of the illegal gold trade.

The Ministry of Mining was then created in February 2015 with the responsibility of mining planning, regulations and supervision of all mining activities in the country. The amendments of the 2009 Mining Law that occurred in July 2013 favored the investment of state-owned companies, saying that these companies do not need a bidding process, as they can obtain a mineral title directly from the federal Government, which has top authority in terms of mineral title decisions (Zaldumbide, 2016).

2.5. Formalization

Many Governments and International Agencies believe that formalization of ASGM is the way to control the sector and manage the social and environmental impacts (Salo et al., 2016). However, without adequate enforcement, training and control, ASGM legislation is useless, as observed by Sousa et al. (2011). The authors analyzed 20 laws, decrees and resolutions for ASGM in Brazil and concluded that there was zero compliance by more than 99% of the 141 artisanal gold mine sites visited in the Amazon. The authors also criticized the role of the Government in amending or creating new laws as a way to resolve the pollution and formalization of ASGM miners. Assessing these ASGM sites in the Brazilian Amazon, Sousa and Veiga (2009) noted that 80% of miners using mercury did not have retorts, as stipulated in the Brazilian Resolution 435 of 1989, whereby miners had to protect themselves from harmful vapors by using mercury capture systems. . This lack of respect for laws, in particular ones associated with environmental regulations, seems to be commonplace in developing countries where ASGM is proliferating (Hinton et al., 2003. Sinding, 2005, Fisher, 2007, Swain et al., 2007, Hilson and Vieira, 2007, Toledo and Veiga, 2018). The overlying perception from all of the many studies that have looked at formalization measures is that this type of process without other necessary education, training and supports does not guarantee best practices. Veiga and Marshall (2018) observed that even formalized operations in Colombia were not found to be using cleaner methods, which include the continued misuse of mercury, irresponsible use of cyanide, and poor tailings management.

Formalization is a process that attempts to integrate the ASGM sector into the subject country's formal economy, as well as adapting mining laws or policies that address the issues from the ASGM sector. The programs and public policy developed by Governments must consider the different aspects of ASGM activities simultaneously and in an integrated manner. Legalization is only one of the dimensions of the formalization process (UNEP 2012). Therefore, if formalization

is not implemented in a holistic manner, together with many other institutional support mechanisms, it is bound to result in no tangible benefits being generated either for the artisanal miners themselves or for the well-being of the countries involved.

Chen (2007) suggested that informal employment comprises 50 to 75% of non-agricultural employment in developing countries. However, in Ecuador, FORLAC (2014) mentioned that informal employment in non-agricultural sectors was reduced from approximately 61% in 2009 to 50% in 2012. In September 2018, ILO (2018) reported that informal employment in non-agricultural activities in Ecuador represented approximately 65% of the working force.

Formalization is complex and several issues exist with the process. Problems arise, due to the lack of participation from the miners, who have no inclination to formalize, adopt cleaner technologies and pay taxes, unless financial incentives are offered (Maconachie and Hilson, 2011).

Governments typically do not have the technical capacity to positively influence the ASGM sector and there is often a lack of government authorities in remote areas to monitor the situation. The lack of knowledge also hinders the formalization process, as without training and education miners do not know how to obtain legal mineral titles and improve their gold extraction methods (Hilson and McQuilken, 2014). If governments could be effective at enforcing the laws and providing technical assistance and advice on how to utilize cleaner production methods, organized companies could then be obligated to follow laws and implement environmentally-friendly processing techniques (McDaniels et al. 2010).

Theoretically, formalization is the precursor to cleaner production, as it creates a sense of ownership of the mineral title, giving transferable capital to the miners (Siegel and Veiga, 2009). The surge in formalization of the artisanal mining sector by many developing countries has created an unmanageable chain of bureaucracy, which is simply unattainable and undesirable for the artisanal gold miners. In Peru, Veiga et al. (2014b) noted that the formalization process has become a complete ‘fiasco’, as the procedures to formalize the 450,000 artisanal miners have generated very little success and interest after years of promotion and planning. Although 50,000 ASGM miners attempted to become formally registered with the Peruvian Government, only 27,000 were actually granted formal mining titles.

Guiza and Aristizabal (2013) attributed Colombia's failure with formalization to the challenging requirements needed for miners to qualify and also due to an overlap of licensed mining areas amongst miners. Siegel and Veiga (2009) further suggested that formalization will not be successful without a participatory approach and involvement of stakeholders in creating and implementing the regulations. The lack of desire from the government to include different entities into the formalization process is a significant hindrance, as well as the lengthy and costly bureaucratic process required for miners to obtain the licenses. An additional complication is that formalization initiatives implemented by the Ministry of Mines in most countries do not guarantee that legal conditions have been met, as the Ministry of Environment is required to issue an environmental permit in order to satisfy the legal requirements (Veiga and Marshall, 2018). Therefore, it is clear that greater collaboration and integration is needed among different ministries, so that inherent deficiencies in establishing formalization protocols can be greatly improved.

Hilson et al. (2017), in a detailed analysis of the persistent informality of ASGM operations, called attention to the increasing and unnecessary bureaucracy created by governments to formalize ASGM. For example, the cost to register a mineral deposit and undergo the necessary bureaucratic process in Ghana resulted in most ASGM miners avoiding this route and establishing informal relationships with other stakeholders, including landowners, gold buyers and equipment distributors.

In addition, formalization cannot be implemented and enforced at sites where artisanal miners have not been organized and educated regarding their rights and the legislation, as well as how to mine, conduct geological exploration, effective processing techniques, mine management, etc. If miners are not organized and educated prior to implementing formalization, then governments basically only end up formalizing the pollution, as artisanal miners will not automatically change their operational practices without considerable orientation, training and capital investment (Marshall and Veiga, 2017).

In developing countries with the presence of artisanal mining, problems with legislation have been identified as a barrier to successfully integrating the sector into legal channels. Unnecessarily complex regulations are a big part of the problem, which results in most miners' lack of

compliance. In addition, the vast majority of mineral titles issued for gold deposits to large-scale mining companies were initially found by artisanal miners (Hilson and Hilson, 2015).

To overcome barriers for formalization of artisanal miners, a functioning framework needs to be in place to ensure that artisanal miners have legal support to obtain permits that will guarantee their mineral title and production. Mineral titles are considered to be the main legal instrument to regulate mining, as they assign certain responsibilities to the title holder and give permission to mine legally (UNEP, 2012). Unfortunately, as most mineral titles are in the hands of large conventional mining companies, the artisanal miners who discovered the deposits are considered "illegal", as deemed in the news. Considering that 99% of the artisanal sector is characterized by informal workers (Marshall and Veiga, 2017), the media and society insist in ascribing criminal characteristics for all artisanal miners.

Currently, all of the mineral in Ecuador where artisanal miners are working do not belong to them. Secondly, training and capital must be in place to ensure safety, efficiency, productivity and sustainability of the operations. Sound legislation is a precursor to transforming the artisanal mining sector into a formal economic activity that will benefit both the miners and the country. Furthermore, land conflicts, complex reporting requirements, and issues with taxation, finance and environmental standards are all cumbersome barriers to real formalization of the sector.

Artisanal mining has vast potential to drive economic development and contribute to poverty alleviation (Hentschel et al., 2002). However, the right frameworks in place are essential for this sector, as history has shown that ASGM often creates a vicious circle of poverty, due to inappropriate legislation, misguided regulations, insufficient enforcement, and lack of education, organization, capacity and participation (Hilson, 2002). In developing countries, the lack of government incentives creates problems, as banks usually do not provide proper financial support for the miners (McDaniels et al., 2010, Hilson, 2011). Without training and capital, it is almost impossible for an artisanal miner to evolve and implement cleaner methods (Veiga et al., 2014b). The result of this often attracts intermediate parties that take advantage of the miners, including the processing centers and black-market gold commercialization dealers. It is important to point out that money laundering is inherent in developing countries that struggle to develop a solid and sustainable relationship with the artisanal mining sector.

A summary of the potential positive advantages for Government and miners that can be gained by formalization include the following:

- taxation opportunities to increase Government revenues;
- economic diversification;
- improvement in social and labor systems for miners;
- more control of the illegal gold market, including reductions in money laundering and support for conflict groups and other criminal activity;
- improvement of mining practices (if training is provided and loans are available);
- establishment of a credit system for miners;
- financial resources to fund proper geological surveying;
- better concession management and regulations to avoid conflicts with large conventional mining companies;
- increased trust in government when miners see positive results for their communities, including improved social programs, increases in standard of living, and allocation of mine titles for the ASGM sector, which increase the incentive to develop his/her concession in accordance with the regulations;
- better opportunities for miners to develop their own companies and become part of mainstream society;
- implementation of cleaner practices, which is facilitated by the ability to access credit for the purchase of new equipment; and better tracking of gold production and gold exports.

Within the current formalization schemes being implemented by the Ecuadorian Government, there are certain challenges that must be highlighted:

- miners are not consulted about formalization initiatives;
- lack of available mineral titles for the ASGM sector;
- lack of incentive to invest in operations, as miners do not have a sense of ownership;
- excessive bureaucracy currently in place for the formalization process;
- paying taxes is problematic to ASGM miners, as there is a general perception that government entities are corrupt;
- lack of training, education and capital for ASGM to access cleaner technologies;

- the black market continues to flourish, which in many cases pays the formalized miners more for their gold than selling through legal channels;
- formalization does not guarantee participation of miners in remote areas, as there is a lack of awareness and institutional support from the Government;
- difficulties (and high cost) in enforcing regulations, especially in remote areas.

2.6. Access to Financing

Individuals involved in the artisanal mining sector need access to credit to be able to avoid getting loans from illegal entities or individuals with money who exploit the miners. Although micro-credits have been used by some governments to support micro-miners, these have had limited positive effect (McDaniels et al.,2010) and most banks are not prepared to provide loans of US$ 100,000 to artisanal miners in order to improve their operations. In addition, non-formalized miners are not able to access the most basic forms of credit, which would allow the miners to take the next step to forming a formal business enterprise.

The current situation in Ecuador involves different scenarios. The first is where the owners of processing centers often finance artisanal mining operations, either through lending money or buying machinery for the artisanal miners. The poverty-driven characteristics of artisanal miners force them to accept the terms laid out by the processing center owners, which clearly are skewed to their advantage. As the artisanal miners prefer using mercury to recover the gold from their ores, often the tailings are left with the owners, who then recover a much bigger portion of the residual gold using cyanidation processes. If a state credit system was in place, together with training and education programs, then artisanal miners could access the financial resources needed to build their own processing facilities, complete with gravity concentration equipment, flotation and cyanidation circuits, as well as learning how to implement more equitable terms for credit.

The other scenario that exists involves conflict, where either drug producers or armed groups use and exploit the artisanal miners for money laundering. In order to counter this threat, the state credit system could be beneficial in marginalizing these intermediaries and improving the lives of the miners involved in the sector by ending the vicious poverty cycle.

Although the credit system can beneficial, the financial institutes issuing these credits need to have some sort of guarantee that these credits will be repaid. However, establishing a method to assess

the credit risk of artisanal miners is difficult, given that many artisanal miners do not have bank accounts or even proper documentation in some cases. In comparison, larger operations would likely have the ability to comply with most of the requirements demanded by banks when loaning money to mining companies, which include the establishment of gold reserves through geological surveys, followed by a feasibility study and assessment of cash flow and other assets. As a security, the lender usually wants a safeguard against the loan, whereby the operation would have the potential to generate twice as much revenue as that being borrowed, at a ratio of 2:1.

For a feasibility study, the bank will normally assess cash flow, properties and other assets in order to determine how much they can viably lend. The banks usually want the reserve tail ratio of the project to go on for two years longer than the payback period. For example, if the mine life is 7 years, then the bank will only give a loan for 5 years, considering that if things go wrong, the miner has two years to compensate. It is important to point out that banks will often use a lower gold sale price than the price used in the feasibility study, which will then determine the repayment period. If it appears that the mining operation is going to generate $200,000,000, then the bank will only lend $100,000,000.

Hilson (2011) suggested that micro-credit in Africa was not successful for the artisanal mining sector, because miners were not fully legalized and banks were very selective about requirements for the loan, demanding sufficient collateral and guarantees. Knowledge of geological reserves, business plans and other requests are expected from individuals who apply for the credits, which are typically beyond the ability of artisanal miners to provide.

It has been noted by Veiga et al. (2014b) that bank financing has typically been a big hurdle for artisanal miners to become responsible small-scale miners. In Portovelo-Zaruma, there are 40 small-scale plants, processing between 60 to 130 tonnes per day of ore, that have been established by private investments. In this case, formalization has been beneficial in encouraging artisanal miners to form business entities. Although an increase in production places artisanal miners into a higher tax bracket, the expansion in scale and modernization of technologies allow for greater revenue potential, due to the attainment of better yields. In addition, this marginalizes the role of middlemen, who profit enormously from artisanal mining operations.

2.7. Illegality of Gold Supply

According to Harland (1996), the term "supply chain management" appeared in the early 1980s as a way to describe the benefits of business integration, namely manufacturing and sales. According to this author, the term had a strong connotation used to indicate the structure and management of a business, in terms of how a product is generated from transformation of raw materials, which is then manufactured and sold to a consumer. Currently, the term supply chain denotes a strong sense of responsibility from the manufacturers of a product in terms of the acquisition of raw materials used in a product. The environmental issues and exploitation of the producers are the basis of Fair Trade concepts, which have now been incorporated into the ASGM sector (Childs, 2014). The unfair distribution of profits from the gold production between miners (ASGM) and final product manufacturers was the trigger point for different NGOs' initiatives seeking to establish a more equitable allocation of benefits for artisanal miners and their communities. According to Reynolds and Greenfield (2015), the Fair Trade movement, which was first disseminated through agricultural products, "*seeks to challenge historically unequal international trade relations and promote social justice and environmental sustainability in global production*".

In 2009, only miners who registered and adhered to the new Mining Code were able to engage officially in mining operations. At this time, Ecuador's armed forces began to strictly enforce and regulate all operations that were not up to code by destroying equipment and all aspects of illegal mining operations. However, despite these efforts, illegal mining operations continue to persist, which only fuels black market gold commercialization. Contrary to what Hilson (2008) described in Ghana, where gold produced by artisanal miners stayed in the country, most gold produced by Ecuadorian ASGM miners is exported mainly through illegal channels. Torres (2015) revealed that gold exports from 2010 to 2014 had been grossly underreported, as "140 exporters sent 74 tonnes of gold on commercial flights from Guayaquil to the US" during this period. Although 74 tonnes of Ecuadorian gold made it to the international markets, the CBE only recorded 22 tonnes as the country's total production over the period from 2010 to 2014. Therefore, only 30% of the country's total gold production was reported to the CBE, while 70% had an illegal origin, as it was never declared to CBE or ARCOM. Several companies located in Guayaquil, which collect and export gold, were identified by this report.

Over the last 5 to 7 years, there has been a surge in gold exports from Ecuador. Specifically, records indicate that China appears just behind the USA and Switzerland as the top gold importers. In her analysis of illegal Ecuadorian gold exports, Torres (2015) revealed that the increase in gold exports has been attributed to a money laundering scheme, following an incident that occurred on March 5, 2015 in El Oro province. Ecuadorian border police stopped two armed trucks that were carrying "a shipment of 90 gold bars, valued at USD $2.5 million", which could not prove the legality of the gold's origin. In Esmeraldas Province in northern Ecuador, the police apparently found another money laundering scheme, which was attributed to drug trafficking and the rebel group FARC. In 2013, a state of emergency was declared, during which the army seized more than 70 gold processing sites and closed down 15 gold purchasing locations, which were suspected to have links with illegal entities (Torres, 2015).

The Peruvian NGO, Ojo Public (https://ojo-publico.com/oro-sucio) has a list of denunciations regarding gold being exported illegally for money laundering in Ecuador, Colombia, Peru and other Latin American countries. However, despite the reports from Ojo Publico to reveal the illegal gold movements and environmental impacts caused by ASGM, the NGO does not offer any solutions other than police action.

