A Strategic Framework for Sustainable and Responsible Artisanal and Small-scale Gold and Diamond Mining in Ghana

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A Thesis submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Doctor of Philosophy.

Johannesburg, 2022

DECLARATION

I declare that this thesis is my own, unaided work. I understand the University's standpoint on Plagiarism and I declare that there has been no conscious attempt at plagiarism in this Thesis. Where use has been made of the work of others, it has been appropriately acknowledged. This Thesis is being submitted for the Degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. I declare that the Thesis has not been submitted before in any degree or examination in any other University.

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Signed at Pretoria on the 19th day of May 2022

DEDICATION

To my late parents, my amazing mom Mary Boaduo, and my exceptional father Dr. Nana Adu-Pipim Boaduo who sacrificed endlessly for my education. To my future children, for them to understand that there are no such things as mental and academic barriers.

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ABSTRACT

Artisanal and small-scale mining (ASM) is an important economic activity in Ghana and a significant source of livelihood for many Ghanaian communities. The sub-sector has a mining value chain that has the potential to generate substantive mineral revenue in addition to employment. In the past, it has produced more gold than any single large-scale mining company in Ghana. ASM offers more employment and entrepreneurship opportunities than all the large-scale mines in Ghana combined. Despite these benefits, the sub-sector is inundated by negative realities. It has a negative image, it is largely illegal, perceived as unorganized and it is damaging to the environment.

Although the government has made several efforts to reform ASM, Ghana still has much to do to ensure that the sub-sector can contribute more to the economy and citizens' well-being. ASM is not well defined or understood, mining legislation does not reflect its current state (i.e. the more modern or semi-mechanized forms of mining), and mineral rights allocation systems lack transparency and appropriateness. In addition to this, the ASM value chain is weak compared to formal or large-scale mining. There has been little to no effort to develop or customize it so that it meets the needs of the sub-sector.

Despite the current state, communities have a positive outlook and high hopes for the sub-sector. They believe that it has great potential and it can catalyse economic growth and development if it is manage correctly. This research develops a strategy called the **PASE** framework to help Ghana in working towards **P**rofessional, **A**ccountable, **S**ustainable and **E**conomic ASM. This strategy is driven by the vision of building a sustainable ASM sub-sector that uplifts communities and creates diverse economic opportunities. More importantly, it is informed by actual case study observations of small-scale mining operations in

Ghana. The PASE framework is founded on 6 pillars, which address the key areas that need to be improved to move the Ghanaian ASM sub-sector forward. The framework is accompanied by an implementation plan (a roadmap to change) to help Ghana work towards the identified vision. The Ghanaian government is encouraged to consider the PASE framework and its implementation plan (through the Minerals Commission) in developing and empowering ASM for the benefit of Ghana's economic growth and development.

List of Abreviations

AME	Africa and Middle East
AMV	African Mining Vision
ANM	Agência Nacional de Mineração or ANM
ASM	Artisanal and Small-scale Mining
AU	African Union
CEO	Chief Executive Officer
CIEC	Conference on International Economic Cooperation
CISL	Cambridge Institute for Sustainability Leadership
CMS	Community Mining Scheme
CoM	Chamber of Mines
COVID	Corona Virus Disease
DMR	Department of Mineral Resources
DWAF	Department of Water Affairs and Forestry
EEITI	Ethiopian Extractive Industries Transparency Initiative
EITI	Extractive Industries Transparency Initiative
ETFs	Exchange Traded Funds
FAO	Food and Agriculture Organization of the United Nations
FoN	Friends of the Nation
GGSA	Ghana Geological Survey Authority
GHS	Ghanaian Cedi
HERD	Hoedspruit Elephant Rehabilitation and Development
HOD	Head of Department
ICLG	International Comparative Legal Guides
IGF	Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development
IIED	International Institute for Environment and Development
IIED	International Institute for Environment and Development
ILO	International Labour Organization
IRR	Internal Rate of Return
JORC	Joint Ore Reserves Committee
LSM	Large-scale Mining

MCAS	Mining Cadastre Administration System
MHSA	Mine Health and Safety Act
MHSC	Mine Health and Safety Council
MinCom	Minerals Commission
MMSD	Mining, Minerals and Sustainable Development Project
MPRDA	Mineral and Petroleum Resources Development Act
MSMEs	Micro Small and Medium-sized Enterprises
NEP	National Exploration Program
NPV	Net Present Value
NSS	National Service Scheme
PAKP	Provincial Assembly of Khyber Pakhtunkhwa
PASE	Professional Accountable Small-scale Mining
PKR	Pakistan Rupee
PMMC	Ghana Precious Minerals Mining Company
QA / QC	Quality Assurance / Quality Control
R&D	Research and Development
SADPMR	South African Diamond and Precious Metals Regulator
SAMRAD	South African Mineral Resources Administration System
SAMREC	South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves
SMEs	Small and Medium Sized Enterprises
SSM	Small-scale Mining
SWOT	Strengths Weaknesses Opportunities Threats
UMaT	Tarkwa University of Mines and Technology
UNECA	United Nations Economic Commission for Africa
UNIDO	United Nations Industrial Development Organization
USD	United States Dollar
USGS	United States Geological Survey
VAT	Value Added Tax
WBCSD	World Business Council for Sustainable Development
ZAR	South Africa Rand

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1 BACKGROUND AND OUTLINE OF THE PROBLEM

1.1 Introduction

The aim of this research is to develop a strategic framework that will improve the way in which artisanal and small-scale gold and diamond mining is conducted in Ghana. This will be done in the effort to enable the ASM sector to maximize its full potential. The framework that will be developed will be accompanied by an implementation plan.

The need for this research is based on the author's observation of the defective state of artisanal and small-scale mining (ASM) in Ghana. It is also based on a discussion that was initiated at a conference held at the Tarkwa University of Mines and Technology (UMaT) in 2016. This discussion was centred around the need for an improved approach to ASM, which would entail an organized, well-engineered and professionally run sector that is better positioned to attract professionals, investors, and entrepreneurs. A well run artisanal and small-scale mining sector will have greater potential to catalyse economic growth and development in Ghana.

The Republic of Ghana is well known for its abundance of mineral resources. According to Hilson (2003), 25% of Ghana is covered in mineral resources. The country is rich in both fuel and non-fuel minerals. The non-fuel minerals comprise of diamonds, aluminium, bauxite, manganese, silver, lead, salt, cement and predominantly gold[1] (Bermúdez-Lugo, 2016). In the Ghanaian ASM sector, gold is the most mined mineral. Furthermore, diamonds are mined exclusively by artisanal and small-scale miners, however, production has reduced a great deal over the

[1] Annually gold has accounted for more than 90% of mineral revenues followed by manganese - 2.8%, and diamonds and bauxite - less than 1% (Bermúdez-Lugo, 2016).

past decade. According to Article 81(a) of the Minerals and Mining Act (2006) of Ghana, artisanal and small-scale mining is reserved only for the locals.

The African Mining Vision (AMV) encourages the African continent to work towards creating *"A mining sector that harness the potential of artisanal and small-scale mining to stimulate local/national entrepreneurship, improve livelihoods and advance integrated rural social and economic development"* (AU, 2009). The African Mining Vision recognizes artisanal and small-scale mining as a vital generator of income, and a vehicle that has the potential to boost the development of small or medium-sized enterprises (SMEs). Learnings from countries such as South Africa show that if the minerals sector is regulated, planned, and managed well, it has the potential to transform mineral resources into significant wealth and income earning opportunities (Boaduo, 2017).

Although ASM has great potential to boost economic growth and activate the local economic multiplier effect, it is overwhelmed by many negative realities. In Ghana and many other countries on the African continent, artisanal and small-scale mining is viewed as an environmentally damaging sector that is inundated with poverty, conflict, and problems, rather than one that is filled with opportunities. The failure of governments to recognize the sector and the lack of adequate law and policy to facilitate the sector fuels the negative realities of ASM. The lack of recognition from governments manifests in the form of system and legislative failures, such as poor regulation, a lack of development effort, as well as the poor management of mineral resources etc. (AU, 2009).

1.2 Research Aim and Objectives

The aim of this research is to develop a framework that focuses on improving the way in which artisanal and small- scale gold and diamond mining is conducted and viewed in Ghana. The objectives of the research are as follows:

I. To understand the definition, legal framework, and value chain of ASM in Ghana. This includes understanding how Ghana compares to other countries that conduct ASM;
II. To understand how Ghanaian artisanal and small-scale mines operate in reality including financial aspects, in specie the profitability of small-scale mining operations;
III. To better understand how ASM is perceived by different stakeholders.
IV. To develop a strategic framework (based on leading practices, feedback, and observations) that will help the sector to improve ASM in Ghana and work towards a clear vision; and
V. To develop an implementation plan that will help Ghana to make the changes that will improve the ASM sector.