2.8. Initiatives of Responsible Gold Supply from Artisanal Miners

In order to help re-organize the gold trade for artisanal miners, some NGOs were created, such as ARM (Alliance for Responsible Mining), IRMA (Initiative for Responsible Mining Assurance), Fairtrade Gold International, RESOLVE, Responsible Jewelry Council, etc. These NGOs have been dedicated to establish methods to trace the illegal gold trade and promote methods to pay extra to miners who sell gold through legal channels. IRMA is a multi-sector initiative that was launched in Vancouver, Canada in 2006, which incorporates jewelers, NGOs and trade associations into a third-party assurance system that ensures mines operate in an environmentally and socially responsible way. The underlying principles of IRMA include: independent verification; fair and equitable distribution of benefits to communities; effective responsiveness to potentially negative impacts to the environment, health, safety and culture; and enhancement of shareholder value.

The Responsible Jewelry Council (RJC) is non-profit organization that was established in 2005, which consists of 14 organizations from a broad cross-section of the diamond and gold jewelry

business. The organization has vastly expanded from the original 14 members to nearly 300 participants. Although RJC is mainly designed for micro-scale mining and large-scale mining, it has the potential to become a "third party certification system with traceability in the chain of custody, providing a real alternative for certification of medium and large-scale mining." (Barreto, 2011).

Childs (2014) commented that although all of these initiatives are valid, they are introductory steps in finding global solutions for a transparent gold supply chain produced by the ASGM sector. The Organization of Economic Cooperation and Development (OECD) was founded in 1961 and is composed of 34 countries. The OECD has become a relevant entity in providing guidelines and frameworks in the mining sector. On August 22, 2012, the OECD's Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas was recognized by the US Securities and Exchange Commission as a comprehensive international framework, and has since been promoted by the US Department of State for company utilization. The due diligence framework deals with management of the supply chain of "tin, tantalum, tungsten, their ores and minerals derivate, and gold (OECD, 2018)." The OECD document provides a comprehensive framework and guidelines to help provide improvements to the supply chain, taking into consideration overlooked factors such as human rights and environmental impacts.

Fair Trade Gold International seeks to improve the ASGM sector through an ethical approach that only certifies gold or other precious metals that come from a clean and responsible supply chain. Products that earn the Fair Trade stamp must be devoid of hazardous working conditions, child labor, and environmental impacts, as well as adhering to women's rights, clean technologies, health and safety, democratic decision making, transparency and traceability. Consumer consideration is the driving force behind this initiative, which ends up humanizing the difficult conditions that ASGM individuals are still having to deal with.

3. SITE DESCRIPTION AND METHODOLOGY

During this research, three phases of investigations were conducted:

Phase 1 (August - November, 2014)

During this phase, initial consultations were conducted with 40 artisanal miners in the gold prolific regions of Nambija, Portovelo-Zaruma and Ponce Enriquez. The purpose of this phase was to obtain a general understanding of the artisanal mining sector in Ecuador through an initial field study.

Phase 2 (November - December, 2015)

During this phase, several gold buyers were consulted in the same gold regions where artisanal miners were interviewed in the first phase. The buyers were asked about the gold buying process, including the prices they paid and the amount they bought from the artisanal miners.

Phase 3 (March - April, 2017)

This phase consisted of conducting consultations with artisanal miners who sold gold to the CBE pilot program that commenced in June, 2016. The purpose of this research phase was to determine the advantages and disadvantages of this type of formalization process.

3.1. Gold in Ecuador

Ecuador is located on the west coast of South America, with Colombia to the northeast and Peru to the west and south (Figure 1). Ecuador is a Spanish-speaking country and has a current population of 16,624,000. The size of Ecuador is 283,560 km^2, which includes four contrasting regions that are composed of coastal plains, Andean uplands, tropical jungle and the Galapagos volcanic islands (MICLA, 2017). Although the capital of the country is Quito, the largest city is Guayaquil, which is also home to Ecuador's largest port and main commercial center.

Since March 13, 2000, the country abolished its use of the Sucre and adopted the US dollar as its national currency. The country's economy has a GDP of $128 billion, which is dominated by petroleum, food processing, textiles, steel production from the industrial sector, as well as bananas, coffee, cacao, rice, cattle, balsa wood and fish from the agricultural and animal husbandry sectors.

The country's main exports are petroleum, bananas, shrimp, coffee and cacao. Raw material exports constitute 90% of Ecuador's export revenues, of which 55.9% are fuels and mining products and 34.1% from agricultural products. Petroleum extraction occurs mainly in the Amazon in the region around Lago Agrio in Sucumbios Province (Ecuador Travel Guide, 2018).

Figure 1. Map of Ecuador. Thered circle indicates the area of study.
(Source : Infoplease https://www.infoplease.com/atlas/ecuador)

Historically, gold production in colonial Ecuador relied heavily on indigenous labor, as opposed to the use of African slaves like in other Spanish colonies (Lane, 2004). The Ecuadorian porphyry Cu-Au district is located in the southern part of the country, in Zamora-Chinchipe Province. This district is characterized by narrow mineralized structures, in which the copper-gold mineralization is disseminated. The age of this structure has been dated to between 164 and 153 million years ago (Drobe et al., 2013).

The historic mines were primarily centered in the southern and eastern parts of the country. Cordillera del Condor region in the Amazon is known for its significant high-grade gold, silver and

copper deposits. This region is in the northern section of a porphyry deposit that was formed between 150 and 30 million years ago. The mining industry is small in Ecuador, and there was little foreign investment in conventional mining projects until the early 1990s. Since the adjustment to the new Mining Code, there have been applications submitted by companies to explore nearly 69% of Ecuador. In 2017, Ecuador's mining industry generated US $1.1 billion in revenues and it is expected to reach US $7.9 billion in 2021. Although the mining sector only employed 3,700 people in 2017, total employment is estimated to reach 16,000 in the 2017-2020 period (Jasmine, 2017).

It is important to highlight that gold production in Ecuador is currently supplied predominantly by the ASGM sector. In 2015, the CBE reported legal gold production of 6.2 tonnes, in which 52.4% came from Azuay Province, 31.6% from El Oro and 9.6% from Pichincha Province. The remaining 6.4% came from Imbabura, Loja, Morona Santiago, Napo, Zamora Chinchipe and Cotopaxi Provinces (CBE, 2016).

Ecuador has a significant resource endowment for mineral production, but currently it only represents 0.32% of the country’s GDP. The average official gold production between 2013 and 2016 reported by the Central Bank of Ecuador was 7.7 tonnes, while between 2016 and 2018 it was only 3.4 tonnes (CBE, 2018). In comparison, the UN COMTRADE (2018), which is a UN agency responsible for monitoring the trade of goods among countries, registered 288 tonnes of gold (classified as export product HS 7108, semi-manufactured or in powder) that were exported in 2013 by Ecuador to many countries (6.45 tonnes in 2018, 5.09 tonnes in 2017, 7.54 tonnes in 2016, 20.8 tonnes in 2015 and 28.6 tonnes in 2014), although the United States received 98% of all gold exports. It appears possible that this was an error by the UN COMTRADE, as the largest global gold producer in 2013 was China with 420 tonnes, followed by Australia with 255 tonnes and the United States with 225 tonnes. Despite illegal exports of gold from Ecuador being denounced by the media (Torres, 2015, El Universo, 2017), it seems that the Ecuadorian Government does not have accurate data regarding gold production in the country, which is mainly conducted by small and medium conventional companies, as well as artisanal miners, mostly in the southern region of the country.

3.2. Regions of Investigation

The regions selected for Phase 1 of the field investigations were chosen based on having the highest gold production in Ecuador.

3.2.1. Nambija, Zamora

Nambija is located in Zamora-Chinchipe Province in the Amazon rainforest on the eastern part of the Andean Cordillera. This region has a tropical and humid climate, with average annual temperatures of 18-24 ^{0}C and an elevation range of 1500 - 2100 m. The geology can be categorized as Jurassic, with limestone and lutite skarns associated with granitic intrusions (Ramirez et al., 2003; Tarras-Wahlberg, 2000). In the quartz-carbonate-adularia-epidote veins within the skarn rocks, gold mineralization occurs in nugget formation or fine disseminations. The common occurring minerals include pyrite, magnetite, chalcopyrite, galena and sphalerite (Ramirez et al., 2003). This region became popular for mining exploration in the 1980s, due to a downturn in the agricultural sector along the coast and an increase in the price of gold, together with on-going issues with the traditional Portovelo-Zaruma mine (Sandoval, 2001; Tarras Wahlberg, 2003)

The Nambija district quickly gained attention from international mining companies that unsuccessfully attempted to claim mineralized deposits in the region (Figure 2). Likely due to a lack of formal mining companies in the area, tens of thousands of informal/illegal miners ended up invading the Nambija Gold Belt district in the 1970s and 1980s (Tarras Wahlberg, 2003). By 1985, the population of Nambija had rapidly grown from 250 to 20,000 inhabitants, which turned it into the top gold-producing region of the country, based upon the “artisan discovery of gold veins and pockets at shallow depths” (Sandoval, 2001). Eventually, the State-backed military intervened in Nambija to prevent lawlessness and regain control of the region, which allowed for the construction of better infrastructure and roads to access the area. A map of the area is shown in Figure 2.

In Nambija, gold extraction and processing are characterized by rudimentary methods and lack of technical guidance, which includes basic gravity concentration and mercury amalgamation. In comparison, cyanidation techniques have now become increasingly used at processing centers in areas like Portovelo-Zaruma.

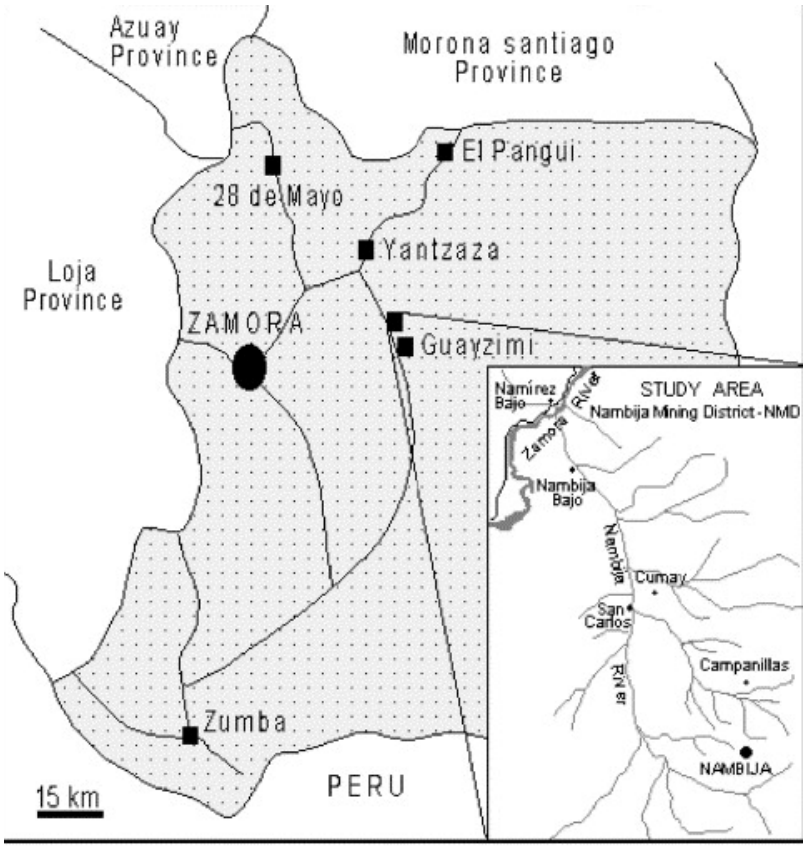

Figure 2. Map showing the Nambija mining district.
(Source: Ramirez et al., 2003)

Up until 1991, total gold production in Nambija was estimated to be approximately 30 tonnes (Ramirez et al., 2003). Tarras-Wahlberg et al. (2003) reported that “intense mining, in combination with poor mine planning, resulted in the exploitation and rapid exhaustion of the region’s most accessible ore deposits.” This exhaustion of easily accessible resources ended up pushing the miners into underground mining, which was hindered by a lack of safety regulations that resulted in several accidents, most notably the mine collapse of 1993 that left approximately 300 people dead.

After 1993, the population of Nambija steadily declined, reaching 8000 by 1997. Due to the widespread use of mercury in the region, fish populations were shown to be contaminated with methyl-mercury and miners burning amalgams were suffering from inhalation of mercury vapor. Appleton et al. (2000) confirmed that residents in and around Nambija district showed high levels

of mercury in the blood (mean 17.5 μg/L, compared with 3.9 μg/L for a non-gold mining area). The methylmercury contamination of fish populations and subsequent effect on people consuming local fish can be attributed to the district's complex system of sluices within the Quebrada Calixto and Quebrada Cambana drainage basins, which were funneling mercury-contaminated effluents directly into the Nambija River (Appleton et al., 2000).

By the early 2000s, Tarras-Wahlberg et al. (2003) reported that the easily accessible deposits in Nambija were already depleted and remaining resources were increasingly difficult to recover, due to the uncontrolled and disorganized nature of mining activities in the region. Currently, although artisanal mining still persists in the region using gravity concentration and amalgamation, technological advances in gold processing utilizing flotation and/or cyanidation have not developed significantly. Then, in August 2015, the Ecuadorian government banned the use of mercury in mining, thereby complicating the ability of artisanal miners to process their ore. Consequently, the mining regulation agency of Ecuador (ARCOM) has shut down numerous mines in the district, leaving a significant number of artisanal miners without work.

3.2.2. Ponce Enriquez, Azuay

The Ponce Enriquez Mining District is situated 40 kilometers northeast of Machala in Azuay Province on the southwestern side of the Andes. The altitude of the mining district is 700-1600 m, with local annual precipitation of 1500-2000 mm. The vegetation and climate are categorized as tropical and humid and the geology is from the Cretaceous period, mainly consisting of Basaltic lava and tuff (Tarras-Wahlberg et al., 2000). Currently, the region is inhabited by an estimated 2000 people, with the local economy revolving primarily around mining, although the production of coffee, cacao, citrus fruits, baby-bananas, mangoes and sugar cane still persist. Due to high gold prices, a decline in the agricultural industry and issues associated with mines in Portovelo-Zaruma, the Ponce Enriquez mining district (Figure 3) gained its prominence in 1983. The gold rush in this region began upon discovery of arsenopyrite-chalcopyrite hydrothermal veins that showed gold grades of 150 g/t in different sectors at shallow depths (Sandoval, 2001). Gold extraction methods included the rudimentary use of gravity concentration techniques, amalgamation and cyanide leaching of the whole ore.

Figure 3. Artisanal mining regions in southern Ecuador.
(Source: Tarras-Wahlberg et al., 2001).

Unlike Nambija, the mining industry in Ponce Enriquez has managed to organize into cooperatives and small mining companies that are relatively responsible. While Nambija lacks proper infrastructure and environmental management systems, Ponce Enriquez is much more developed. Ponce Enriquez has been identified as a district that has particularly attracted newcomers to artisanal gold mining, who have little prior experience or knowledge of mining and processing techniques. Generally, these newcomers have tended to concentrate on abandoned tailings in search of low-grade gold (Velásquez, 2010).

3.2.3. Portovelo-Zaruma, El Oro

The Portovelo-Zaruma Mining District in El Oro Province is arguably the most prolific gold mining region in Ecuador. The district is located in the headwater region of the Puyango-Tumbes River basin in the southwestern part of the country. The district's geology is Tertiary and includes volcanic rocks and andesite. The gold veins in the Portovelo-Zaruma deposits are associated with continental arc magmatism that occurred in the Lower Miocene period (23.03 ± 0.05 to 15.97 ± 0.05 million years ago) (Vikentyev et al., 2005). The altitude of Portovelo-Zaruma is 700-1400 m,

annual precipitation varies between 1200-1500 mm,, and the vegetation and climate is characterized as tropical and medium-dry, respectively (Tarras-Wahlberg et al., 2000).

Currently, 87 operating processing centers exist in the Portovelo-Zaruma area, which use different combinations of gravity concentration, amalgamation, flotation and cyanidation processing to recover the gold from ore that artisanal miners bring to the centers. In addition, some centers process ore from their own mines (Gonçalves et al. 2017).

3.3. Other Areas

The second phase of the field investigations was conducted between November - December of 2015, which focused on gold buyers in Ecuador. From these investigations, the following towns in the three study regions were identified by personnel from the Central Bank of Ecuador (CBE) and artisanal gold miners as 'hot spots' for gold buying: Zamora, Zumba, Yantzaza and San Carlos near the Nambija area in Zamora-Chinchippe Province; Chordeleg (a town near Cuenca) in Azuay Province; and Portovelo, Zaruma, Pinas and El Pache in El Oro Province.

Apart from Chordeleg, the majority of the above-mentioned locations for gold selling are in close proximity to gold-producing areas. Chordeleg differs from the rest, as it is the jewelry shop capital of the country. In Chordeleg, there are over 100 gold and silver jewelry shops within a 2-kilometre radius and gold merchants have a history of bringing their gold to these shops.

3.4. Methodology

Consultations were conducted with different stakeholders involved in Ecuador's ASGM supply chain. The first set of consultations were performed between August and November, 2014, with artisanal gold miners from the gold mining districts of Nambija, Portovelo-Zaruma and Ponce Enriquez. During these consultations, a total of 29 questions were aimed at establishing the social background of the miners, the processing techniques used, knowledge of Ecuador's mining legislation and government schemes, and the current and potential commercialization of gold.

The support of the CBE was crucial to this research, as it is the entity responsible for legal gold transactions. In addition, further contact and support came from ARCOM, a government institution responsible for regulation and enforcement of the mining sector. As ARCOM operates in numerous locations in gold-producing districts throughout the country, it was able to provide

transportation in order to visit ASGM locations and helped to establish formal contacts with different stakeholders involved in the research.

Through informal conversations with CBE personnel in 2014, Ecuador's main gold-producing regions were identified, which included Nambija, Portovelo-Zaruma and Ponce Enriquez. The next step was establishing communication with the different ARCOM offices in the southern part of the country, which was essential in order to gain access to some of the more remote mines. The first region visited was the Nambija mining district, where an ARCOM driver provided transport from Zamora to Nambija. Consultations with artisanal miners in Nambija were conducted over an eight-hour period, during which 9 miners from 9 different mines were asked to participate in the research.

In Portovelo-Zaruma, the research was conducted over a three-day period, whereby an engineer and driver from ARCOM's Portovelo office provided assistance and support. Mine sites in the Portovelo-Zaruma district were visited between 10 a.m. – 4 p.m. during each of the three days, culminating in consultations with 20 artisanal miners.

In Ponce Enriquez, the research was conducted over a two-day period from 10 am to 4 p.m., during which a trainee driver from ARCOM was able to provide transport. Due to difficulties accessing many of the more mechanized and gated operations in Ponce Enriquez, as they requested an official written statement from the ARCOM office, a total of 11 consultations were conducted in two days.

In Phase 2, the research was conducted in November/2015 at the main gold purchasing locations (gold-shops) in southern Ecuador, which were indicated by both ASGM individuals consulted in 2014 and from recommendations given by the Gold Commerce sector of the CBE. These included jewelers and gold-shops in Chordeleg, Yantzaza, San Carlos, Zamora, Zumbi, Zaruma, Portovelo, Pinas and El Pache.

As government organizations did not provide any support for Phase 2 of the research, all results were obtained completely independently. In total, consultations with 21 respondents were conducted: five from Chordeleg in Azuay Province; three from Yantzaza, one from San Carlos, three from Zamora and one from Zumbi in Zamora-Chinchipe Province; two from Zaruma, one from Portovelo, one from Pinas, and four from El Pache in El Oro Province. The 14 questions

formulated for this phase of the research were aimed to investigate: the amount of gold each shop buys per month; the gold analysis methods; presence of gold impurities; the prices paid for gold, profit tax, and commercial licenses; identity of buyers in the supply chain; export data; frequency of ASGM visits; origin of the gold bought from ASGM individuals; amount of gold brought at one time by ASGM individuals; invoice requests; opinions regarding the CBE program; and the effect of the CBE program in diminishing the illegal gold market.

In Phase 3 conducted in March-April/2017, the aim of the research was to gain information about the CBE's Gold Purchase Program (GPP) from miners who were actively selling gold in Sangolqui, as well as from administrative personnel in charge of the gold commercialization program. Upon access to the CBE GPP, observations were made regarding the selling process, together with consultations with miners who went there to sell their gold.

The next step of the research in Phase 3 was to travel south to Portovelo-Zaruma, where 52% of the miners who sell to the CBE GPP come from. Once in Portovelo, active sellers to the CBE were contacted and a meeting was arranged to garner different perspectives regarding the program.

4. RESULTS

4.1. Results from Initial Consultations with Miners

The first set of results was obtained from consultations conducted between August-November/2014 with 40 ASGM miners from Nambija, Portovelo-Zaruma and Ponce Enriquez. During the consultations, not all of the 29 questions included in the surveys were responded to by all of the miners. The results of each question from miners of the 3 regions are presented, together with an overall summary. The questions covered different topics, including the social background of the miners, the processing techniques used, knowledge of Ecuador's mining legislation and government schemes, and the current and potential commercialization of gold.

4.1.1. Social Background Trends

From the surveys conducted in 2014, a general background of the miners was established, which included information on the miners' nationality and place of birth, age of the miners, family sizes, and whether miners had family members accompany them to the mines (Table 2).

Table 2. Social backgrounds, families and work trends of artisanal gold miners from Nambija, Portovelo-Zaruma and Ponce Enriquez in southern Ecuador.

All of the miners who were consulted were born in Ecuador, with the majority being from El Oro Province, which encompasses the Portovelo-Zaruma mining district.
31 of the 40 respondents (77.5%) were between 30 - 50 years old. Family sizes: 23% of the miners had 3 family members, 20.5% had 4 family members, 17.9% each had 5 or 6 family members, 5% had 7 family members, and 2.5% applies to individuals with either no family members, or 2, 8, 9, 10 and 11 family members.
A little over half of the miners (56.4%) had families who would accompany them to their work/mine sites and 51.3% had their families involved in mining activities at the sites.
Approximately 21% of the miners have been mining for 20 - 25 years, 16% have been mining for 1 - 5 years, 13.2% for 10 - 15 years, another 13.2% for 30 - 35 years, 10.5% for 25 - 30 years, 7.9% from 5 - 10, another 7.9% that mined for 15-20 years, 2.6% for 35 - 40 years and another 2.6% mined for less than a year.
All of the miners lived locally and relatively close to their work sites. The majority of the miners in all 3 regions (65.5%) lived 5 minutes away from their mine site, 20.6% lived 10 minutes away, 3.4% were 15 minutes away, another 3.4% were 30 minutes away, and finally 6.8% of the miners lived an hour or more away. In regards to daily work hours, 30.5% worked 6 hours a day, 25% worked 8 hours or more, 19.4% worked exactly 8 hours, 11.1% worked 4 hours, another 11.1% worked 5 hours a day, and 2.8% worked 7 hours a day.
A total of 44.7% of the respondents worked 6 days a week, 42.1% worked 5 days a week, 10.5% 7 days a week, and 3% worked only 2 days a week.

4.1.2. Familiarity with Mining, Environmental Regulations & Mercury Usage

This section aimed at investigating the artisanal miners' knowledge of the country's mining and environmental regulations, whether they were aware of when the mercury ban would be taking effect, and the amount of mercury that they used per month (Table 3).

In 2014, artisanal miners were asked if they were familiar with Ecuador's mining laws and environmental regulations, especially regarding the ban on using mercury coming into effect in 2015. Three options were given: "yes", "no", and "somewhat". It was observed that the majority of the artisanal miners were familiar with the mining and environmental laws of the country, as 47.4% responded "yes". The remaining twenty respondents were divided between having little knowledge of the regulations and those miners who had no idea about any of the restrictions, registering 26.3% each.

Table 3**.** The knowledge of artisanal miners with respect to the country's laws and the mercury ban, as well as their average consumption of mercury by region.

	n	**Familiarity with Mining & Environmental Regulations**			**n**	**Knowledge of Mercury Ban**			**Average Amount of Mercury Bought**
	#	**Yes**	**No**	**Somewhat**	**#**	**Yes**	**Yes & Deadline Date**	**No**	**Mercury (kg/mo)**
Nambija	**9**	2	5	2	**9**	1	5	3	10.3
Portovelo-Zaruma	**19**	9	4	6	**19**	9	6	4	0.32
Ponce Enriquez	**10**	7	1	2	**10**	6	2	2	7.12
Total	**38**	18	10	10	**38**	16	13	9	kg/miner/mo = 4.42
Total %		**47.4**	**26.3**	**26.3**		**42.1**	**34.2**	**23.6**	

In 2014, Ecuador's mining regulatory agency (ARCOM) gave the gold mining sector miners a deadline of one year to stop using mercury. During the consultations, the miners were asked if they had knowledge of the deadline to stop using mercury. In Nambija, 100% of the miners provided an answer to this question, of which: 5 out of 9 or 55.6% replied "yes" and gave the exact deadline date at the end of 2015 (Moncada, 2016); 1 (11.1%) replied "yes", but did not know when the mercury ban would be going into effect; and (33.3%) replied "no". In Portovelo-Zaruma, 19 out of

20 miners (95%) responded to the question, where: 6 (31.6%) said “yes” and confirmed the timeframe; 9 (47.4%) said “yes” without knowing of the exact deadline; and 4 (21%) did not know anything about the mercury ban. In Ponce Enriquez, 10 out of 11 (91%) answered the question, of which: 2 (20%) provided the exact date of the mercury ban initiation; 6 (60%) said “yes”, but did not know when it would be taking effect; and 2 (20%) did not know about the ban. In total, 38 responses were obtained from the three regions, of which: 13 (34%) said ‘yes’ and knew when the ban was taking effect; 16 (42%) replied “yes”, but did not know when; and 9 (24%) did not know about the ban.

The artisanal miners in the 3 study regions were also asked to indicate the amount of mercury each of them purchased per month for their operations (Table 4). This question is more relevant than one asking them “how much mercury they use” as they recycle almost 50% of the mercury they use (add to the amalgamation process) when they squeeze the amalgam to remove excess mercury. In contrast, the amount of mercury they “buy” supposes to be amount of mercury they “lose” per month.

Table 4**.** Amount of mercury bought per month
in all 3 regions combined.

Mercury Bought in All 3 Regions (lb/mo/miner)	**Miner Responses (n)**	**Miner Responses (%)**
0	8	26%
1	8	26%
2	6	19%
3	3	10%
5	3	10%
15	1	3%
90	1	3%
120	1	3%

In Nambija, 6 of the 9 miners (66.6%) responded to the question, with the amount of mercury being bought varying from 1 to 54.4 hg (120 lb) per month/miner, with an average of 10.3 kg/month/miner. In Portovelo-Zaruma, 18 of the 20 (90%) answered the question, with mercury bought per month ranging from 0 to 2.27 kg/month/miner. In total, 7 out of 18 (39%) bought 0.32 kg of mercury/month/miner, while 33% stated that they no longer used mercury. In Ponce

Enriquez, 7 out of 11 (63.6%) responded to the question, where the consumption range varied from 0 to 40.8 kg (90 lb) of mercury bought per month/miner. In average, 43% of the miners buy 7.12 kg/month/miner, while 28% responded that they do not buy any mercury for their operations. Overall for the 3 regions, the weighted average revealed that approximately 4.53 kg (10 lb) of mercury/month was being bought per miner.

4.1.3. Government Participation in Artisanal Mining

In this section, the miners were asked to rate the level of any type of Government presence in artisanal gold mining in their district (Table 5). The participation was understood to represent not only enforcement of mining regulations, but also technical assistance, loans, training, technical assistance, orientation on the legalization process, etc. Six options were given: very good, good, regular, bad, very bad, or no participation. Miners were also allowed to express their own opinions regarding this matter.

Table 5. Miners' opinions regarding the Ecuadorian Government's participation in artisanal gold mining in the three study regions.

	Response Rate (%)	Very Good	Good	Regular	Bad	Very Bad	No Participation
Nambija	89% (7/9)	1/9	3/9	2/9	1/9	0	0
Portovelo-Zaruma	95% (19/20)	1/20	4/20	11/20	3/20	0	0
Ponce Enriquez	100% (11/11)	1/11	1/11	5/11	1/11	1/11	2/11
Total	92.5% (37/40)	8.1% (3/37)	21.6% (8/37)	48.6% (18/37)	13.5% (5/37)	2.7% (1/37)	5.4% (2/37)

4.1.4. Processing Techniques

The miners from each of the three regions were asked to name the processes that they utilize to extract gold from their ores (Table 6).

In Nambija, 100% of the miners responded to the question and all stated that they used amalgamation as their only processing method. It was clear by the answers that very few miners amalgamated the concentrates, as theypreferred amalgamation of the whole ore, which is the

favorite process still in place. In second place, the most trained miners used cyanidation with activated carbon, avoiding the use of mercury. Amalgamation followed by cyanidation was practiced by 7.5% of the 40 miners interviewed.

Table 6. Processing techniques utilized by the artisanal gold miners in the 3 studied regions.

Region:	**Nambija**	**Portovelo-Zaruma**	**Ponce Enriquez**	**Total for the 3 Regions**	
	Number of Miners Using Process	**Number of Miners Using Process**	**Number of Miners Using Process**	**Total Number of Miners**	**% of Miners' Responses**
Amalgamation	9/9	3/20	5/11	17/40	42.5%
Flotation		1/20	1/11	2/40	5%
Cyanidation (Zinc)		4/20		4/40	10
Cyanidation with Activated Carbon		9/20		9/40	22.5
Gravity Separation			1/11	1/40	2.5
Combo: Amalgamation & Cyanidation		2/20	1/11	3/40	7.5
Combo: Flotation & Cyanidation with Activated Carbon			1/11	1/40	2.5
Combo: Flotation & Cyanidation with Zinc Precipitation			2/11	2/40	5
Do Not Process		1/20		1/40	2.5
Total	**9**	**20**	**11**	**40**	**100**

4.1.5. Methods & Amount of Material Processed per Month

The artisanal miners were asked whether or not they own their own processing equipment or use a processing center (PC) to extract gold from their ores (Table 7).

Table 7. Number of artisanal gold miners from the 3 study regions who own their own equipment or use processing centers (PC) and the volume of material (tonnes) processed per month.

	Ownership/Use of Processing Equipment (PC)			Volume of Material Processed (tonnes/month)					
	Responses (n)	**Own**	**Use PC**	**Responses (n)**	**50 or less**	**50 – 100**	**300 - 350**	**1000 - 1500**	**3000**
Nambija	9	9	-	8	2	1	5	-	-
Portovelo-Zaruma	18	2	16	18	14	3	-	-	1
Ponce Enriquez	7	1	7	7	5	-	-	2	-
Total	**34**	**12**	**22**	**33**	**21**	**4**	**5**	**2**	**1**
Total %	**85%**	**35%**	**65%**	**83%**	**63.6%**	**12%**	**15%**	**6%**	**3%**

In Nambija, 100% of the miners used their own equipment to process ores, as processing centers are not popular in the region, whereby all artisanal miners use primitive methods of amalgamation to extract gold. In contrast, the large majority of miners in Portovelo-Zaruma (90%) took their ores to processing centers. It is interesting to note that more and more miners are preferring to pay for cyanidation of their ores instead of paying the processing centers for amalgamation or simply leaving the tailings as payment. A similar observation was also made by Gonçalves et al. (2017).

In terms of the volume of material (tonnes), 64% of the miners from the 3 study regions processed less than 50 tonnes/month, while 34% processed more than 300 tonnes/month. In Portovelo, a processing plant with capacity to process more than 3000 tonnes/mo of ore was observed. Gonçalves et al. (2017) observed that 20% of the 52 processing plants investigated in Portovelo had a processing capacity above 100 tonnes/day.

4.1.6. Processing Center Costs

Only 9 miners, and all from Portovelo-Zaruma, were willing to provide details regarding the amount they paid per tonne at the processing centers (PC) where they took their material. The

services they were paying for included amalgamation, as well as a combination of gravity separation, flotation and cyanidation. The lower processing costs (Table 8) refer to amalgamation in "chanchas", with the condition that they had to leave their tailings at the PC. If miners requested to have their ores concentrated by gravity concentration and/or flotation, followed by amalgamation, the price increased. If they wanted cyanidation of the concentrates of the tailings from amalgamation, the cost was even higher.

Table 8. Costs reported by the artisanal miners from the Portovelo-Zaruma for using the processing centers to process their ore.

Cost of Using a Processing Center (per tonne of ore)	**Number of Individuals**
No Cost	1
$40	1
$120	3
$140	1
$160	1
$215	1
$1800	1
AVG: $301.70	**9**

4.1.7. Technical Assistance Providers

The miners from each region were asked to provide information on whether or not they received technical assistance from Ecuadorian state agencies such as ARCOM or INIGEMM, or if they privately paid third-party technicians to help them (Table 9).