1.3 Evaluation of Related Studies

Extensive research about ASM has been conducted in Ghana. Most of this has focused on the legal framework and discussing the extent of the problems associated to ASM. There is also significant research on the social and environmental impacts of ASM, and its coexistence with large-scale mining companies. Existing local and international studies have looked more into general and socio-economic issues and solutions. Although the existing research is very valuable, there is a lack of investigations into the other legs of the sector such as the business and technical functions.

A study applicable to this research topic was conducted by Amankwah & Anim-Sackey (2004). This research focused on the sustainable development of artisanal and small-scale gold and diamond mining operations in Ghana. The study proposed strategies on applying sustainable development principles to ASM. It discussed issues such as the technical and financial support requirements for the sector, its socio-economic significance, the mineral supply process, and its legal framework. It also analysed the steps that were being taken to address the challenges of skills development, environmental conditions, education, and living standards in small-scale mining areas.

In a paper titled *"Organization of small-scale mining activities in Ghana",* Appiah (1998) presented a study about how ASM operations are structured and how they function in Ghana. Appiah compared the structuring of Ghanaian ASM to the co-operatives of Latin America and Brazil. The researcher also discussed the formalisation of ASM as well as the environmental impacts of the sector.

Hilson (2002) gave an overview of the rigorous efforts that the government of Ghana has made in promoting sustainable development amongst the local small-scale gold miners. This paper discussed the various means of support that the Ghana Minerals Commission has provided to the small-scale gold miners to empower their business functions.

The International Institute for Environment and Development (2016) conducted research that proposed the formalisation of artisanal and small-scale mining. The research recommended for relevant stakeholders to engage in a dialogue to assist the miners in ore prospecting, land allocation and acquisition of finances. It also motivated for the improvement of the mineral licensing system to make it easier for the miners to acquire mining licences.

Guidelines, frameworks, handbooks, and compendiums have been developed by the government of Ghana to guide the ASM sector. In 2015, the Minerals Commission developed the Ghana Artisanal and Small-scale Mining Framework. This framework identifies gaps and opportunities for improvements in the ASM sector. It also engaged with stakeholders in identifying challenges and developing solutions. During 2017, the Ghanaian Government's Ministry of Land and Natural Resources published a handbook for artisanal and small-scale mining. The book was developed as an outcome of a training programme that was held to improve the ASM knowledge of geoscientific professionals in the country. The handbook was also designed to equip the reader with appropriate skills and tools that will enable them to mitigate the challenges associated with ASM.

In 2005, the South African Department of Water Affairs and Forestry published a document (similar to the Ghanaian ASM handbook), which is a best practice guideline for artisanal and small-scale miners. This guideline was designed to give the reader practical or hands-on advice on ASM. The guideline was published in some of the local languages.

In 2002, the United Nations Economic Commission for Africa (UNECA) published the Compendium on Best Practices in Small-Scale Mining in Africa. The compendium captures best small-scale mining management and development practices that have been observed on the African continent. The goal of the compendium is to disseminate these best practices across the continent.

1.4 Benefits of the Research

This research is important because it draws attention to the technical and business functioning of ASM operations. Realizing the importance and the potential of these two functions will cause people to view the sector in a different way. The research will encourage interested parties to conduct efficient, responsible, and professional artisanal and small-scale mining. The research identifies areas where there are opportunities to improve on ASM policies and legislation, as well as opportunities to increase operational efficiency and profitability. In addition to the technical and financial approach, the research takes a people-centred approach to solving the identified problem. This is achieved through stakeholder engagements.

According to the World Economic Forum (2018), small and medium-sized enterprises are the key to economic growth and poverty alleviation in Africa. Empowering the ASM operations to function as efficient SMEs will have great economic benefits for Ghana. Entrepreneurs, individuals, and cooperatives can use the research as a guide when embarking on opportunities to establish ASM operations. The envisaged framework will give a mining engineering approach to artisanal and small-scale mining. This will help the sector in attracting skilled professionals.

The research will also appeal to investors, fellow researchers, mining companies and mining communities. The research can guide ASM operations in motivating for funding. It can also make financial institutions and investors aware that ASM operations have the potential of being worthwhile investments. Governments can use the research to develop ASM training materials and to guide the development of future legislation, policies, and strategies. This will assist the Ghanaian government in working towards controlling, restructuring, and formalizing the ASM sector. Universities can use the material to teach students about efficient, productive, and professional ASM.

The strategic framework is accompanied by an implementation plan. This makes the research unique because in many cases, solutions are provided but execution plans are not given.

1.5 Rationale and Problem Statement

Mining plays a fundamental role in our day-to-day lives. The global mining industry supplies essential minerals and metals that are critical in making various systems in our modern lives function. It is plausible to say that mining has played an essential role in sustaining the existence of human beings in the past and present. It will play an even more important role in the future (Mining Global, 2015).

The need for metals and minerals produced by mining is very broad. It spreads from health to technology and machinery, to the development of infrastructure etc. (Mining Global, 2015). The demand for many minerals (especially strategic and precious minerals) is expected to continue to increase in the future. However, the supply is expected to decline because mineral deposits are finite. This will make mining areas that produce these minerals very important. It is one of the reasons why mineral exploitation needs to be conducted in an efficient manner that will benefit both the host communities, the suppliers, and the market.

This section of the report will provide the justification for this research. It will raise the reader's awareness of the significance of gold and diamond mining globally, as well as in the context of Ghana.

1.5.1 General Overview of the Gold Sector

According to an article published by Mining Global (2015), there are ten critical minerals that make modern life work[2]. Amongst them, gold is ranked fifth. Not only does gold hold technological value but it also has financial, cultural, and emotional or conceptual value (Council, Global gold demand, 2018c). Historically, gold has been a treasured monetary mineral that was used as a royal ornament and a standard for global currency. To many countries, gold is the backbone on which

[2] These minerals are (ranked according to their importance) copper, platinum, iron ore, silver, gold, cobalt, bauxite, lithium, zinc and potash (Mining Global, 2015).

economies are built. It is therefore vital to the stability of financial markets and economies. Gold is considered to be a good hedge during difficult economic times. Over the past century, gold has become more popular with technology because of its superior chemical and physical properties. It plays a vital role in the generation of communication equipment, spacecrafts, aerospace, satellites, computers etc. (Amadeo, 2018).

Global supply and demand of gold

The World Gold Council (2018) estimated that the world has produced 190 040 tonnes of gold so far. It is estimated that one third of this gold was mined before the year 1950, and two-thirds were mined afterwards. Figure 1.1 shows the uses of the 190 040 tonnes of gold that have been produced historically.

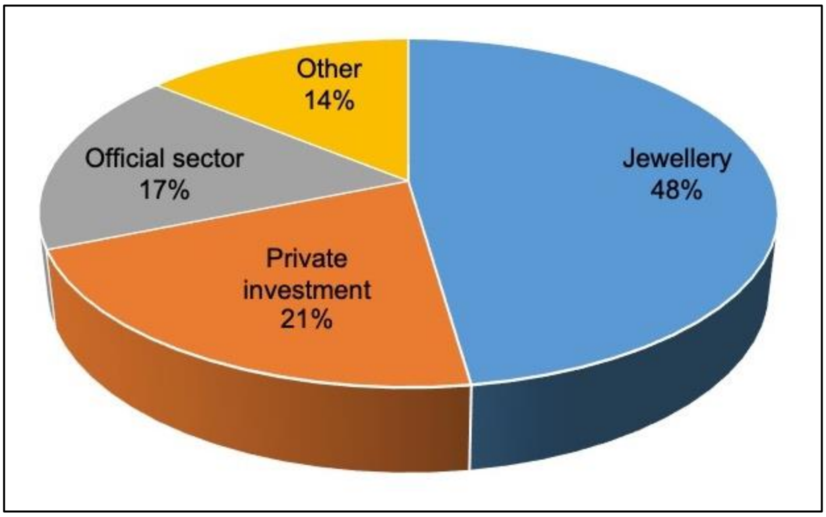

Figure 1.1: The uses of gold that was historically produced. Source: World Gold Council -a (2018)

The follwing observations can be made from Figure 1.1:

- Most of the gold that was produced throughout history (90 718 tonnes or 48%) was used to manufacture jewellery;

- Private investment has been the second largest consumer of gold using just over 40 000 tonnes (21%);
- The official sector, which is made up of institutions such as central banks, commercial banks, government entities etc, consumed 32 575 tonnes or 17% of the gold produced;and
- The remaining 26 000 tonnes (14%) was used in a variety of other sectors such as the manufacturing technology and awards, dentistry, and medical.