It was clear that miners learned how to process their ore using local private technicians who charge for their services to the miners and PCs. In Nambija, the situation was deemed critical, as all of the miners stated that they did not receive any technical assistance from the Government and had never hired any external technicians to help them with their processing. In Portovelo-Zaruma, 63% responded that they did have some knowledge about gold processing, as they received technical assistance from private technicians that they paid. The responses showed that the Government is not a significant provider of technical assistance to the miners or the PCs.

Table 9. Artisanal miners who received technical assistance from either the State or third-party technicians

		Technical Assistance		Technical Assistance Provider	
	(n)	**Yes**	**No**	**State**	**Third-Party Technician**
Nambija	9	0	9		
Portovelo-Zaruma	19	12	7	1	12
Ponce Enriquez	8	4	4	2	4
Total	**36**	**16**	**20**	**3**	**16**

4.1.8. Miners' Knowledge about Gold Price

This set of questions was aimed at establishing whether or not the artisanal miners were familiar with the London Metal Exchange (LME) gold spot price, whether they thought they received a fair price for their last transaction, what that price was, and if they were willing to travel to Quito to sell their gold to the CBE (Table 10).

When asked whether or not they were familiar with the international gold price, about 70% of the interviewed miners responded that they knew the LME spot price, and 89% were unhappy with the gold price paid by the gold-shops.

When asked about how much the miners received in their last transaction at local gold-shops, the prices ranged from US $20 to $39 per gram of gold. At the time of these consultations with the miners, the LME spot price was approximately US $39 per gram. In Nambija, one miner said that he received $30 per gram of gold in his last transaction in Yantzaza. In Portovelo-Zaruma, 55% revealed the price they were paid during their last transactions at a gold-shop. In Zaruma, 4 miners received $22/g, $22/g, $36/g and $23/g, respectively, while in Portovelo 3 miners received $24/g, $30/g and $30/g, respectively. In Piñas, one miner received $35/g, while in Ponce-Enriquez the gold prices were very similar, varying from $20/g to as high as $39/g.

Table 10**.** Artisanal miners' familiarity with the London Metal Exchange (LME) gold spot price, the perceived fairness of the price received for their gold in their last transaction, the price they received, and whether or not they were willing to travel to Quito to sell their gold to the CBE.

CATEGORY		Nambija	Portovelo-Zaruma	Ponce Enriquez	Total	Total %
Familiarity with Gold LME Spot Price	Yes	2	16	9	27	69%
	No	6	3	2	11	28%
	Somewhat	1	-	-	1	3%
	(n)	9	19	11	39	100%
Perceived fairness of price received in last transaction at a gold-shop	Fair	2	2	0	4	11%
	Not Fair	6	16	6	32	89%
	(n)	8	18	6	36	100%
Average price paid by gold-shop in last transaction		$30/g	$27/g	$33.7/g		
LME Spot Price at the time of transaction		$39/g	$39/g	$39/g		
Willingness to sell gold to CBE	Yes	8	10	4	22	56%
	No	1	8	6	15	38%
	Maybe	-	1	1	2	5%
	(n)	9	19	11	39	100%

4.1.9. Willingness to Sell Gold to the CBE

This part investigated whether or not the miners were willing to travel to Quito to sell to the CBE. In Nambija, all miners responded, of which 89% were willing to sell gold to the Government. In Portovelo-Zaruma, 52% said "yes", 42% said "no" and 6% said "maybe". In Ponce Enriquez, 73% said "yes", 18% said "no" and 9% said "maybe".

Approximately 56% of the 39 miners interviewed were willing to sell their gold to the CBE. There were 15 miners out of 39 (38%) who answered “no” to the question, and 2 of the 39 (5%) said “maybe”. However, there was a general consensus that the CBE GPP would be more appealing if it was located closer to their mines, which would likely mitigate the concerns of the miners who responded “no”. In terms of security and transport, some miners were afraid of getting robbed, while others did not produce enough gold to make the trip worthwhile.

4.1.10. Locations of Artisanal Miner Gold Sales

The miners were asked to provide information regarding the most frequent location of their gold sales (Table 11).

Table 11. The most frequent gold sale locations for the miners consulted in this study.

Location of Gold Sales								
	Yantzaza	**Cuenca**	**Zaruma**	**Portovelo**	**Pinas**	**El Pache**	**Chilla Cantonne**	**Ponce Enriquez**
Nambija	8	1						
Portovelo-Zaruma			7	7	4	1	1	
Ponce Enriquez								9
Total	**8**	**1**	**7**	**7**	**4**	**1**	**1**	**9**

In Nambija, 89% stated that they sold their gold to gold-shops in Yantzaza. In Portovelo-Zaruma, 35% sold to gold-shops or jewelers in Zaruma, 35% in Portovelo, 20% in Pinas, 5% in El Pache, which is the site where the processing centers are concentrated, and 5% in Chilla Cantonne. In Ponce Enriquez, 82% responded and that they sold their gold locally. Overall, this information suggests that the majority of the miners were selling their gold within a 10 km radius of their mine sites.

4.1.11. Familiarity with Financial Assistance Options from the Government

This section investigated the level of awareness regarding financial credit offered by the Ecuadorian Government for ASGM to improve their operations, and what the miners would use

the capital for (Table 12). According to Ecuador's National Mining Plan of 2010, the Government was looking for ways to finance artisanal miners, which is fundamental to helpthe miners get out of unfair deals with middlemen and other third parties that often take advantage of the miners' disparity for cashflow. Although a lack of geological studies makes it hard for any institution to lend money, including the Government, main subsidiaries such as ARCOM and CBE have developed a credit system for miners who switch to more environmentally-friendly technologies. As Table 12 shows, the majority of the miners had no idea about these credits for good environmental performance, particularly in more remote areas such as Nambija.

Table 12. Artisanal gold miners' knowledge of the Ecuadorian Government's financial credit program for ASGMs, as outlined in the National Mining Plan of 2010, and what the miners would use the capital for if they received it.

	Familiarity with Financial Credit Provided by the State			**Use of Financial Credit**				
	Familiar	**Not Familiar**	**Somewhat Familiar**	**Machinery**	**Exploration**	**Infra-structure**	**Machinery, Exploration & Infra-structure**	**Did not Specify**
Nambija	-	9	-	-	-	-	-	-
Portovelo -Zaruma	7	7	3	10	3	1	3	
Ponce Enriquez	4	7	-	3	-	1	4	
Total	**11**	**23**	**3**	-	-	-	-	-

In Nambija, miners were not familiar at all with any credit program offered by the Government. In Portovelo-Zaruma, only 41.2% had knowledge of the Government program, while in Ponce Enriquez only 36% were familiar with it, with 64% being totally unfamiliar. In total, approximately 30% of the 37 miners were familiar with the financial credit program.

When asked what they would use the credit for if received, miners from Nambija did not give a response. In Portovelo-Zaruma and Ponce-Enriquez, the large majority stated that they would prefer to use most of the credit to buy better machinery, with some used for exploration.

Approximately 20% of the 37 miners interviewed responded that they would want to use the financial assistance for a combination of machinery, exploration and infrastructure.

4.2. Stakeholder Consultations

4.2.1. ARCOM, Zamora

A meeting was held with an engineer from ARCOM's Zamora office in March/2015. The engineer was asked several questions regarding the state of the country's artisanal gold mining sector and how it could be improved, as well as his thoughts on the financial credit program for artisanal miners. The engineer suggested that in order to improve the artisanal mining sector in the country, Ecuador's Geology, Mining and Metallurgy Investigation agency (INIGEMM - Instituto Nacional de Investigación Geológico Minero Metalúrgico) was the most capable entity to accomplish this task.

The reasoning behind this was that INIGEMM was already working on mercury eradication initiatives and introducing new clean processing technologies to miners. However, the agency is in need of more resources and needs to expand their program to reach more remote areas. On the subject of financial credit for artisanal gold miners, the ARCOM engineer suggested that the only feasible way to provide miners with credit was to find representative individuals from mining districts who would have the legal and financial wherewithal to pay back the loan. For example, in Nambija, as the mining district is divided into a north and south section, representative individuals from each of these areas would be the most likely to qualify for financial credit.

4.2.2. Ministry of Mines, Zamora

A representative from Ecuador's Ministry of Mines was consulted in the Zamora office. The discussion consisted of topics on improving the artisanal mining sector, the country's formalization process, financial credit and credit accessibility. The representative from the Ministry of Mines suggested that in order for formalization to be successful, detailed knowledge of all of the mining operations was crucial, as they vary throughout the country and some regions are more heavily concentrated than others. Furthermore, the representative mentioned that capacity building and education were fundamental in the formalization process, which needed to be addressed *a priori*. When asked about the credit program, the representative said that the miners needed proper documentation, including valid work and environmental permits, as well as declaration of the exact location of their work sites. In short, the miners who qualify for credit would be the ones that have

properly declared themselves and their production rates and have all the necessary permits. Therefore, the miners that do not meet the criteria would not be able to gain access to the State credit program.

4.2.3. Ministry of Environment, Zamora

Employees from the Ministry of the Environment in Zamora were asked about their agency's role in the artisanal gold mining sector. The respondents identified that their agency was responsible for evaluating and monitoring environmental performance and issuing environmental permits to the miners who met the criteria. Although the Ministry of the Environment was currently holding classes for miners in environmental awareness, there was apparently a general lack of interest and participation from artisanal gold miners, particularly from Nambija. In the near future, the agency expects to have all of the miners regularized with environmental permits and licenses to mine in their particular location, as well as implementing better control measures and monitoring of all of the environmental aspects.

4.2.4. ARCOM Portovelo-Zaruma

Several engineers from the ARCOM office in Portovelo-Zaruma were consulted regarding the state of the artisanal gold mining sector in this particular district. ARCOM personnel identified that their agency's objective in the region was to legalize, control, register and regulate the miners and the processing centers, as well as gathering information regarding the country's gold imports and exports. In October, 2014, the respondents stated that out of 94 processing centers that exist in the area, 79 had been completely legalized.

The engineers from ARCOM Portovelo-Zaruma identified that the issuance of credit by financial institutions could be extremely problematic, due to a lack of studies on mineral reserves in the country. There would need to be a detailed plan of the concession resources for the financial institutions to have confidence in their investments, as well as some sort of assurance that the miner would have the capacity to pay back the loan.

4.3. Results from Consultations with Jewelers and Gold-shops

Research conducted during the months of November and early December, 2015, focused on the gold buyers. This part of the study followed up on the consultations done in 2014 with artisanal miners from three regions of Ecuador, including Nambija, Portovelo-Zaruma and Ponce Enriquez.

The miners who participated in the previous research identified several gold purchasing locations, including Yantzaza, Cuenca, Portovelo, Zaruma, Pinas, El Pache, Chilla Cantonne and Ponce Enriquez. The research conducted in 2015 covered the majority of the locations identified by the miners, as well as including other well-known towns where gold was bought. Current gold buying entities were investigated with the purpose of obtaining information on Ecuador's gold supply chain. The Ecuadorian Government through their subsidiary, the Central Bank of Ecuador, commenced a program in January/2014 to actively buy gold from the informal artisanal mining sector. During the research conducted from 2014 to 2015, the CBE initiative was still in its early stages and had not yet made any direct gold purchases. In 2016, the CBE established an office in Sangolqui, Quito, where it began buying gold directly from ASGM individuals.

By investigating the current gold buyers, who were jewelers and gold-shop owners, this research investigated whether or not the CBE initiative could be profitable over the long term, as well as determining what more could be done to entice artisanal gold miners to sell their gold to the CBE.

In the investigation conducted in November 2015, 14 questions were formulated for the gold buying entities in Ecuador. The gold purchasing locations covered by this research included Chordeleg, Yantzaza, San Carlos, Zamora, Zumbi, Zaruma, Portovelo, Pinas and El Pache. In total, 21 gold buyers were the subjects of this survey, which consisted of jewelers and gold-shop owners. The town of Chordeleg is 25 kilometers away from the center of Cuenca and is known for the large number of jewelry shops that are located in close proximity of each other. The towns of Yantzaza, San Carlos, Zamora and Zumbi are all located near the Nambija mining district and have long been gold purchasing locations for ASGM miners. In El Oro province, gold-shops in the towns of Zaruma, Portovelo, Pinas and El Pache, which bring in miners from the nearby mining district, were visited during the course of this research.

Looking at the results from a regional perspective: Buyers 1 - 5 from Chordeleg, Azuay Province, were summed up into the Azuay category; Buyers 6 - 13 from Yantzaza, San Carlos, Zamora and Zumbi were placed into the Zamora-Chinchippe Province category; and Buyers 14 - 21 from Zaruma, Portovelo, Pinas and el Pache were put into the El Oro Province category.

The gold buyers were asked approximately how much gold they bought per month from the ASGM sector. During the research period (Nov. 26 – Dec. 2, 2015), the international LME spot gold price was approximately US $1060/oz or US $34.1/gram. The reported data refers to the gold

content in the *doré*, i.e. the silver and copper content was not accounted for. The range of gold bought per month for all 3 regions ranged from 20 - 10,000 grams. In Azuay, it varied from 20 - 300 grams/month, with an average of 164 grams/gold/month, as reported by the 5 respondents. In Zamora-Chinchippe, it varied from 50 - 10,000 grams/month, with an average of 2,366.5 g/gold/month by the 8 respondents. In El Oro, the range of gold bought per month was between 100 - 4,000 grams, with an average of 1,525 grams of gold/month.

When asked about the most recent transaction with the artisanal miners and the price paid for gold content in the "*doré*", this ranged from $21.5 to $34 per gram of gold. In Azuay, the range was between $26.48 and $33.33 per gram, as reported by the 5 buyers in this province. In the Zamora-Chinchippe region, 7 out of 8 responses were obtained and the range was between $27 - $34 per gram of gold. In El Oro Province, all respondents provided a value for the price they charged in their last transaction, and they ranged between $21.5 - $34 per gram (Table 13).

As gold has a density of 19.3 g/cm^3 and the most common impurities in gold *doré* (impure gold) are silver and copper with densities of 10.5 and 8.96 g/cm^3, respectively, miners are familiar with the method of measuring the density of the *doré.* Again, gold-shops pay only for the gold content in the *doré*, not for the silver, and this is what is reported. The equipment is a simple laboratory balance with an arm that suspends the *doré* immersed in water. The balance uses the Archimedes' buoyancy principle and determines the density of the solid. The difference between the density of pure gold and the value analyzed refers to the amount of impurities in the *doré*. In total: 11 of the 21 buyers (52.4%) used density alone as their method of analysis, whereas 5 (23.8%) buyers performed tests with nitric acid (observing the color change when the doré has silver or copper), while only 2 (9.5%) used both the density and nitric acid tests. All of these methods are accepted by the miners when they sell gold. Finally, two buyers did not use scientific methods and judged the gold fineness only in terms of its color, while one buyer did not disclose what analytical methods he used.

The gold buyers were asked if they paid the country's 12% tax on all profits, and 71% provided a response. In Azuay, 60% of the buyers answered the question, with 67% stating that they paid the profit tax, while 33% did not pay. In Zamora-Chinchippe, 71% responded to the question and 40% of the buyers reported that they paid the 12% profit tax, while 60% did not pay. In El Oro, 87.5%

of the buyers provided an answer to the question, with 71% paying the profit tax, while 29% said that they did not pay the tax.

Table 13. The practices of gold buyers from the three study regions.

Gold Buyer Identification	Price for Gold ($/g)	Amount of Gold Bought (g) per month	Analytical Method	Impurities	Pay Profit Tax?	Commercial License	Number of Sales/ Month	Average Amount of Gold bought per miner (g)	Miners Ask for a Receipt?
Buyer 1 (Chordeleg)	27	20	Not specified	Not know	N.A.	Yes	10	N.A	No
Buyer 2 (Chordeleg)	33.3	300	Nitric acid	Pure	N.A.	Yes	4	164	No
Buyer 3 (Chordeleg)	28	200	Nitric acid	Ag	No	Yes	8	40	No
Buyer 4 (Chordeleg)	26.48	150	Density	Ag & Cu	Yes	Yes	4	15	5%
Buyer 5 (Chordeleg)	32.3	150	Density	Ag & Cu	Yes	Yes	18	10.5	50%
Buyer 6 (Yantzaza)	32.3	10000	Density	Ag & Cu	Yes	Yes	400	25	50%
Buyer 7 (Yantzaza)	N.A.	2000	Density & Nitric Acid	Ag & Cu	Yes	Yes	100	7.5	Yes
Buyer 8 (Yantzaza)	34	1000	Density	Not know	N.A.	No	300	5.5	No
Buyer 9 (San Carlos)	27	100	Visual	Ag & Cu	No	No	10	1.75	No
Buyer 10 (Zamora)	32	50	Nitric acid	Ag, Cu, Fe	No	No	30	10	No
Buyer 11 (Zamora)	30	1600	Visual	Not known	No	No	2	Not known	No
Buyer 12 (Zamora)	30.4	4000	Density	Ag & Cu	N.A.	No	30	260	50%
Buyer 13 (Zumbi)	28	150	Density	Ag & Cu	N.A.	No	15	10	No
Buyer 14 (Zaruma)	34	3000	Color / Density	Not known-	Yes	Yes	30	55	No
Buyer 15 (Zaruma)	34	500	Density	Ag & Cu	No	Yes	N.A.	5.5	No
Buyer 16 (Portovelo)	21.5	100	Density	Agr	Yes	No	10	5.5	Yes
Buyer 17 (Pinas)	34	1000	Density	Not known	Yes	Yes	N.A.	100	80%
Buyer 18 (El Pache)	34	800	Density	Ag, Cu, Pb	N.A.	Yes	10	80	5%
Buyer 19 (El Pache)	23	4000	Density & Nitric Acid	Fe	No	No	200	4001.5	No
Buyer 20 (El Pache)	25	800	Nitric acid	Ag. Cu, Fe	Yes	No	20	25.5	50%
Buyer 21 (El Pache)	32	2000	Nitric acid	Cu, Fe, Zn	Yes	No	30	35	No

NOTE: N.A. = Not Answered. Amount of gold refers to the gold content in the *doré.*

Gold buyers from the 3 regions were asked if they had a commercial license for gold purchasing, and all of the buyers answered the question. In Azuay, all of the buyers had a commercial license, which was expected, since all of the respondents owned jewelries. In Zamora-Chinchippe, only 25% of the buyers had a commercial license, while 75% did not have a license. In El Oro, 50% of

the buyers did have a license, while the other 50% did not have a commercial license for gold purchase.

The buyers were asked to provide an approximate number of miners that sell gold to their shops every month, and 90% of the buyers answered the question, with answers ranging from 2 to 400.

The buyers were asked to identify whether the miners who sell to them ask for receipts or not. In Azuay, 100% of the respondents answered the question, stating that only 40% of the miners asked for a receipt, while 60% did not. In Zamora-Chinchippe, only 37.5% asked for a receipt, while in El Oro, 50% of the miners asked for one. However, in Pinas in El Oro Province, Buyer 17 stated that 80% of the miners asked for a receipt.

In terms of impurities, although the responses by the buyers varied considerably, including differing amounts of silver, copper, lead, iron and zinc, they did not show any chemical analyses to support their statements.

Gold buyers were asked whether they sold the gold after purchasing it from the artisanal miners, and if so, to whom. All of the jewelers in Chordeleg said that they used the bought gold to make jewelry, which was then sold to clients who came into the store. Two of the gold-shop owners in Yantzaza sold their product to gold merchants, while one sold to a gold exporter. In San Carlos, the buyer said that he re-sold the gold to other buyers in Yantzaza. In Zamora, Buyer 10 sold his gold to jewelers, while the other two buyers claimed to sell their gold in other provinces, including in the cities of Cuenca and Quito. In Piñas, Buyer 17 stated that he sold his gold to factories. In comparison, the buyer from Zumbi said that intermediary gold merchants would buy his product and then take it elsewhere for sale or export. Buyers from Zaruma and Portovelo also claimed to re-sell the gold to merchant intermediaries, the same as Buyers 17 and 18 from El Pache, while Buyers 20 and 21 from El Pache exported to Peru and to large investors, respectively.

In terms of exportation, 11 of the gold-shop owners claimed to have exported or know where the intermediary merchants were exporting to, including: USA (mentioned 8 times); Colombia (8 times); Peru (4 times); Canada (once); and Russia (once).

The gold buyers were also asked whether they thought formalization and the CBE's program to purchase gold (GPP) was a good idea. Most of the buyers agreed that the program was beneficial, as it would require documentation prior to performing a gold sale transaction. It would also be

good for the miners, as only one commercial price would be used and the supply chain could be regulated. Furthermore, 14 out of 20 gold buyers thought that the CBE GPP would diminish the illegal gold market, including reducing the number of black-market traders and money launderers. However, 3 out of 20 buyers thought that it would not make a difference, as they considered that there was not enough education incorporated in the program for the miners. Finally, 2 buyers stated that it might make a difference, as long as there was some way to accurately track the amounts of gold bought.

4.4. Current and Future CBE Activities

4.4.1. CBE Initial Business Model

The employees of the CBE involved in the gold GPP were asked to provide information regarding the bank's initial business model for buying gold. The Mining Law and the Organic Code of Monetary and Financial Affairs are the guiding documents, which indicate that the CBE has the exclusive right to purchase gold from the ASGM sector. From May 2012, the CBE began to purchase gold from the State-owned company ENAMI. The CBE is developing a Manual for Processes and Procedures to provide the necessary framework for the gold commercialization program for the ASGM sector. This document intends to lay out the procedures and mechanisms for gold purchases that the CBE must use.

4.4.2. CBE 2016 Business Model

The CBE altered their initial business plan in 2016 and established only a pilot gold purchasing office in Sangolqui, located near Quito. In comparison with the southern part of the country, the CBE was able to set up proper security measures at the location in Sangolqui. In addition to buying gold from ENAMI, the CBE would also be buying directly from ASGM miners. During this pilot stage, the CBE presented the gold commercialization program to the ASGM sector and other stakeholders to demonstrate the processes and mechanisms that will be used during the full implementation phase of the program.

4.4.3. Obstacles Encountered by the CBE with Gold Purchase Locations

This section investigated the obstacles that the CBE has faced in establishing other gold purchasing locations. Although the CBE does not have offices in the prolific mining regions in the southern part of the country, there are certain issues identified as barriers to expansion in these

areas. Some of them include logistics due to lack of proximity with the CBE head office, security concerns, and significant costs in maintaining offices.

4.4.4. CBE's Relationship with ENAMI

CBE gold commercialization employees were asked to describe the bank's relationship with ENAMI (the State-owned mining company) and comment on the amount of gold that has been bought from this entity. They specified that ENAMI had signed an agreement of inter-institutional cooperation with the CBE, which committed ENAMI to sell all the gold produced from their concessions to the CBE. The CBE bought over 200 kilograms of raw gold from ENAMI's two operations in San Lorenzo, Esmeraldas Province, and Conguime, in Zamora-Chinchipe Province. ENAMI also engages in purchasing gold from the ASGM sector and then selling directly to the CBE.

4.4.5. Direct Gold Purchases by the CBE from 2016 - 2018

The CBE established a gold purchasing office in early 2016 and began buying gold directly from the ASGM sector by June, 2016. The Central Bank of Ecuador reported purchasing gold from artisanal miners from June, 2016 to end of 2018 (Table 14). It should be noted that the Machala gold purchasing office opened in January, 2018, and that 62% of the gold purchases for the year took place in Machala and 38% in Sangolqui.

Table 14. Reported gold purchases by the CBE.

Year	2016*	2017	2018
Avg. Kg of Au/mo	43.9 kg	97.5 kg	190 kg
Avg. US$ of Au/mo	$1,937,500	$3,625,000	$7,508,333
Total Kg of Au/year	527 kg	1,170 kg	2,273 kg
Total US$ of Au/year	**$23,250,005**	**$43,500,000**	**$90,100,000**

Source: (CBE, 2019)

NOTE: * 2016 purchases are only from June to December

4.4.6. Miners Who Have Sold Gold to the CBE

From March 25-April 8/2017, 8 miners who actively sell gold to the CBE GPP in Sangolqui were consulted regarding their experiences and 25 questions were asked. In order to guarantee anonymity, the miners were labelled from Miner A to H.

4.4.7. Location of their Mines and Processing Methods

All 8 miners revealed where their mines were located. Half of them had their mines in the area near Portovelo-Zaruma, while 3 were in Portovelo, and 1 in Zaruma. All of these miners were working underground operations. For processing, 6 out of the 8 miners stated that they took their ore to processing centers, where they paid for different services, while 2 of the miners said that they had their own equipment. When miners were asked what processes they used to produce gold, 83% claimed that they did not use amalgamation, while Miner C claimed that only 10% of his gold came from using amalgamation, while 90% of his final product was processed using cyanidation.

4.4.8. Previous Sale Location

Prior to selling to the CBE, 3 out of 8 miners (37.5%) exported their gold abroad. Two of the miners exported to NTR Metals in the USA, while the third shipped his gold to MKS (Switzerland) S.A. and Buenoro L.L.C. in Miami, Florida. The remaining 5 miners sold their gold locally, primarily in Portovelo.

4.4.9. Prices and Markdowns

The miners were asked to explain the markdowns that occurred when they sold their product to other entities in the past, as compared to the CBE. In total, only 6 out of 8 responded to this question, while Miners A and B, both of whom exported to NTR Metals in the USA, declined to answer. The miners who primarily sold locally to gold-shops in Portovelo (Miners C, D, F, G and H) reported the following deductions, as outlined in Table 15. Miner E, who previously had exported his product to MKS Switzerland S.A. & Buenoro L.L.C., reported a 3% deduction.

Although Miners C, F, G and H paid buyer deductions from 3 to 8%, Miner D claimed to pay 20% deductions at gold-shops in Portovelo (El Pache) or Cuenca, which included a 14% IVA tax, a 4% buyer deduction tax and a 2% invoice fee. Although not mentioned by the others, it is logical to assume that all of them would have paid the IVA and invoice taxes on top of the buyer deductions. Furthermore, it appears that Miner D cannot be considered a conventional ASGM individual, as he

owned his own processing equipment, was the owner of 8 mines and had a commercial license to sell gold.

Table 15. Summary of tax deductions imposed on artisanal miners who sell gold at gold-shops

Miners	Buyer Deductions	IVA 14%	2% Invoice	Total Deductions
Miner C	3%			
Miner D	4%	14%	2%	20%
Miner F	6%			
Miner G	5% - 8%			
Miner H	4% - 7%			

4.4.10. Gold Production

In terms of gold production, all 8 miners gave details, which are outlined in Table 16. Their gold production ranged from 9 to 288 kg of (pure) gold per month, which would generate revenue ranging from US $373,022 to $11,936,720 per month if the gold was sold by the LME international day price of US $1289/oz or US $41.40/g (October 17, 2017). In fact, if the miners received the minimum price of US $21.50/g paid by the gold-shops, their revenue would vary from $195,500 to $6,192,000.

In terms of the best price for gold, all of the miners responded that the CBE paid the international LME price, with no taxes, except 3% of fees, which would be much better for them.

Table 16. Gold production reported by the artisanal miners.

Miners	Gold Production (kg/month)	Gold Production (kg/year)

Miners	Gold Production (kg/month)	Gold Production (kg/year)
Miner F	0.75	9
Miner H	1	12
Miner E	1.5	18
Miner G	2	24
Miner B	16	192
Miner C	20	240
Miner D	20	240
Miner A	24	288

4.4.11. Registration Process

Regarding the registration process required to sell gold to the CBE, the miners provided their opinions on the matter, which included both positive and negative comments (Table 17).

Table 17. Opinions from miners who sold gold to the CBE regarding the registration process.

Positive Responses	Negative Responses
Process is simple, but depends on government organizations in order to approve or qualify a supplier.	Lots of paperwork to fill out and had to take a plane with hired armed guards from Sta. Rosa to Quito.
The process is easy. Despite a wait of 2 weeks before being approved, it is worthwhile.	The process is not that easy and you have to wait a while to receive the money, even though the CBE says it is supposed to be deposited within two days.
Easily accessible, but only after the registration process has been completed.	Not that easy at first, but gets easier after the initial stages. Sometimes I had to wait longer than 2 days to receive the money.

4.4.12. Inclination to Sell to the CBE

Some miners were asked why they were more inclined to sell their gold to the CBE instead of local gold-shops, jewelers or exporters. All of the 8 miners responded to this question and provided reasons for selling the gold to the CBE. In fact, 5 out of 8 miners liked the fact that there was no IVA to pay, 4 out of 8 said they received better prices for their gold, and 3 miners said that they preferred to sell to CBE, as they did not like the 7% deductions charged by gold-shops.

When asked on how the CBE could improve their gold commercialization program, every miner said that a CBE gold purchasing office needed to be closer to their operations. The only other suggestions were voiced by Miner D, who also provided other services to miners, including processing their ores and financing. This particular miner wanted access to Government credit and faster payments, in order to keep his lucrative business flowing smoothly.

4.4.13. Opinions Regarding Large-Scale Mining in Ecuador

The miners were asked their opinion of large-scale mining (LSM) in Ecuador, such as Lundin Gold and its Fruta del Norte property. The miners' specific comments are outlined in Table 18.

Table 18, Opinions of artisanal miners about the presence of LSM in Ecuador.

Large-scale mining has good potential in Ecuador (mentioned by 2 miners).
It does not affect nor concern me.
It is good for the country, but they need to respect the small miners and their concessions. LSM should come and absorb the small miners into their business. Miners could learn a lot from LSM in the country, which would help the ASGM miners in terms of clean processes and new techniques.
LSM does not affect us, they are not our competition. They have different objectives.
It does not affect me, as long as LSM does not start taking our concessions.

4.4.14. Travel to Sangolqui to sell gold to the CBE

The miners who sold gold to the CBE were asked to provide their opinion regarding the safety and ease of the journey to the CBE office in Sangolqui, near the capital Quito. In total, 7 of the 8 miners responded and their comments are outlined in Table 19.

Although 4 miners responded positively to the question regarding the safety and ease to travel to Sangolqui, 3 miners did not think it was easy, due to the flights leaving at night to Quito. Furthermore, in order to protect themselves against robbery, they had to hire two armed guards to travel with them, including the expense of providing food and accommodation in Quito, before travelling an hour by car to Sangolqui the next day. Even for the miners who did not hire security guards, safety was definitely a concern.

When the 8 miners were asked how frequent they flew to Sangolqui, 3 of them responded “every week”, while 2 of them traveled once a month, 2 every two months and 1 every three months. It appears that the trip from Portovelo to the Santa Rosa airport by car (around 2 hours) and the flight to Quito (about 1 hour) offer many opportunities for bandit attacks, making it difficult for miners producing small amounts of gold to sell their production to the CBE office in Sangolqui.

When these miners were asked whether there were other preferable locations to sell their gold, all of the subjects provided a response, whereby 6 of the 8 claimed that the CBE was the best place, albeit with the challenges regarding distance and safety, while 2 of the miners suggested that the gold-shops in Guayaquil and Machala normally charged less fees than the ones in Portovelo.

Table 19 Opinions of miners who travelled to Sangolqui to sell gold to the CBE, regarding the safety and ease of travel to this location.

Is Travel to Sangolqui Safe and Easy?		
	Yes	**No**
Number of Responses	4	3
Comments	1) Yes, I have not had problems, but I have had to hire two armed guards to accompany me. 2) Yes, it is safe but I fly with armed guards. The flight on the other hand (Sta. Rosa to Quito) is not good, as it leaves late at night, requiring us to spend the night in Quito. 3) More or less safe. 4) It is hard to access Sangolqui in the winter. There are only 2 flights daily to Quito and they leave very late. We need something closer to our mine in Portovelo. 5) It is not that easy because of the distance and also due to the fact that flights from Sta. Rosa to Quito only leave at night. Therefore, we have to be very cautious, as we are scared of being robbed. We do not use security guards, as that would be a large extra cost for us. 6) The bank is only worried about their own safety, that is why they are located in Sangolqui. They do not really care about us. 7) It is not that easy to travel. We do not have security and the distance we have to travel is very far.	

Regarding whether the CBE paid a fair price for the gold, all 8 miners were content, despite one being slightly dissatisfied.

When asked about the advantages and disadvantages of selling to the CBE, the 8 miners provided responses that are summarized in Table 20.

Regarding the disadvantages, the main concerns were that the distance to the CBE office in Sangolqui was both problematic and costly, and that the miners perceived that the analytical methods used by the CBE did not always seem fair.

Table 20. Advantages and disadvantages of selling gold to the CBE.