Gold is virtually imperishable, which means that most of the gold that was produced historically still exists in the world in one form or another (Council, How much gold has been mined, 2018a).

Each year gold miners add roughly 2 500 to 3 000 tonnes to the existing gold stocks. Production from mines has increased steeply over the recent years, especially after 2008 (as shown in Figure 1.2). The sharp increase after 2008 was attributed to the global financial crisis, which was said to be the worst the world has ever experienced since the great depression. The dark economic days of 2008 drove many investors and financial institutions to invest in gold. This is because gold is viewed as a “safe haven” in times of economic turmoil (Carlson, 2013). The high demand of gold during this period also contributed to the increase in the commodity price (as shown in Figure 1.2).

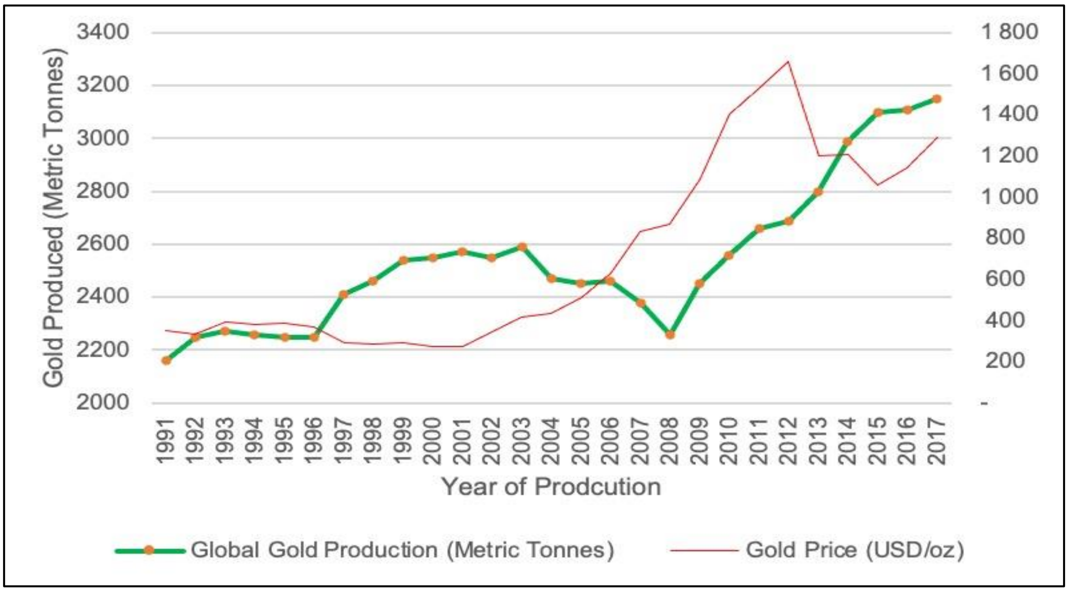

Figure 1.2: Global Gold Production 1991-2017. Source: USGS (2018), World Gold Council (2018)

China has been the largest gold producing country for the past decade. It supplied the world with 14% of its gold between 2007 and 2017. During this period, gold production in China increased by 160%. At the time of this research Ghana was the 11th largest gold producing country in the world and the second largest producer on the African continent. In recent years Ghana has surpassed South Africa to become the highest gold producing country on the continent. The gold production information for the years 2007 to 2017 is depicted in Figure 1.3.

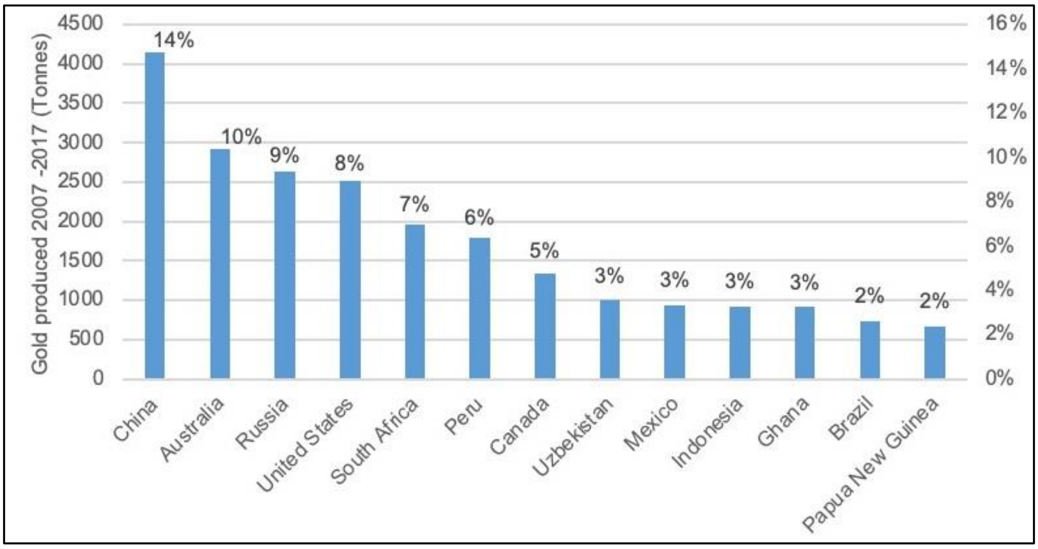

Figure 1.3: Sum of gold produced by country from 2007 - 2017. Source: World Gold Council (2018)

Market forecasts show a decline in the demand for gold in the jewellery market over the past years. Statistics published by the World Gold Council (2018) showed that the demand for gold jewellery has been on the decline since 2013. Before 2006, the jewellery market consumed around 80% of the gold that was produced, however, over the recent years this figure has declined to less than 50%. The decline in the jewellery market was particularly steep between the years 2007 and 2011. According to analysts, this was caused by sharp increase in gold prices during these years. Exchange Traded Funds (ETFs) on the other hand experienced an increase in demand during this period. However, ETFs went on to decline in recent years due to various economic reasons in the countries of high consumption (ScotiaMocatta, 2017). Although the overall demand for gold increased by 4% between 2017 and 2018, it has been fluctuating since 2010 (as shown in Annexure 1.

Despite the fluctuations, Goldberg and Brlas (2014) expected the demand for ETFs and gold to increase in the future. The gold output of mines (supply) is expected to decrease gradually in the future due to the depletion and difficulty in accessibility of gold reserves. This supply-demand overview is shown in Figure 1.4.

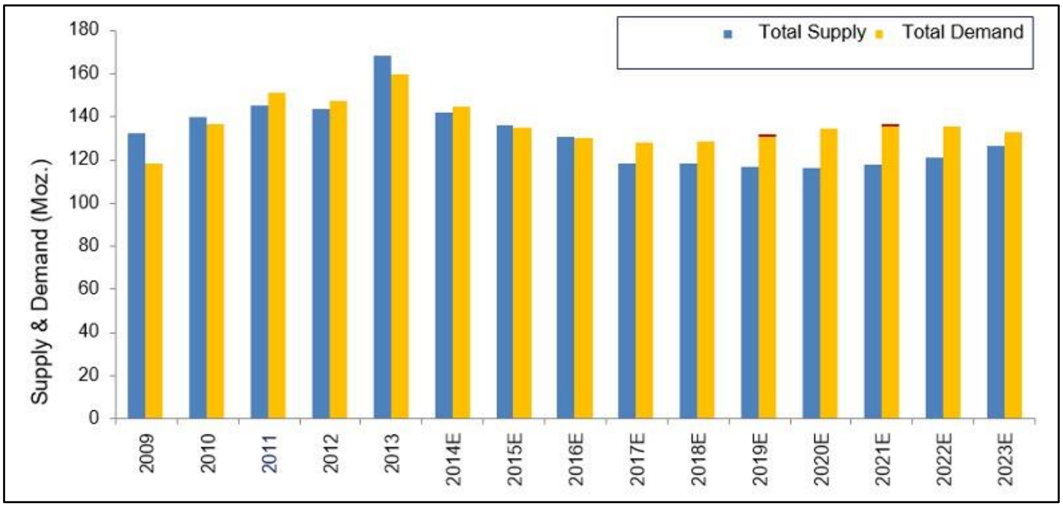

Figure 1.4: Forecast of gold supply and demand. Source: Goldberg & Brlas (2014)

a. Gold production in Ghana

Ghana is well known for the production of gold. During the colonial era[3], the country used to be known as the Gold Coast. Although modern production of gold dates to the late 19th century, gold mining and trading began many centuries earlier (Boaduo, 2017).