Advantages of Selling Gold to the CBE	Disadvantages of Selling to the CBE
6 of the 8 miners stated the main advantages were: 0% IVA, 0% deductions and CBE consistently pays the international spot gold price.	No offices in Guayquil or Machala.
One miner claimed that the tax exemption is the best feature of the CBE program.	Long journey to Sangolqui.
One miner claimed that the 0% IVA and potential benefit to the country are the most appealing factors of selling gold to the Government.	Need more help with financial credit; need to receive the money faster after making the sale.
	The distance is too far.
	Distance is a problem; Sometimes the CBE tells us that our product is not 99.99% pure, only 85% - 90%, so then we don't receive the full price.
	Distance is too long; we waste lots of money to travel there.

4.4.15. Consultation with a Professor from Machala Technical University

An informal conversation with a mining professor from Machala Technical University in El Oro Province, who has done extensive studies on Ecuador's ASGM sector, was conducted on March 8, 2016. The professor pointed out the main hurdles for implementing a fair-trade gold system in Ecuador. He criticized the lack of communication, coordination and exchange of knowledge among ENAMI, ARCOM and INIGEMM, which has created problems for formalization of the

artisanal mining sector in Ecuador. There appears to be an overlap of work done by the three agencies. For example, although ENAMI does research on the ASGM sector, INIGEMM should be leading the way in this regard. In addition, prior to proper formalization, the agencies need to know how to regulate the sector, how many miners are operating, and where the main mining areas are to concentrate on first. In his opinion, the CBE needs to have a detailed plan of how they are going to purchase gold from the ASGM sector. Although the issue of money laundering from drug traders and armed groups in the Portovelo-Zaruma and Ponce Enriquez regions is only anecdotally known at this point in the mining sites, the CBE must confirm this with actual evidence. In addition, the large number of processing centers is a problem in Ecuador, which requires the Government to prohibit the installation of further plants and instead build one centralized processing center. He suggested a pilot project in a specific region of the country, and then work from the bottom-up. It is important to start by organizing everything that is needed, then educating the miners and other stakeholders, before implementing formalization initiatives.

4.4.16. Conversation with Head of CBE Gold Purchase Program

In a conversation with the head of the CBE Gold Purchase Program (GPP) in March/2017 in Quito, different points were discussed regarding the gold commercialization program with artisanal miners. This individual expressed that the GPP cannot work with miners who are not registered with ARCOM or those who have not met the criteria to sell gold legally to the CBE. According to this executive, the GPP needs more support from ARCOM and other government agencies to reach out to more artisanal miners. The main challenges to expand the GPP activities are logistical, in terms of needing to implement more offices with adequate security in the artisanal mining areas, and more capital.

The head of the GPP emphasized that a lack of capital is hindering the CBE from opening offices in other regions of the country. In July/2017, it was noted that a second location was supposed to be established in the south of the country in Machala, which is only two hours away by road from Portovelo-Zaruma in El Oro Province, which is the region that produces 52% of the country's gold.

Although the opening of this office would most likely encourage a higher flow of artisanal miners to sell their gold to the CBE, this planned expansion has still not occurred. The current program

appears to be limited to the miners who have already gone through the regularization process, as the bank will not deal with any individuals who are not registered with ARCOM.

5. DISCUSSION

5.1. Fieldwork Consultations with Artisanal Gold Miners

As shown from the results in Section 4, fieldwork consultations with ASGM miners from three different regions in Ecuador showed variations in different aspects related to background, processing techniques, frequency to sell gold, etc.

Ecuador is attempting to formalize its artisanal mining sector and maximize potential tax revenues, while at the same time minimizing sales to the open or illegal gold market and mitigate environmental degradation associated with rudimentary processing techniques. To begin with, organization of the sector has been identified by the Government as a vital first step for the formalization process to succeed. Awareness and participation of the miners in the decision-making process must also be included, as interview responses showed that approximately 47% of the interviewed miners from the 3 studied regions were aware of the country's mining and environmental laws. Miners from Ponce Enriquez showed the most awareness of these laws, as 70% claimed to have knowledge of them. The remoteness of Nambija and the prevalent use of amalgamation in the region demonstrates a lack of knowledge regarding mining, processing and environmental regulations.

Formalization as a way to reduce pollution without other necessary supports has been criticized (Veiga and Marshall, 2018). Mercury pollution is the main vehicle used by the Government of Ecuador, as well as other Latin American countries, to demonize artisanal miners. International agreements like the Minamata Convention, despite its ambitious objectives, are not resulting in less pollution, as these top-down approaches only end up imposing laws and regulations without being accompanied by education and technical assistance. The actual formalization process is fraught with components that include legalization, training, financial access, compliance with regulations, access to mineral titles, etc. The transformation of artisanal miners into responsible small-scale miners is not simply a case of issuing legal licenses to operate, as both capital and training are necessary for the miners to evolve (Marshall and Veiga, 2017).

In spite of some miners (~30%) stating that they have received assistance from the Government, none of the miners from Ponce-Enriquez had received any support whatsoever from the Ministry of Mines. Therefore, by and large, although the Government wants the miners to change their practices, it generally offers little to no funding or technical assistance. In addition, it appears that

Government support is mainly offered to miners who are already established and legalized, who have greater technical and financial means than poor micro-miners.

In 2014, artisanal miners were told that they had about a year to improve their practices and stop using mercury in their processes. From field study consultations, approximately 26% of the miners in the 3 regions claimed that they did not use mercury, while the rest was buying 0.45 to 2.27 kg (1 to 5 lb) of mercury per month. Despite Nambija's remote location, 55.6% of the miners visited knew that they had to stop using mercury by the end of 2015. However, as the primary processing techniques used by miners in Nambija were sluicing and amalgamation, it was not a surprise that many individuals were unaware that they needed to change their practices. The question that remains is: how can artisanal miners change their polluting practices if they do not have any capital or training? (Veiga et al., 2014b).

In Portovelo-Zaruma and Ponce-Enriquez, the situation is different in terms of environmental awareness. Approximately 80% of the interviewed miners knew the exact date or had an idea when the Government would be prohibiting the use of mercury in mining operations. The miners and owners of the processing centers in these two regions are much more advanced in terms of knowledge of mineral processing and use relatively "sophisticated" methods such as centrifuging, flotation and cyanidation. Portovelo, despite the current pollution caused by mercury use and poor tailings management, has routinely been used to train miners from other regions and countries, due to the high level of knowledge that processing center owners have regarding gold extraction (Veiga et al., 2015, Garcia et al., 2015, Gonçalves et al., 2017).

The majority of the miners (65%) in all 3 regions paid for services at processing centers (PC) to process their ores, whilst 35% owned their own plants. Unlike miners who own amalgamation equipment, it is not very common to encounter individuals who won flotation and cyanidation equipment, as these methods are technically complicated to operate and require significant capital to implement.

It was noted that 63.6% of the miners in all 3 regions processed 50 tonnes or less of ore per month. In Nambija, the maximum capacity did not exceed 350 tonnes per month, which only accounted for 15% of the total. However, the ability to take ore to nearby processing centers in Ponce

Enriquez or Portovelo-Zaruma allowed for a few miners to be able to process 1500 tonnes/mo in Ponce Enriquez and 3000 tonnes/mo in Portovelo-Zaruma.

When asked if they would be willing to sell gold to CBE's gold commercialization program, 92.3% of the miners said yes. Those not willing to participate complained about the difficulties to obtain certificates, the wait time before receiving payment (usually 2 days) and the distance they had to travel to sell the gold. There was also reluctance to trust the Ecuadorian Government, as many perceived it as only another opportunity for the Government to tax their profits and put the money in their pockets, instead of using the monies to improve the sector.

The current locations where the artisanal miners sell their gold were identified, including the reasons for choosing these buyers. The majority of the miners sell their gold locally and very few travelled long distances. When the miners were asked if they would travel to either Quito or Cuenca to sell their gold for better price, the majority of the miners from Nambija were willing to make the trip. However, in Portovelo-Zaruma, 52.6% were willing to travel to one of the two locations, while in Ponce Enriquez this was reduced to 46%. In total, 59% of the miners interviewed would not mind making the trip to Quito or Cuenca to sell gold to the CBE, although security was a re-occurring issue that was strongly mentioned amongst the miners. Not only did the negative responses generate this answer, but even the miners who were willing to travel mentioned safety as a concern. For the CBE to address this issue, more accessible locations need to be provided for the miners to increase participation and the success of the program. Other options would be to have armored vehicles transport the miners to the purchasing locations or take the CBE employees to the mines. If this concern is not fully addressed, the CBE GPP program will have limited success over the long term.

The CBE must start a strong engagement process to generate confidence about their buying process by clearly demonstrating to the miners that the bank's process is transparent, the chemical analyses are accurate and the price paid for the gold is fair. In addition, it must be strongly promoted that the profits generated from the program will be channeled into strengthening and improving the ASGM sector.

The inclination of some miners to leave their locality and sell their gold to the CBE GPP can be attributed to the current unfair gold prices paid to them by their local buyers. Approximately 89%

of the miners did not believe that they had been receiving a fair price for their gold from the gold-shops in the 3 assessed regions. When asked about the miners' familiarity with the gold spot price prior to selling their gold, only 69% were aware of the international market price, including no miners from Nambija, which is a region where the miners critically need training on more effective, cleaner and safer methods to produce gold.

Knowledge of the daily spot price is crucial, as miners who are unaware of gold price fluctuations can easily be underpaid by a buyer. It is interesting to note that in Peru a strong movement for fair trade gold has been launched, and the NGO Solidaridad Sudamerica has developed a cellular application that provides the daily international gold price for ASGM miners (Arista, 2014 and 2018). The application allows the miners to access the LME spot price and calculate what they should receive based on the fineness of his/her *doré*. The author explained that this application was developed as the Peruvian artisanal miners were complaining about abusively low prices being paid by gold buyers. Although the Ecuadorian website PrecioOro.com (https://www.preciooro.com/oro-ecuador.html) also provides the daily international price of gold and silver, the miners interviewed were apparently not familiar with this site.

It is also important to stress that neither the gold-shops nor the CBE GPP pay the miners for the silver alloyed in the *doré*. Although some *dorés* contain up to 50% silver (Velasquez, 2010, Gonçalves et al., 2017), most are normally in the realm of 12% Ag, according to some miners and gold-shop personnel from Portovelo. The international price of silver in 2017 was approximately US $0.55/gram. For example, if a gold-shop or CBE buys 10,000 g/month of *doré* with 88% gold and 12% silver or 8,800 g/gold and 1,200 g/silver and pays the miner the LME price of US $34/gram of gold, this works out to be almost US $300,000 for the gold, whereas the US $660 for the silver would not be paid to the miner.

Between September 24 - October 5, 2014, although the international price (LME) of gold was approximately US $1215 per ounce or $39 per gram, miners received as low as $21.50/g of gold. In the twin towns of Zaruma and Portovelo, the gold price ranged from US $24 to $30 per gram. Therefore, some miners preferred to travel 15 km to Piñas, a dormitory town for the miners and also larger than Zaruma and Portovelo combined, to sell their gold for $35/gram.

In Yantzaza, during the 2014 research, the average price paid for gold was US $30 per gram, and in 2015, US $33.15 per gram, when the LME was US $39/g and US $34/g, respectively. In Zaruma, the average price paid was US $25.75 per gram, while the spot price at the time was $39 per gram, which shows a disparity of US $13.25 per gram. In 2015, the prices reported by the two gold buyers were equal to the LME, as the owners of the gold-shops claimed to pay international prices. In comparison, the average price paid per gram of gold in Portovelo in 2014 was US $28, constituting a difference of US $11 per gram, whereas in 2015 the discrepancy increased to $12.50 per gram. In Piñas, the average prices reported in 2014 were US $35 per gram, which differed only by $4 from the spot international price at the time, whereas in 2015, the reported price improved to match the LME value. In El Pache, the difference in price was US $15 in 2014, but then reduced to a discrepancy of only US $5.50 in 2015. It appears that the gold-shops and other buyers adapted their prices immediately after the CBE announced its Gold Purchase Program.

In the 3 regions visited in 2015, 43% of the gold buyers stated that they paid the 12% profit tax, compared to 29% that did not, while 29% did not respond. In the same regions, 53% of the gold buyers had a commercial license, compared to 47% that did not. It is surprising that only a slight majority of the gold-shops had a commercial license, as one would expect that all of the gold buyers would possess this document, since they work in a fixed location that is vulnerable to police seizure.

It was observed that 52.4% of the interviewed gold buyers used density as the main method of analysis, compared to 23.8% that used the nitric acid test, while 9.5% used a combination of both. The rest, 14.3% of the buyers, used only visual inspection of the *doré* color. Overall, density tests were well accepted by the miners to determine the fineness of their gold. This is also peculiar, as the method is no more accurate than the X-ray fluorescence method used by the CBE GPP in Sangolqui, which was perceived by the miners to be less reliable.

In order to obtain an idea of the profits generated by gold-shops, it was assumed, for example, that a shop would pay the lowest price of US $21.50/g, when the LME price is $34/g. Gold-shops usually refine the *doré* removing silver, copper, etc. using nitric acid and precipitate the silver with NaCl, before selling the 99.9% pure gold at the international price. Therefore, if the gold-shop bought 10,000 g of Au/month at $21.50 and did not pay taxes, the shop would pay $215,000 and receives $340,000/mo, which represents a profit of $125,000. Although this simplistic calculation

does not take into consideration overhead costs including rent, labor, energy, refining costs, etc. the owner of the gold-shop is definitely generating a good profit margin.

Consultations with gold-shops and jewelers in 2015 showed that the majority of the known export locations were the United States and Colombia, each of which were identified 8 times by the respondents as the most frequent destinations of exported Ecuadorian gold. In 2014, UN COMTRADE data showed that 87% of the 28.57 tonnes of gold were exported by Ecuador to the US, followed by 7% to Switzerland and the rest to Canada, Hong Kong, Panama, etc. The situation was similar in 2015. In 2016 and 2017, the total exported (reported) gold to all countries dropped dramatically to 7.5 and 5 tonnes, respectively. These dramatic reductions corroborate the accusations of Torres (2015) and other articles (Ministerio del Interior, 2016, El Universo, 2017) that gold has been smuggled illegally to the United States. The frequency of exports to Colombia was identified by the gold buyers interviewed in 2015.

In 2015, although several buyers claimed to not charge any service fees to artisanal miners who sold to them, it appears that this is not true, as field research showed that gold-shops were charging 3% to 8%. Therefore, if they were paying the miner the international gold price of US $34 per gram and charging 3%, this would represent US $1.02/g. If they charged an 8% service fee, this would represent US $2.72/g, which would be on top of the 12% IVA tax.

5.2. Government Participation

The Central Bank of Ecuador began its Gold Purchase Program in June, 2016, purchasing gold directly from the ASGM sector. Government participation in the ASGM sector is an important component in the formalization process, and the miners in the 3 regions were asked to rate the Government's presence in their activities. As explained above, the Government's participation is characterized as the frequent presence of Government employees in the field providing information for ASGM miners interested in applying for financial credit, orientation regarding the legalization process, technical assistance, training, enforcement against the illegal market and unregistered operations, etc. Although the majority of the miners (70.2%) stated that the Government presence was either "good" or "regular", they did not stipulate what type of service the Government provides other than collecting taxes and inspecting their operations.

A few of the respondents (8.1%) were very content with the Government's actions, but the majority was either dissatisfied or indifferent with the participation (or lack thereof). They perceived that the Government were too demanding in terms of the bureaucracy and lacked a clear plan for the future of the ASGM sector, with little technical assistance and funding to support cleaner gold mining for artisanal and small-scale operations. Some miners mentioned that the Government needs to have a well-developed strategy with skilled personnel in order to promote the implementation of cleaner mining techniques, as part of a successful formalization process. Lack of support for miners will only perpetuate the presence of illicit actors in the illegal gold market, resulting in only partial adherence to laws and regulations.

When asked about the miners' level of awareness regarding the Government's credit program, 50% did not have any knowledge of this initiative, compared to 39% that did and 11% who were slightly familiar. The surveys held in Nambija did not generate any responses to the question, suggesting a complete lack of knowledge of any Government initiative to assist artisanal miners. In Portovelo-Zaruma, the responses were split evenly between respondents who knew of the credits offered and those who did not, each constituting 41.2%, while the other 17.6% were somewhat familiar with the credits. In Ponce Enriquez, 64% did not know about the credits offered by the CBE, while 36% were partially or well-aware.