According to CIEC (2018), a company that publishes global economic data, and reports from the USGS, Ghana produced close to 2000 tonnes of gold between 1991 and 2017 (as shown in Figure 1.5). During the desktop study, the author observed that between the years 1991 and 2000, gold production in Ghana increased steeply. However, after the year 2000, production only increased at a fraction of the rate experienced during the 1990s.

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[3] Ghana was colonised by the British between from 1874 to 1956.

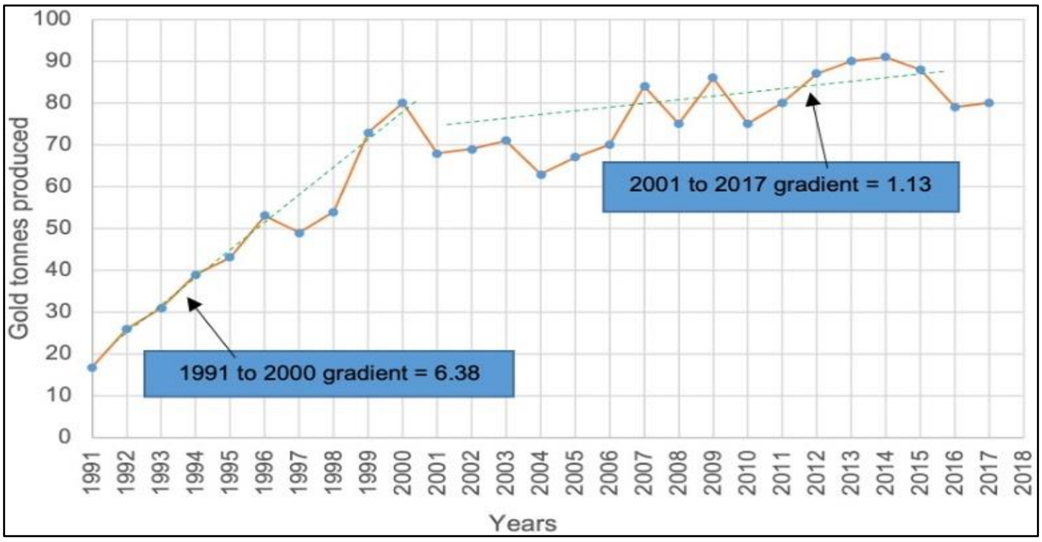

Figure 1.5: Ghana Gold Production 1991 to 2017. Source: USGS (2007-2017), CIEC Data (2018)

The gold produced in Ghana is sourced from both large-scale and the artisanal and small-scale mines. The Ghana Precious Minerals Mining Company (PMMC) [4] is the only channel through which gold and diamonds from artisanal and small-scale miners can be traded in the country. According to the Ghana Chamber of Mines' *"Perfomance of the Mining Industry 2016"* report, the artisanal and small-scale gold miners collectively produced more gold than any single large mining company in the country for the years 2015 and 2016 combined. The PMMC reported that the ASM sector produced 7.6 tonnes of gold in 2015 and 44.5 tonnes of gold in 2016 (52.1 tonnes combined). This makes up approximately 26% of the gold produced in Ghana during that period (as shown in Figure 1.6) and almost 1% of the gold produced in the world. According to a Ghanaian newspaper

[4] The PMMC was established during the 1960s after the legalization of small-scale mining in the country. By establishing a formal market through which precious minerals could be traded, the country curbed gold and diamond smugling (PMMC, 2018).

Myjoyonline (2015), the contribution that artisanal and small-scale mining has made to gold production in Ghana increased from 2.2% in 1989 to 34% in 2013.

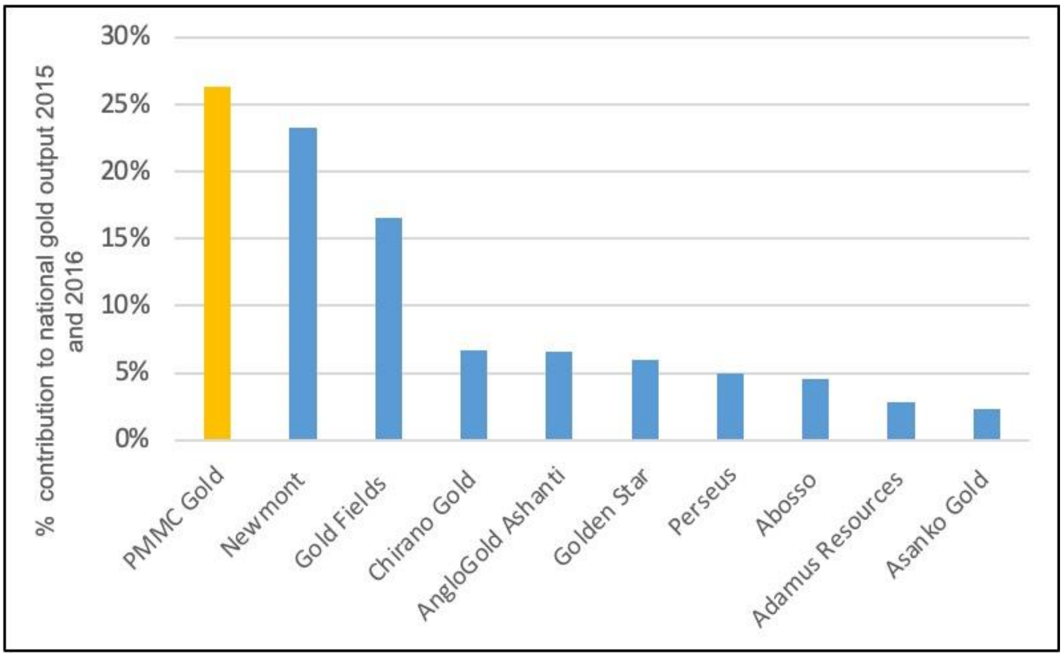

Figure 1.6: Gold generated by mining companies in Ghana for 2015 and 2016 combined. Source: Ghana Chamber of Mines (2016)

According to Adjaye & Ampofo (2017), the artisanal and small-scale gold miners of Ghana produced an estimated 851 000 troy ounces of gold between 1989 and 2010. This production generated about 2.5 billion USD in revenue, and contributed 11.68% towards gold exports. Given that the ASM sector is unorganized and it lacks sufficient support, it makes a contribution that is higher than one would expect. Export numbers also show that the sector is very fast growing in Ghana despite the lack of organisation, skills, and lack of structure (FoN, 2014). The statistics clearly show that ASM is significant to gold production in Ghana.

1.5.2 General Overview of the Diamond Sector

According to an article published by Diamondocks and Guide Magazine (2018), diamonds are considered to be the most valuable gemstones (by mass). They are also the most admired and most sought-after gemstones on earth. Historically, diamonds were a symbol of courage and strength and were only worn by kings. However, over time they have become recognized as one of the greatest gifts of love and affection (Diamondrocks, 2018).

The value of diamonds is increased not only by their hardness and their captivating beauty, but also by their uniqueness and scarcity. Diamonds are unique because each gem is enriched with a character that is distinctively its own. This means that one can never find two diamonds that are alike.

The few diamonds that can be accessed on the surface of the earth endured an extremely difficult journey from the mantle. This has caused them to also be known as “miracles of nature”. What adds to the scarcity of diamonds is that only about 50% of those that are extracted by mining meet the quality requirements for the market (Diamondrocks, 2018 ; Petra Diamonds, 2018). After rough diamonds are produced, they are sorted into the following three groups:

- Gem-quality diamonds;
- Industrial quality diamonds; and
- Diamonds that are to be crushed (Diamondspot -b, 2002).

Diamonds are more closely associated with the manufacturing of jewellery. However, their unique chemical properties such as their high thermal conductivity, abrasiveness, and hardness, also make them ideal for industrial use and research applications[5]. Out of the natural rough diamonds that reach the market, only 25% are used for jewellery manufacturing (dubbed gem-grade or gem quality diamonds) and the remaining 75% are used for industrial purposes. Their properties make them ideal for cutting and grinding, piercing, and polishing other diamonds, the manufacturing of laser technology, information processors, and electronic chips etc. Industrial diamonds have also proven to be more cost effective in industrial processes because they cut faster and last longer than other materials (Olson, 2003; Treadgold, 2013).

The industrial properties of diamonds have made them highly sought after. According to the USGS (2006), not all industrial diamonds are natural diamonds. Industrial diamonds comprise of natural diamonds and synthetic diamonds[6]. About 90% of industrial diamonds are man-made or synthetic and only 10% are natural diamonds (as shown in Figure 1.7.)

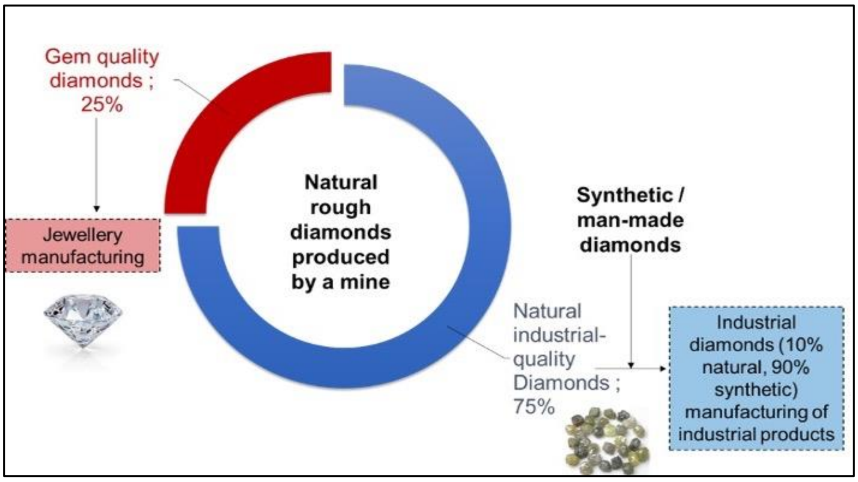

Figure 1.7: Illustration of gem and industrial quality diamond sources. Source: Industrial Diamonds Lab (2018); De Beers (2018)

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[5] Diamonds are considered as one of the hardest, or possibly the hardest, materials known to man (statista.com, 2017)
[6] Industrial diamonds comprise of natural and synthetic diamonds (synthetic diamonds are manufactured in a laboratory). The research will only focus on natural diamonds.

a. Diamond Pricing

After diamonds are sorted into their various categories they are graded individually because each stone has unique qualities that determine its value. Although there is a set global market price for diamonds, the pricing is very complicated compared to that of other precious stones or mineral commodities. According to the Gemological Institute of America (2018), diamonds are described and graded according to the “4 Cs”, which are colour, clarity, cut and carat weight. Top gem-quality diamonds can fetch over 30 000 USD per carat. Whereas natural industrial diamonds range between 0.3 USD per carat for smaller stones, 7 to 10 USD for regular stones and 200 USD for larger stones (Ajediam, 2018; Olson, 2003).

Due to the difference between the prices of gem diamonds and industrial diamonds, this report displays two different historical price charts. The first chart (Figure 1.8) shows the global historic prices of top-quality gem diamonds from 1960 to 2017. The second chart (Figure 1.9) displays the industrial diamond prices that were set for Ghana (the country of study) between the years 2004 and 2017.

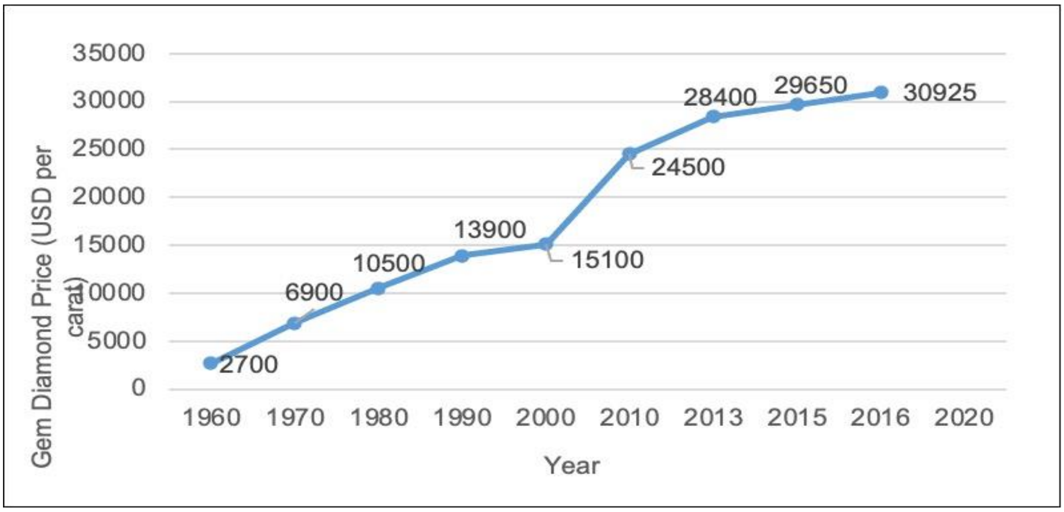

Figure 1.8: Global historic prices for top quality gemstone diamonds. Source: Ajediam (2018)

Figure 1.8 shows that the prices of top-quality gem diamonds have been increasing by approximately 14% yearly (Ajediam, 2018). This is attributed to several significant historical events and economic factors (such as inflation), but more importantly the increase in the diamond demand and the shortage of supply (reserves).

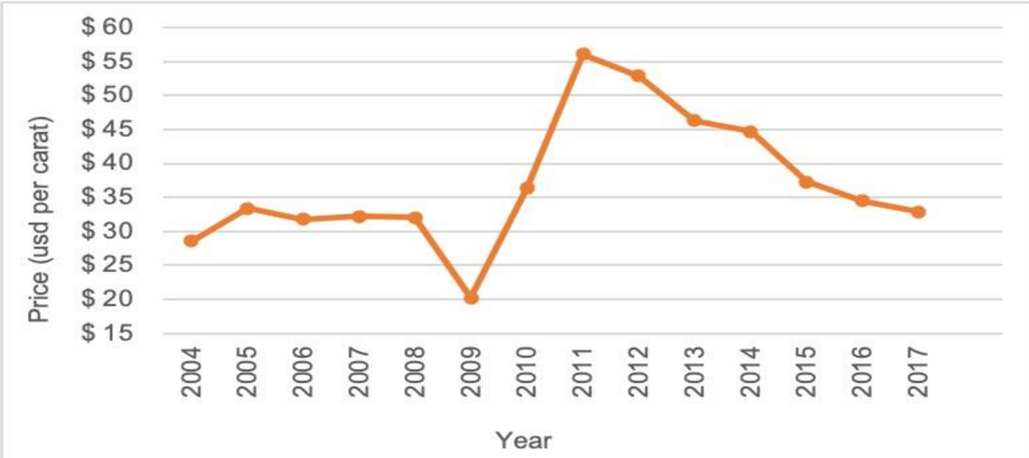

Figure 1.9: Historical prices of natural industrial diamonds produced by Ghana 2004-2017. Source: Kimberlyprocess (2018)

Figure 1.9 shows that the price of industrial diamonds in Ghana increased by more than 200% between the years 2009 and 2011. However, after 2011, industrial diamond prices in Ghana decreased rapidly.

b. Global Diamond Supply and Demand

The African continent has produced most of the world's market worthy diamonds since the year 1870. However, over the years, countries outside the continent such as Russia, Australia and Canada have grown to be some of the largest producers of diamonds in the world (Ajediam, 2018). Figure 1.10 shows the highest gem-diamond producing countries in the world and their diamond production for the past 13 years.

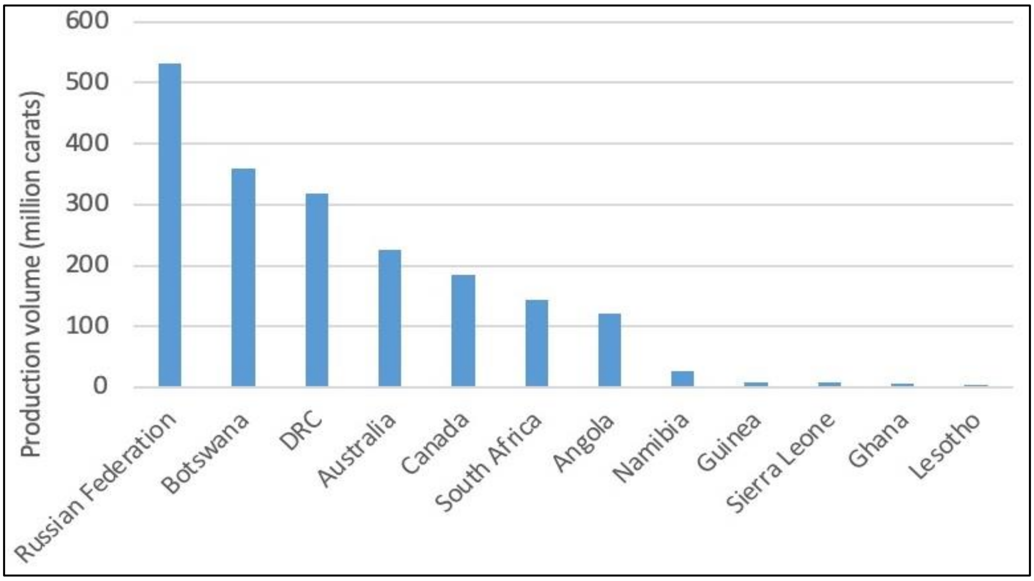

Figure 1.10: Global Diamond Production (2004 – 2017). Source: Kimberly Process (2018)

The following observations can be made from Figure 1.10:

- Over the past decade, Russia has been the highest producer of rough diamonds in the world accounting for 18% of the global production.
- Botswana produced 16% of the world's diamonds, making it the second largest diamond producer in the world and the largest in Africa.
- Botswana is followed by the Democratic Republic of Congo, which is the second largest producer of diamonds in Africa. The DRC has supplied the world with 11% of its diamonds between 2004 and 2017.
- The country of study, Ghana, produced 6.5 million carats of rough diamonds (0.3% of the world's production) between 2004 and 2017, making it the eighth largest diamond producing country on the African continent.