Credits are an important part of the formalization process, as well as education and training on effective mining and processing techniques. These kinds of supports are crucial to mitigate the ongoing problems of miners being exploited by processing center owners or money launderers, while at the same time increasing the miners' capacity to form business enterprises and escape the vicious cycle of poverty (Hilson, 2011, 2018, Veiga et al., 2014a), .

The majority of the interviewed miners stated that they would buy new machinery if they received have loans from the Government. However, it is important to highlight that many miners do not use the proper techniques to mine or to process the ore. With low gold recoveries, it is common to see that miners simply want to produce and process higher volumes of ore, instead of improving their processing methods (Hinton et al., 2003). Therefore, it is normal that miners want more mining machinery such as excavators, trucks, jackhammers, etc., instead of improving the processing end with centrifuges, classifiers, flotation cells, etc. As the vast majority do not have sound knowledge on how to assess gold recoveries in the process, they are skeptical that more

sophisticated processing equipment will improve their recoveries. Although it is challenging to change this type of perception and adjust their mindset to adopt cleaner and efficient processing methods, the role of the Government is essential in this matter. As argued by some authors, technical assistance is futile without permanent training and the necessary capital for improvements (Veiga et al., 2014b, Jønsosn et al., 2009).

The miners were asked if they have received technical assistance with their operations. Although the majority of the subjects (59.3%) did receive some sort of technical assistance, they had to pay private technicians who were working as consultants. Overall, technical assistance from Government institutions was very low, only accounting for 4.1% of the responses. According to conversations with Government authorities, it became clear that INIGEMM, the Ecuadorian Geology, Mining and Metallurgy Research Institute, has the responsibility to provide training for the ASGM sector, but they lack financial and human resources.

5.3. Formalization of the ASGM Sector

The Ecuadorian government is attempting to formalize its large artisanal mining sector to increase control of the sector's gold production, while at the same time hoping to mitigate pollution stemming from rampant mercury and cyanide releases. Currently, there are several companies that produce gold in Ecuador through legal channels, including Bira, Elipe, Casaderos, the State-owned ENAMI and others. Although these companies have the funds, resources, licenses and legal mineral titles, they account for only a small amount of the country's total gold production. As the informal artisanal mining sector does not meet this criterion, the Government formalization model is ill-equipped to attend to the inadequacies that the ASGM sector faces in order to be successfully incorporated into a fully regulated and well-functioning system.

5.4. Problems with the CBE Model

5.4.1. Bureaucracy and No Presence of CBE at the Mining Sites

After several years of uncertainty, the CBE finally established a gold purchasing office as a pilot project to begin gold commercialization with the ASGM sector. However, logistics, security and limited capital influenced the allocation of the bank's office in the "Casa de la Moneda" (Mint) in Sangolqui office, near Quito. The main objective of the CBE is to buy gold from artisanal miners, who normally would sell their gold to local gold-shops, processing centers, middlemen or jewelers.

Several factors proliferated the advancement of the CBE's gold commercialization program with the ASGM sector, including the mercury ban regulations at the beginning of 2016, export taxation, and political pressures to provide fair prices for the miners' gold to avoid illegal smuggling out of the country.

The most important aspect that has attracted miners to sell gold in Sangolqui is the international price paid by the CBE for their product, in addition to 0% deductions for service and 0% IVA. Only a 2% tax is charged, which overall gives the miners 16% to 20% more money than selling to gold-shops. The CBE motto: "precio justo, tiempo justo y peso justo" (fair price, fair time and fair weight) has been positively perceived by the miners as an incentive to sell gold to the CBE. This research suggests that the prices the miners have been receiving from gold-shops in the Azuay, Zamora-Chinchippe and El Oro provinces are "unfair" according to 87.5% of the consulted miners. Therefore, a willingness exists to participate in the CBE program, even though travel to the Sangolqui office from mining locations in southern Ecuador is expensive and fraught with risk of thievery from bandits along the way. In addition, other disadvantages included the cumbersome registration process, legal loopholes, time lag to receive payment (up to 14 days), exclusivity, and attainability.

By and large, the main barrier is the location of the CBE office, which is inconvenient for the majority of the individuals who are participating in the program. Most of the gold produced in the country comes from the southern provinces of El Oro and Azuay. Portovelo-Zaruma, in El Oro province, accounts for 52.5% of the active gold vendors to the CBE. Gold producers living in and around Quito or in other regions nearby only make up approximately 2% of the miners who sell gold to the bank. Typically, miners from southern Ecuador have to take a late-night flight from Santa Rosa airport (about an hour and a half from Portovelo) to Quito, and then stay overnight to go to the CBE office the next day. All of the miners who sell to the bank were adamant about a government purchasing location to be established closer to the prolific gold-producing region in southern Ecuador.

Security is a huge factor for miners who want to sell to the CBE. As the government does not provide any sort of security for miners to get to the purchasing office in Sangolqui, many hire armed guards if they are worried about the safety of the trip. Although there are miners who make the trip alone, they do it in a state of constant anxiety.

The research in 2017 identified a loophole in the CBE program, which prides itself on only buying from registered miners. If Ecuador is similar to other Latin American countries like Peru and Colombia, likely only 1-2 % of artisanal miners are legalized (although not fully formalized). If the CBE plans to target only the legal artisanal miners, many gold-shops might improve their purchase prices to compete with the CBE. One of the buyers in Portovelo, who is both legal and registered with a commercial license, said that he buys gold from both registered and non-registered miners. If he pays a good price, compatible with the CBE price that covers the costs for the trip to Sangolqui, the inclination of miners to register and barter with the CBE fades away, thereby hindering the formalization process.

Selling gold to the Government requires the miners to go through a rigid bureaucratic process that takes two or more weeks, assuming they have already the permits from the Ministry of Mines (mineral titles) and Ministry of Environment. During this process, the miners' backgrounds are also thoroughly checked for their legal status and previous criminal activity, such as money laundering or narcotics. After this criminal check verification, the miners may then begin to sell gold to the CBE without any required training and he/she does not need to disclose how which processes were used to produce the gold. In other words, even if the gold was produced by amalgamation or cyanidation from Hg-contaminated tailings, the CBE has no idea and buys it regardless based on the legality of the miners' documents.

Inherent in this registration process is the registered and legal status of the miners, as well as a clean criminal record. Although this is an important aspect, the registration process is based on the assumption and hope that this initiative will force miners to register with ARCOM and become completely formalized, which in time will lead them to utilize cleaner processing techniques. The problem is that the miners who are capable of navigating this bureaucratic process are those who have the necessary education, time and financial resources to fulfill all the registration requirements. In contrast, the ASGM miners who do not have the wherewithal to register with the bank will not be included in the CBE GPP program and instead will continue using polluting processing methods and taking their ore to processing centers, where they receive 'unfair' prices for their ores.

The registration process must be made much simpler in order to entice poor, uneducated and informal miners to participate in the program. As more than 99% of the miners do not possess the

necessary legal documentation and informally work on somebody else's mineral title, the CBE program currently does not provide enough incentive to the miners.

5.4.2. Market Failure

A concept that can be used to characterize the Ecuadorian government's intervention in the ASGM sector is the market failure principle. Market failure generally characterizes solutions where free markets fail to allocate resources efficiently. The causes of market failure can include: monopoly power, missing markets, incomplete markets, de-merit goods, negative externalities, property rights, information failure and inequality. Markets may be subject to degradation by the abuses of the monopolies, as they fail to have control of these entities. Cases of missing markets is when markets have problems in their initial formation and therefore fail to meet a need or a want, like the need for public infrastructure. Market failure can happen when markets fail to produce enough of some crucial public services for their public like education and healthcare. In the cases of de-merit goods, markets may fail to control the manufacture and sale of a certain product, which have less merit than consumers perceive (Kenton, 2018; Types of Market Failures, 2019).

Negative externalities in market failure suggests that consumers and producers fail to take into account the effect of their actions on third parties. These third parties are indirectly benefiting or suffering as a result of the actions of consumers and producers who attempt to pursue their self-interest only. Information failure is when markets may not provide enough information because during a market transaction one party sees an opportunity to capitalize by not providing full details to another party. When consumers and producers cannot gain property rights, markets will not work effectively, therefore failure to assign property rights may limit the ability of successful formation (Ross, 2016; Types of Market Failures, 2019).

When market are highly unstable and a stable balance cannot be established, like in agriculture markets, foreign exchange, and credit markets, an intervention is needed in the market as it passes the threshold to be considered a failure. In the case of inequality, markets may fail to limit the size of the gap between income earners, generating an income gap. This is when market transactions reward consumers and producers with income and profits, but also these rewards may be concentrated in the hands of only a few (Types of Market Failures, 2019).

In Ecuador's case of government intervention in the ASGM sector can be classified by the following market failure categories: missing markets, incomplete markets, negative externalities, property rights, information failure and inequality.

Missing markets can be seen in Ecuador because the market fails to invest into capacity of mining regulation around the remote mine sites as well as provide the proper help to facilitate the transfer of technologies from mercury. Incomplete markets are apparent as not enough is done to educate miners on better practices, to raise awareness of mercury risks, to raise awareness of credits opportunities and entrepreneurial opportunities. Negative externalities in Ecuador's consumers and producers fail to see that their activities harm the miners and proliferate the third party middlemen. If gold is bought that comes from illicit origin, in which bad practices were undertaken to obtain it, by buying or trading this product it sustain this practice. The middlemen benefit from this, as they are the ones who give miners low prices or trap them in a cycle of poverty where they either take the majority of their gold or loan them money for equipment which the miners cannot afford and are therefore indebted for years if not forever.

Property rights for Ecuador's miners are not always apparent, and no existing mechanism can stop illegal mining on concessions that belong to LSM companies. Information failure takes place, as third party buyers often do not report the LME spot price to the miners because they want to profit more. Or in the case of a miners who sells to CBE, who buys gold from unregistered miners charing them a markup and then going to sell to the CBE with 0% IVA, 0% tax. Inequality income gap in Ecuador is prevalent, as the government GPP allows for those are well off to profit because they are registered and can afford the travel, the miners who are not registered and struggle to get by do not benefit from this program or their status is unchanged by the program.

Latin American governments keep using formalization as an attempt to try and solve issues related to artisanal mining, which include environmental degradation and the illegal commercialization of minerals (Veiga and Marshall, 2018). However, instead of targeting the miners and labelling them as "criminals, invaders, and polluters", which just creates more of a divide, as well as perpetuating the vicious cycle of poverty, governments should incorporate simplified policies and regulations similar to those in the agriculture sector.

During the research, a visit to the "Casa de la Moneda" at the Central Bank of Ecuador in Quito identified the existence of "economic agents", who are intermediaries hired by some artisanal

miners to sell their gold to the CBE in Sangolqui. These economic agents are registered with the CBE and ARCOM and have clean records, thereby meeting all the bureaucratic criteria required to sell gold to the bank. These agents work for multiple miners and charge a fee to pick up their gold, make the trip to the CBE office in Sangolqui, and then pay them directly or deposit the money into an account.

A consultation with one of these economic agents from Portovelo showed that he worked for two artisanal miners, both of whom entrusted him with their *doré* bars. After a density analysis, it was determined that there was a 12% impurity average (mostly silver) in the *doré* bars. Therefore, the artisanal miners expected to receive 88% of the gold price. Although the agent would not reveal how much he charged for his services, a CBE employee said that it usually was in the realm of 3-10% of the total gold sold.

5.5. How to Improve the CBE GPP Program

In order for the CBE GPP program to be successful in a significant way, they need to have a permanent presence in all of the main gold production locations. As the large majority of ASGM operations are found in southern Ecuador, the CBE should have influence and accessibility for the artisanal miners in that region. As El Oro, Azuay and Zamora, which are the main gold producing areas of the country, are all located between 460-850 km from Quito, it makes the idea of a central location for selling gold very complicated.

The CBE could improve its presence and influence in these regions by establishing temporary or permanent offices near the producing areas, or by using an armored vehicle with a mobile lab to make gold purchases at mine sites weekly or biweekly. Not only would this facilitate the miners to sell their gold to the government, but also the CBE's presence would increase awareness of the initiative and incentivize other miners unaware of the program to participate. At the same time, this increased presence of the CBE would help to reduce the number of illegal and/or unfair buyers proliferating in the country. The CBE Gold Purchase Program could also fulfill a desire of the Ecuadorian Government to offer more training and advice to the miners. The constant presence of the CBE in the field would also make the miners more inclined to take an interest in the formalization process and going through the rigid, bureaucratic registration process.

Although the CBE and ARCOM officially work together in terms of the formalization and registration of artisanal miners and their gold production in the country, in reality the situation is quite different. The two institutions essentially work independently, with ARCOM monitoring and registering miners, while the CBE is trying to persuade miners to formalize and sell their gold to them. The CBE entices miners with the premise that their initiative is much more beneficial than processing centers due to the 0% IVA, fair weight system and fair revenue return. However, the CBE GPP needs to have a more accessible registration system for miners to sell their gold. Currently, there are too many steps for the miners to pass for them to sell gold to the CBE. For example, a miner needs to be registered with ARCOM and go through a vigorous background check prior to selling their gold to the CBE. Considering the significant level of informality of artisanal miners in Ecuador, who do not want to or cannot go through the complex registration process required by the CBE, the success of the program requires a complete de-simplification of the necessary requisites.

The current proliferation of processing centers and gold-shops that exploit the miners is an endemic situation in Latin America that governments have typically turned a blind eye to (Veiga et al., 2014a). Due to a lack of regulatory control and poor government presence, these processing centers and gold shops capitalize on the inexperience and poor economic standing of artisanal miners for their own financial gain. Furthermore, the poverty cycle of artisanal miners continues, without the means to elevate their economic standing and reduce the social and environmental impacts generated by ASGM operations. However, the formation of artisanal miner cooperatives could be one solution to alleviate this situation, especially if this helped to gain legal status and have better means to sell their gold collectively. For example, if the CBE was not prone to open an office in the south of the country, cooperatives could bring large amounts of gold to Sangolqui in an armored car, thereby reducing time and travel costs for the cooperative's members.

All of the artisanal miners in the country, either legal or informal, should be able to do a simple registration process and sell their gold to the CBE, instead of waiting weeks for an approval or having to sell to illegal buyers. The lack of a more broad-based system to reach the informal micro-miners that do not produce enough gold to warrant an expensive trip to Sangolqui will relegate these miners to "unfair" gold-shop owners or illegal buyers. Local gold-shops, jewelers

and processing center owners charge whatever they like to the artisanal miners, who do not have much choice.

The CBE has attempted to solve this problem by having employees buy the gold from the artisanal miners at the mine sites and taking it to Sangolqui. Although this is a good temporary solution, it is costly and risky, as the CBE employees are vulnerable to bandit attacks. Instead, as mentioned above, the CBE should invest in armored, mobile buying units that go to the mine sites and bring the gold to security offices to be transported to Sangolqui. However, honest, responsible employees would be needed and how much would it cost? Would it be cheaper than just opening a CBE office in a central location in southern Ecuador? What sort of security would be required for a permanent office of this type? Could the 2% tax currently charged by the GPP also be eliminated in order to entice artisanal miners even more? These are questions that need to be considered and delineated in a sound business plan.

5.6. SWOT Analyses

A SWOT (Strengths, Weaknesses, Threats and Opportunities) analysis is a management strategy that is very useful in the decision-making process. This process was conceived in the 1950s to assist a business school professor to demonstrate different perspectives in a decision process (Madsen, 2016). The SWOT analysis was applied here as a type of assessment to help organize the opinions from the interviewees regarding the advantages and disadvantages of participating in the CBE GPP and how it could be improved.

5.6.1. Selling to Local Gold-shops

The first SWOT analysis assessed the strengths and weaknesses of artisanal miners selling their gold to the local gold-shops or jewelries, instead of selling to the CBE office in Sangolqui (Table 21). It is important to highlight that the local gold buyers are in a very advantageous position, since they can modify their prices based on the rate offered by the CBE GPP, due to the fact that their profits are based on high gold volumes. In addition, there are many unregistered and illegal gold buyers that can buy gold at the same price offered by the CBE, as long as this will allow them to launder their illegal money.

Table 21. SWOT analysis of artisanal miners selling their gold to local buyers instead of selling to the CBE office in Sangolqui.