Figure 1.10 shows that Africa remains a very important contributor to diamond production as eight out of the twelve top producers are from the African continent.

The demand of diamonds is currently high, and it is expected to continue to grow in the future. This is firstly because the consumers of industrial diamonds are constantly on the lookout for high performance tools and low production costs. The increase in the demand of industrial diamonds is expected to have a domino effect on all diamond categories (DiamondSpot - a, 2002). Market forecasts also show that the demand of gem-quality diamonds is expected to increase in the future because of high consumer demand in the developing and the developed markets (Gem diamonds, 2018).

Mineral deposits are finite, explaining why the existing diamond reserves become more depleted as the demand for natural rough diamonds continues to grow. Statistics show that the gap that currently exists between the demand and supply of diamonds will continue to grow in the years to come. According to global forecasts, the global supply of diamonds will fall short by 278 million carats by the year 2050. This diamond supply gap is depicted in Figure 1.11. The increase in demand and shortage of supply will consequently result in an increase of the price of natural rough diamonds (Statista -a, 2018).

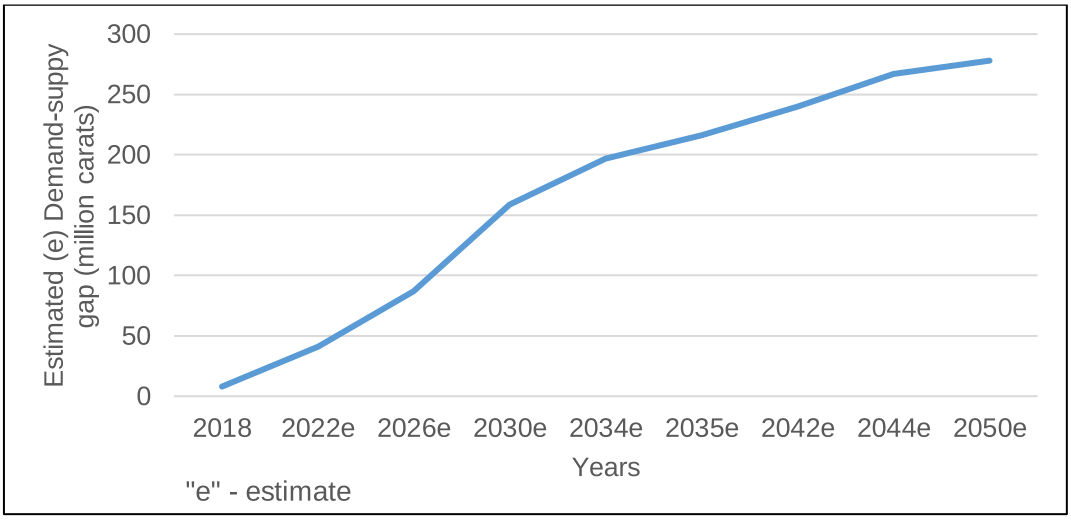

Figure 1.11: Forecasted global diamond supply and demand gap. Source: Statista (2018)

c. Diamond Production in Ghana

In Ghana, diamond mining predominantly occurs in the Birim diamond fields located in the country's Eastern region, and in the Bonsa fields located in the Western Region. The diamonds are sourced from artisanal and small-scale miners who mainly practice alluvial mining. The artisanal miners sell their diamonds to the Ghana PMMC, which exports them. The PMMC is the only company with the mandate to conduct all diamond purchases and sales in the country.

Although it is very difficult to accurately estimate the amount of diamond resources and reserves remaining in Ghana, a study published by the United States Geological Survey in 2010 estimated that 89 million carats were present in the Birim fields, and approximately 2.6 million carats remain in the Bonsa fields (resulting in 91.6 million carats). The study also determined that these areas have the potential to produce 765 000 carats of diamonds per year (Chirico, et al., 2010). Despite this estimation, diamond production remains very low in Ghana. Statistics published by the Kimberly process (2017) showed that diamond production in Ghana has declined drastically, from 1 million carats in 2004 to just under 200 000 carats in 2017. This information is shown in Figure 1.12.

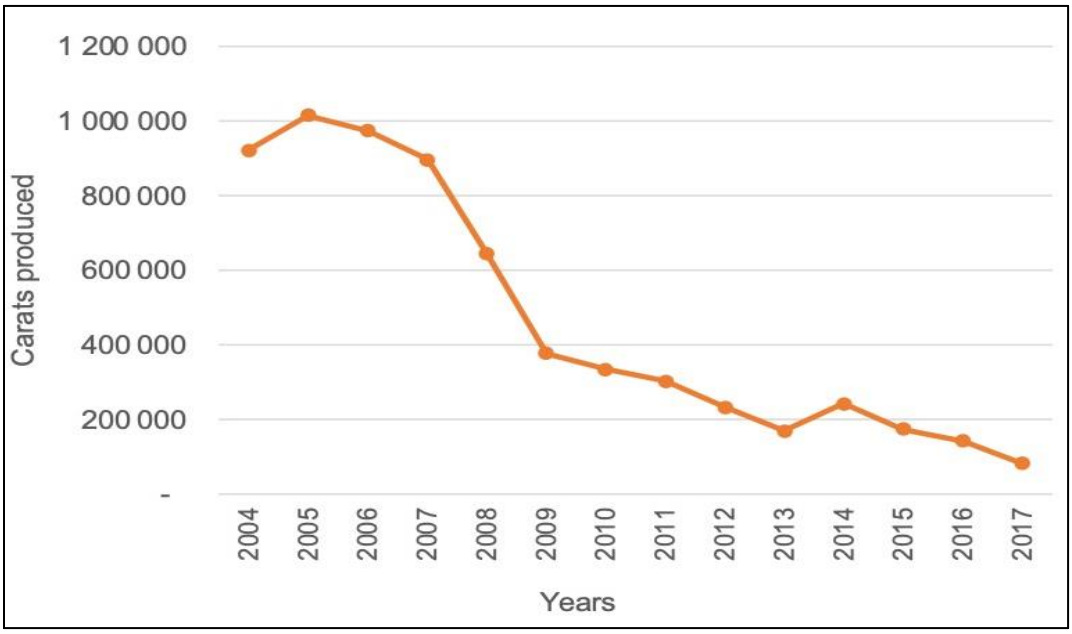

Figure 1.12: Ghana diamond production 2004-2017. Source: Kimberlyprocess (2018)

Figure 1.12 shows that the diamond production decline was very steep between the years 2006 and 2009. This was due to the closure of Akwatia mine, which was operated by Great Consolidated Diamonds, Ghana's only commercial diamond mining company (Nyaungwa, 2006). This led to the PMMC relying solely on artisanal and small-scale miners for diamond production. According to a Ghanaian newspaper, the Ghana Chronicle (2018), other causes of the decline were the low production of the artisanal and small-scale diamond miners in the areas, the recent ban on artisanal and small-scale mining, as well as the scarcity of diamonds in the country.

1.5.3 Large-scale versus Artisanal and Small-scale Mining

Mining operations can be classified into two main categories which are: large-scale and small-scale mining. Artisanal mining is a subcategory of small-scale mining. Although medium-scale mines exist, it is difficult to find a description, definition, or an example of this category. Figure 1.13 provides a schematic of the different scales of mining operations and their subcategories.