Strengths	**Weaknesses**
1) Very little travel time to sell locally.	1) Potentially unfair prices paid for gold by local gold-shops (miners' perspective).
2) Save money on gas, accommodation, security vehicles and plane tickets to Sangolqui.	2) Lack of government control of gold flow (government perspective).
3) Save money over the short-term.	3) Lack of benefits for the local communities (miners' perspective).
4) More secure to sell locally - miners do not have to take the gold very far, thereby minimizing the risk of getting robbed.	4) Environmental performance unchanged, therefore no progress made (government perspective).
5) Allows for miners to have more time to mine instead of travelling.	5) Illegality of gold supply and proliferation of money-laundering (government perspective).
Opportunities	**Threats**
1) Government is losing the opportunity to increase their control over the gold production.	1) Miners receive prices below the LME international price.
	2) Gold being used as a money-laundering tool by narco-traffickers and conflict groups.

5.6.2. Travel to Sangolqui to Sell Gold

Having the CBE purchasing office near the capital, Quito, requires substantial travel time by the artisanal miners, who are predominantly based in the southern part of the country. Travel time and the security required to sell gold in Sangolqui have been the main enticement obstacles for miners to enroll in the CBE Gold Purchase Program. While the trip from southern Ecuador to Quito by car or bus takes at least 3 days, it only takes one day by plane. Then, from Quito the miners travel by car to Sangolqui, where they must wait to get their gold analyzed, credentials checked, organize the payment, etc. Although it would be much safer for the miners to transport their gold from the mines to the Santa Rosa airport or to Sangolqui via armored car, this is prohibitively expensive, which would thereby eliminate any financial advantage of selling to the CBE over selling at local gold-shops or jewelries.

The SWOT analysis (Table 22) revealed that the benefits of better gold prices offered by the CBE are diminished by the cost and lack of security in travelling to Sangolqui.

Table 22. SWOT Analysis of travelling to sell gold at the CBE office in Sangolqui.

Strengths	**Weaknesses**
1) Fair price.	1) Travel time.
2) Fair time.	2) The costs associated with security and travel.
3) Fair weight.	3) Flights & bodyguard costs.
Opportunities	**Threats**
1) Disrupt illegal gold trade.	1) Risk of miners getting robbed during travel.
2) Improve gold registration.	2) Dissatisfaction with CBE could alienate miners.
3) Build trust between the government and miners.	3) Lack of short-term benefits could bolster mistrust.

5.6.3. Selling to an LSM Company in Ecuador

Another option that should be considered is the possibility of selling gold to a large conventional mining company (LSM), such as Fruta del Norte or Lundin Mining. Although this option was never discussed with either of these two companies, it was raised in conversations with miners who provided their opinions to the SWOT analysis (Table 23).

If ASGM miners see that LSM companies have more contact and receive more respect from the Government, then a co-existence type arrangement between ASGM and LSM garners more appeal for artisanal miners. For example, it was mentioned that LSM companies could possibly partner up with the CBE to support a fair gold purchase program, whereby they would buy either ores or concentrates from the miners, thereby reducing the exploitation from the processing centers.

An example where LSM and ASGM worked good together can be seen in a past case in Venezuela. Artisanal gold mining around El Callao, Bolivar state, Venezuela consisted of many small, underground mines. The miners took their ore for processing to “Molineros” (millers) and the ore was passed through wet hammer mills and free gold was recovered using mercury plates. The tailings from this process, often containing more than 50% of the contained gold were accumulated by the Molineros and sold periodically.
From 1997 to the end of 2000 the Revemin plant, owned by Bolivar Goldfields, located in El Callao, Venezuela bought and processed these tailings. A standard practice for sampling and analysing the material was established, with emphasis on transparency, the sellers being

encouraged to witness the sampling and were given duplicate samples to have analysed if they wished. A standard table was developed by Revemin which showed the percent of the contained gold that would be paid, depending on grade. Grades as low as 3 g/t were accepted and payment was of the order of 50% of the contained value (as the previous day's London fix) with more than 70% being paid for high grade material (over 20 g/t). The transparency and timely payment meant that the Revemin plant was the preferred processor for these tailings. A small amount of mercury contained in the material was recovered by retorting the gold precipitate obtained in the plant, the rest, still in the tailings was stored in a zero discharge tailings dam.

An attempt to buy the ore directly from the miners was unsuccessful, as the "Molineros" provided finance and materials to the miners, something an industrial mining operation could not do. This also avoided conflict the Molineros, an influential group in the area.

Table 23. SWOT Analysis of selling to Lundin Mining or other LSM companies.

Strengths	**Weaknesses**
1) Fair international price for the product or concentrate.	1) Government could lose out on potential profits.
2) Proper weight analysis method utilized to judge quality of product.	2) Government more susceptible to losing control over legal and environmental matters.
3) Closer to mining regions in southern Ecuador.	
Opportunities	**Threats**
1) Opportunity for CBE to create partnership with LSM.	1) Threat of CBE program being marginalized.
2) Opportunity for miners to save travel time and costs.	

5.6.4. Opening CBE Offices in Southern Ecuador

Another option mentioned above was to have temporary or permanent CBE offices opened near the gold-producing mines in southern Ecuador. This option was discussed with miners and with CBE executives and the SWOT analysis was delineated (Table 24).

Table 24. SWOT Analysis of opening purchasing offices in southern Ecuador.

Strengths	**Weaknesses**
1) Travel costs cut.	1) Potential problem with logistics for the government.
2) Potentially higher miner turnout.	2) Security problems.
3) Increased volume of gold bought from the artisanal miners.	3) Existing gold buyers' livelihoods threatened by CBE's program.
Opportunities	**Threats**
1) More government influence and control over legal and environmental issues in ASGM sector	1) Security risk.

The CBE has already posed this idea, but logistical problems associated with maintaining security of the purchase locations, transferring money and gold back and forth between different offices and Quito, and the cost were the main obstacles identified. The CBE also mentioned that purchasing centers would compete with the local gold buyers, which could create protests and even threats. However, with gold buying offices near the southern producers, the ability of the Government to influence and control legal, technical and environmental issues associated with gold production would be increased, which would curtail illegal export activities. In turn, this could be the difference in providing a real technological transfer from polluting techniques to cleaner production from artisanal miners, while at the same time generating more taxable revenue for the Ecuadorian Government.

6. CONCLUSION

This research studied artisanal and small-scale gold mining (ASGM) operations and collected opinions from miners and authorities about the gold supply chain in 3 regions in southern Ecuador: Ponce-Enriquez in Azuay Province, Portovelo-Zaruma in El Oro Province, and Nambija in Zamora-Chinchipe Province. These are the most important gold producing regions in the country, with more than 10 tonnes/a of gold (Gonçalves et al., 2017). The official gold production in Ecuador given by the Central Bank reported an average of 7.7 tonnes produced between 2013 and 2016 and 3.4 tonnes between 2016 and 2018 (CBE, 2018). In contrast, UN COMTRADE (2018) data reported an apparently exaggerated total of 288 tonnes of gold exported in 2013 alone by Ecuador, with the vast majority (98%) destined for the United States. Despite illegal exports of gold from Ecuador being denounced by the media, miners, gold buyers and other stakeholders, it seems that the Ecuadorian Government does not have accurate statistics about the gold production in the country, which is basically conducted by small, medium conventional and artisanal miners, mostly operating in the southern part of the country.

After reviewing the existing literature on the ASGM supply chain and conducting 3 sessions of field work that evaluated the Central Bank of Ecuador's Gold Purchase Program (CBE GPP), the following findings of this research are highlighted as follows:

- A total of 40 miners were interviewed from the 3 regions, in which 77.5% were between 30-70 years old, whereby approximately 50% did not have some basic knowledge about the Ecuadorian legislation on mining and environmental issues. Approximately 24% of the miners in the 3 regions had no idea about the mercury banning legislation that was in effect at the beginning of 2016. In Nambija, where the gold processing methods are still very rudimentary using sluice boxes and amalgamation, approximately 90% of the miners were not aware of the Government's mercury prohibition in ASGM.
- Amalgamation is still a popular method to extract gold. In the 3 regions, approximately 10 lbs. of mercury were being consumed per month per miner. In Nambija, 100% of the interviewed miners used amalgamation, while in Ponce–Enriquez about 45% and only 9% in Portovelo-Zaruma. The sophistication of the processing centers in Portovelo-Zaruma is noticeable, with gold concentration methods including the use of centrifuges and flotation, followed by cyanidation. Unfortunately, cyanidation of Hg-contaminated tailings and the generally poor

management of tailings was still causing significant pollution in local drainages (Marshall et al., 2018).

- The volume of material (tonnes) that the miners processed from the 3 studied regions was usually less than 50 tonnes/month (64% of the responses), although more than 300 tonnes/month were significant (34%). In Portovelo, 20% of the processing plants had the capacity to process more than 100 tonnes/day of ore (Gonçalves et al., 2017).
- The processing centers are getting more flexible and offering services of amalgamation, concentration using flotation or leaching using cyanidation. The prices for the services vary from no cost if the amalgamation tailings are left with the processing center to US $1800/tonne processed if the miners want to concentrate and cyanide the concentrates.
- Many of the consulted miners from Portovelo-Zaruma and Ponce-Enriquez stated that they pay for technical assistance from local private technicians, who work for both miners and also processing centers. However, in Nambija, as none of miners receive any technical assistance from the Government or private technicians, their processes are very rudimentary with low gold recovery.
- Approximately 30% of the miners from the 3 regions responded that the Government presence (technical assistance, enforcement, orientation regarding legalization procedures, control against illegal operations, etc.) was good or very good. However, miners' perspectives also showed that while the Government wants the miners to change their practices, it does not offer any technical or financial assistance for making this happen. In addition, it appears that Government assistance mainly occurs with miners who are already legalized.
- In total, although approximately 30% of the 37 consulted miners were familiar with the financial credit program offered by the Government, most miners from Nambija had never heard about it. Most miners want to access these loans to buy new equipment, but it seems that the miners would only prefer to increase the volume of material produced than improve the gold recoveries.
- From interviews with gold buyers in the 3 studied regions, it was revealed that the price paid for the gold content in the "*doré*" ranged from $21.50 to $34 per gram of gold when the

international LME gold price was US $34.10/g. Prices paid by the local gold-shops in the 3 study areas were perceived by 89% of the consulted miners as “unfair”.

- In the 3 regions visited, only 43% of the gold buyers paid the 12% profit tax and approximately 53% of the gold buyers had a commercial license.
- Approximately 52% of the gold buyers interviewed used density as the main method of determining gold fineness, compared to 24% that used the nitric acid test, and around 10% that used a combination of the two. The rest, approximately 14%, used only visual inspection of the *doré* color to determine the level of impurities (usually Ag and Cu) in the gold. The density method was widely accepted by the miners selling gold. Curiously, the equally accurate X-ray fluorescence method used by the CBE GPP in Sangolqui raised suspicions by the miners.
- Approximately 70% of the interviewed miners were familiar with the international LME gold price, but most of the miners from Nambija were unfamiliar with it. Although there are cell phone applications that can provide the daily price of gold (e.g. Oro Justo, PrecioOro.com), the iners were not familiar with these sites.
- A total of 56% of the 39 interviewed miners expressed willingness to sell gold to the CBE GPP, with 5% responding “maybe”. In Nambija, 90% of the interviewed miners stated that they wanted to sell to the CBE, as they had been exploited by local gold buyers.
- The CBE GPP started in June 2016 and until September/2016 purchased approximately 163 kg of gold content in *doré* bars; In 2017, the CBE office purchased 1170 kg and in 2018, 2273 kg of gold.
- The most influential aspect that enticed miners to sell to the CBE GPP was the international price offered, including 0% service charge and 0% IVA. As only a 2% tax was being charged, it ended up resulting in an overall increase of 16% - 20% than selling to gold-shops.
- There were several disadvantages observed in the CBE GPP program, including:
  - Location of the CBE GPP office in Sangolqui, near Quito, is far from the gold-producing regions in the southern part of the country. Portovelo-Zaruma, in El Oro Province, accounts for 52.5% of the active gold vendors to the CBE. Typically, the participants have to take a personal or armored car to go to the Santa Rosa airport, a late-night flight to

Quito, and then stay overnight to drive one hour to Sangolqui to sell the gold doré the next day. To overcome the time and money spent travelling, some miners are hiring agents to sell their gold for them in Sangolqui, resulting in a commission charge of 3 to 10% of the total gold sold.

- Neither local gold buyers nor the CBE pay for the silver content in the doré, which can reach 50%, although the average is 12% Ag.
- A lack of security for the miners when travelling to Sangolqui with their gold, increasing the risk of getting robbed by bandits along the way.
- Legal inadequacy, as the CBE GPP was only buying gold from legal and registered sellers. As less than 1% of the artisanal miners in Ecuador were likely to be fully legal, the program ignored the vast majority of miners who are informal and need Government assistance to receive better prices for their gold, as well as improving gold recoveries, use cleaner processing techniques, reduce health and environmental impacts, etc. In comparison, local gold buyers at the mine sites do not care about the origin of the gold nor about the situations of the miners.
- To sell gold with the CBE, it is required that the miners register with ARCOM, which is a complex process. Miners must go through a rigid bureaucratic process that takes two or more weeks to complete, assuming that they already have the permits from the Ministry of Mines (mineral titles) and Ministry of Environment. During this process, the miners' background is also thoroughly checked for their legal status and previous criminal activity, such as money laundering or narcotics. After verification is completed, the miners may then begin to sell gold to the CBE.
- Miners complained that in some cases the time delay to receive the money from the CBE GPP was too long (up to 14 days).

• Some suggestions to improve the CBE GPP program include:

- The CBE could reinforce its presence and influence in the mining regions by establishing permanent or temporary offices near the producing areas.

- The CBE currently have employees that buy gold from the artisanal miners at the mine sites and processing centers and take the gold to Sangolqui. An alternative solution would be to use mobile buying units in armored cars. Although this would be costly, it would protect CBE employees from bandit attacks. The CBE could have a set of secured transport vehicles to visit each gold-producing zone weekly or biweekly to collect the gold from individuals participating in the program.
- As the current registration process is complex and cumbersome, this should be simplified to increase participation by informal ASGM and micro-miners. In doing so, small gold producers who cannot afford to go to Sangolqui would be able to participate, which would also reduce the influence of "unfair" gold-shop owners or illegal buyers.
- An additional incentive to miners unsure about participating could be a reduction in the 2% tax charged by the CBE or its elimination altogether. Although this would greatly reduce the profitability of the program, it would help to reduce illegal exports.
- The CBE and ARCOM could organize the ASGM in cooperatives, thereby creating a way to buy large amounts of gold from miners and reducing the travel costs for individuals. If the CBE is not receptive to opening an office in the southern region of the country, cooperatives could bring the gold to Sangolqui in an armored car, reducing time and costs for the cooperative's members.
- The CBE could establish a partnership with large–scale conventional mining companies to purchase gold from ASGM miners. As these companies have projects in areas with artisanal mining, this would be a good way to improve the co-existence of artisanal miners and companies.

- The SWOT analyses identified that the local gold (legal or illegal) buyers were in a very comfortable position, as they were able to modify their prices based on what the CBE GPP program was offering. In addition, although this reduced their profitability, it was clearly a good trade-off for the illegal buyers, as it allowed them to continue using this as a vehicle to launder their illicit money.

7. LIMITATIONS

Although this research was intended to provide an analysis of Ecuador's ASGM gold supply chain, certain factors hindering 100% accuracy of the findings reached in this thesis were always considered. These factors included: access to some artisanal mining areas, sample size, limited access to official data, and researcher safety considerations.

Ecuador has over 100,000 individuals involved in the ASGM sector. Although the number of miners consulted in this study was a small sample in comparison, the study areas were focused on the gold-prolific provinces in southern Ecuador, including Portovelo-Zaruma, Ponce Enriquez and Nambija, due to their history in mining in the country and their volume of gold production. Although mining exists throughout the country, no samples were taken from the northern provinces such as Esmeraldas or Cotopaxi, as the production in this region and the number of ASGM miners is much less significant. Therefore, the author believes that this study is a good representation of the country's ASGM sector.

An important dimension of the limitation of the research is the reliability of the information collected from both the ASGM individuals and the gold-buying entities. The research relied on the honesty and willingness of the subjects.

Engineers from the government organization ARCOM assisted the author in accessing remote mine locations to conduct field research in 2014. The miners were wary of ARCOM employees, as they are a regulation agency that scrutinizes the miners' practices and shuts down operations that do not abide by the rules. Therefore, the author's affiliation with ARCOM produced its own limitations, as many ASGM individuals might assume that they were being persuaded into providing information to the foreign student that could end up jeopardizing their livelihoods.

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