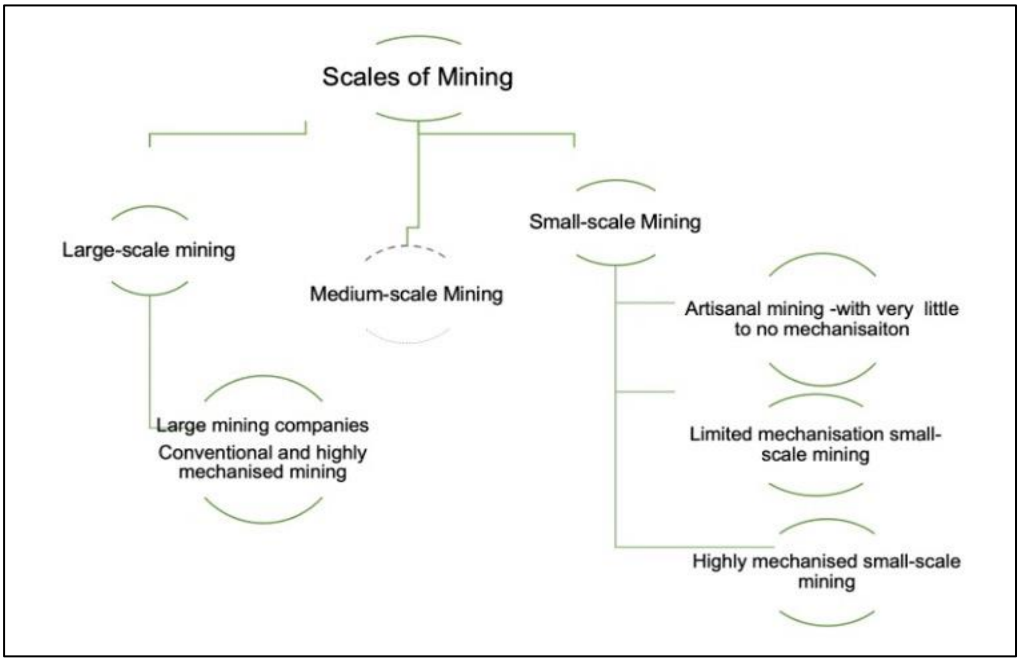

Figure 1.13: A schematic of the large, medium and ASM (author's interpretation).

According to various publications, the following factors determine whether a mining operation can be classified as large-scale or artisanal and small-scale:

- The number of people employed on the mine;
- The production output of the mine;
- The amount of capital invested into the mine, and
- The mining method.

Large-scale mining is normally practised by multi-national companies, which either employ a large labour force usually in the thousands (for conventional mines) or a high degree of mechanisation to extract the ore. These mines are capitally intensive and generate a very high production output (also in the region of thousands weekly), depending on the type of mining method used. Large-scale mines mostly operate formally within the boundaries of mining regulations, and they also have a formal managerial structure. They comprise of surface and underground mines that employ technical and well-planned methods to mine and process complex ore deposits. Large-scale mines function on proven reserves that are reported according to certain mining codes (Department of Water Affairs and Forestry, 2006).

Small-scale mining is a broad category, which includes artisanal or subsistence mining operations that are run by individuals, families, communities etc. It also includes junior mining companies that are normally run by organized structures such as cooperatives and registered companies. Junior mining companies are usually more mechanised and utilize extensive equipment such as a fleet of trucks and loaders, and sophisticated equipment for ore processing etc. Artisanal or subsistence miners usually employ very limited to no mechanisation on their operations. They practise rudimentary ways of mining[7] (Department of Water Affairs and Forestry, 2006; Weber-Fahr, et al., 2002). Some perceived common traits of artisanal and small-scale mines are that they operate with very little to no capital, outside mining and environmental regulations. ASM operations also tend to work informally, they appear to be unstructured, unstable and they practice “hit-or-miss” mining methods. Because of the lack of regulation, they tend to have a negative impact on the environment as well as the health and safety of employees (Department of Water Affairs and Forestry, 2006).

1.5.4 Artisanal and Small-scale Gold and Diamond Mining in Ghana

Gold and diamonds are very attractive for artisanal and small-scale mining because they are high unit value minerals. In many ASM areas, these high unit value minerals are often available in abundance and they are easily accessible

[7] Rudimentary mining using methods such as panning, mining with picks, shovels etc

from surface. They require minimum execution time and low barriers to entry (with regards to reserves, capital, infrastructure, technical knowledge and technology) compared to large-scale mining projects (Kambani, 2009).

In Ghana, small-scale mining is a large creator of direct and indirect employment. It is an important means of income generation for the mining host communities (Hilson, 2003a). Although there has been no official estimation of the number of Ghanaians involved in artisanal and small-scale mining, sources estimate that the activity provides direct employment for 200 000 to a million people, and supports an additional 4.5 million people indirectly. (FoN, 2014; McQuilken & Hilson, 2016). Artisanal and small-scale mining provides more employment than large-scale mining in the country[8] (Hilson, 2003a).

In Ghana, illegal ASM mining is referred to as “Galamsey”. According to the former CEO of the Ghana Minerals Commission, Dr. Tony Aubynn (2016), most of the ASM operations in the country have shifted from non-mechanized (artisanal) to limited and highly mechanized. More recently, there has been a large presence of earth moving equipment and other machines on the ASM operations. The improvement in mechanisation has resulted in minerals being exploited at a faster rate and the need for some miners to be allocated bigger portions of land.

a. The poverty conditions of ASM host communities

Despite the abundance of precious mineral resources, and the contribution that gold and diamond small-scale mining makes to the economy, the small-scale mining communities remain underdeveloped and impoverished (Adjaye & Ampofo , 2017). Figure 1.14 shows the distribution of gold and diamond mineral resources across Ghana relative to the the poverty levels in the various mining districts. A

[8] Large-scale mine is estimated to employ only 16 000 people directly and 66 000 people indirectly (McQuilken & Hilson, 2016).

few of the artisanal and small-scale mining communities are identified in Figure 1.14 to give the reader an indication of their locations and poverty levels.

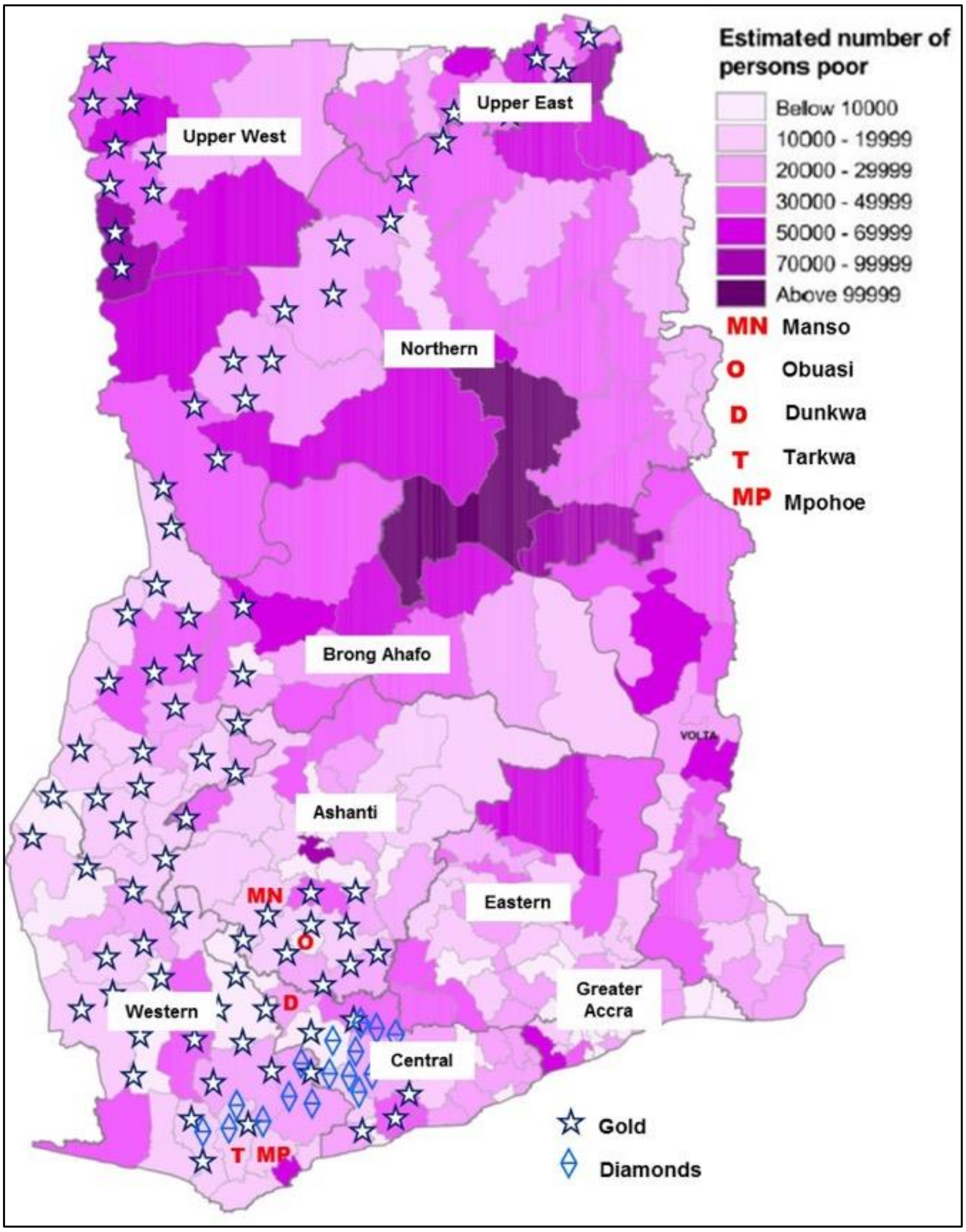

Figure 1.14: Poverty map with gold and diamond distribution. Source: Ghana Statistical Service (2015); Amankwah & Anim-Sackey (2004). Ghana Statistical Service (2014).

According to various sources, small-scale mining mainly occurs in the following areas:

- Dunkwa, located in the Upper Denkyira East Municipal District;
- Tarkwa which is located in the Tarkwa-Nsuanem Municipality;
- Obuasi Municipality;
- Mphor District; and
- Manso which is located in the Amansie West District.

Table 1.1 gives a summary of the poverty and development conditions that exist in these four mining areas.

Table 1.1: Development and poverty indicators in the various Ghanaian mining regions and districts

	Gold				**Diamond**
	Upper Denkyira East Municipal **(Dunkwa -D)**	Tarkwa Nsuaem Municipality **(Tarkwa -T)**	Obuasi Municipality **(Obuasi -O)**	Amansie West District Assembly **(Manso -MN)**	Mpohor District **(Mpohor-MP)**
Household Population	71 519	86 566	165 052	132 443	41 976
Percentage of population employed in mining	5%	23%	14%	17%	13%
Percentage of population rural	82%	71%	41%	96%	75%
Poverty headcount	31%	15%	5%	10%	40%
Estimated number of poor persons	21 878	12 353	8 682	12 701	16 971
Gini coefficient - Inequality	42%	37%	38%	32%	31%

Sources: Ghana Statistical Service (2015), Ghana Statistical Service (2014), Poverty Mapping Report (2015).

The following observations can be made from Figure 1.14 and Table 1.1:

- Mining is significant in these areas because it provides more than 10% of the locals with employment. Dunkwar is the exception with 5%;
- More than 70% of the households are rural in most of the identified ASM areas. Obuasi is the exception where 59% of the households are urban;
- More than 10% of the households in three of the identified mining areas live below the national poverty line[9], with Mphor and Dunkwa showing the highest levels of extereme poverty; and
- Inequality is higher in the mining areas.

Mining districts and host communities remain rural and impoverished. Many ascribe this to the lack of adequate government support and systems that can properly regulate the sector. The poverty levels shown in Table 1.1 also contribute to the disorganisation and lack of structure in the ASM sector. Living in poverty and having limited economic opportunities causes the locals to rely on the daily output from the operations for survival (Hilson, 2003a). The low literacy levels in the communities also count against the development of the ASM sector.

1.6 Research Question

Although artisanal and small-scale gold and diamond mining has generated significant revenue for Ghana, the negative perceptions of the industry continue to outweigh the positives. The sector lacks the skills and expertise that are necessary for proper mining. It struggles to attract the required funding opportunities. As a result, it remains under-resourced for optimal mining. Literature shows that the sector is not well recognized, and it lacks provision and support from government. These challenges make it almost impossible for most artisanal and small-scale

[9] The poverty line of Ghana is 0.76 USD (3.60 Cedis) per day.

mines to operate as formal enterprises. It is because of this that the research presents the following fundamental question: What strategic framework can be developed to guide artisanal and small-scale gold and diamond mining to be conducted in a sustainable, responsible, and economic manner? This crucial question has brought about the following derivatives:

- How significant is artisanal and small-scale mining in Ghana?
- What is the definition of ASM around the world and in Ghana, and how does its legal framework compare to that of other countries?
- How does the mine value chain apply to ASM, and what gaps exist within the ASM value chain?
- What is the rationale behind ASM, and are mining engineering principles applied in ASM?
- How is ASM practised and how are the operations managed in reality? What is the profitability of these operations?
- What is the perception on ASM in Ghana and the view of stakeholders on the sector?
- What strategic framework can be developed in working towards the improvement of ASM in Ghana?
- How can this strategic framework be effectively implemented to empower sustainable and responsible ASM?

1.7 Hypothesis

This research develops a strategic framework that will aid artisanal and small-scale mines to operate sustainably, economically, and professionally. Governments can use the framework to reform the sector. People who are interested in engaging in ASM can use the framework to increase their knowledge and manage their operations better. This will help to maximize the economic benefits of ASM. It will also position the sector to take advantage of the high global demands that are forecasted for the future. The framework will help to make the sector more attractive to potential investors, professionals, and entrepreneurs.

1.8 Research Methods and Structure of Thesis

The Thesis contains ten chapters. It examines the legal, technical, operational, and financial management aspects of the ASM operations. In the final chapters of the Thesis, the findings from the preceding chapters are merged into a strategic framework that is accompanied by an implementation plan. A further explanation of the chapters and methodology is provided below.

Chapter 1 (Background and outline of the problem) introduces the topic and orients the reader into the research. It provides the background and context of the study as well as the methodology of the research. This is achieved through a desktop study.

Chapter 2 (International Lessons on ASM: Definitions, legislations, and the value chain) reviews literature about the definition, the legal framework and the value chain of ASM. It conducts a comparative analysis of various countries that conduct ASM and identifies international lessons to be learnt. This chapter also identifies gaps within the ASM value chain. The information in this chapter is derived through a desktop study**.**

Chapter 3 (A comparative analysis: Applying international lessons to Ghana) is a continuation of the literature study with focus on Ghana. This chapter compares the ASM definitions, legislations, and value chains of the international community to that of Ghana. The chapter examines how Ghana is aligned and positioned relative to the other countries.

Chapter 4 (The mining engineering principles behind ASM) examines the rationale behind ASM. It gives context on how a standard ASM operation should function from the early stages (i.e., mineral exploration) to the later stages (i.e., mine rehabilitation). This chapter also examines the alignment of ASM practices to mining engineering principles. This information is obtained through a desktop study.

Chapter 5 (ASM case studies) provides the first segment of a three-part field work exercise. It examines how Ghanaian artisanal and small-scale mines are set up and how they operate. This chapter documents two case studies. The chapter also examines the differences between how legal and illegal small-scale mines operate in Ghana.

Chapter 6 (Production and financial valuation for small-scale mining) investigates the financial viability of small-scale mining. Here the production data from one of the case studies is used to conduct financial valuation. The research builds a discounted cashflow for small-scale mining and analyses it for different production scenarios.

Chapter 7 (Stakeholder engagement feedback) provides the last component of the fieldwork, which documents the insight, thoughts, and perspectives of different stakeholders about ASM in Ghana.

In **Chapter 8** (Developing a strategic framework for Ghana), the research uses the information gathered in the preceding chapters to create a strategic framework for viable and responsible ASM. **Chapter** 9 (Developing an implementation plan for the strategic framework) develops an implementation plan for the strategy document. The research is concluded in **Chapter 10,** where recommendations are given.

Discussions were held with professionals in the small-scale mining industry to verify the credibility of the information in this research. The information was also discussed with governing bodies such as the Ghana Minerals Commission and the Ghana Chamber of Mines. Existing research and professional mining networks were also used to validate the information. The field observations in this research were conducted in line with the Wits University Code of Ethics.

1.9 Conclusion

Chapter 1 introduces the research topic. It describes the problem and provides a context for the research. The chapter also shows how the research will be investigated, and it provides an outline of the report structure.

Chapter 1 confirms that the Ghanaian ASM plays a significant role in the supply of gold and diamonds, and this is not expected to change in the future. It shows that the current and projected global demand for gold and diamonds is high, and if Ghana positions itself well, it can benefit from this demand. The chapter also shows that despite the important contribution of ASM to the production of precious minerals, the sector continues to have a negative image, and poverty levels remain high in many ASM host communities.

The next chapter (Chapter 2) gives a global view of ASM. It compares the definitions, legislation, and value chain of ASM for various countries, with the aim of identifying international lessons.

2 INTERNATIONAL LESSONS ON ASM

Chapter 2 examines the ASM definitions, legislations, and value chains from different countries. The purpose of this chapter is to identify lessons in the international community that can help Ghana.

There is no clear or fixed global definition for artisanal and small-scale mining. The understanding differs from one country to another. Local circumstances and legal frameworks cause each country to define ASM differently. The sector is also complicated because it works in different ways. It is difficult to identify two countries that practice ASM the exact same way, or a country that conducts ASM in a way that is considered to be correct (IIED, 2002). Therefore, when studying the topic, it is not ideal to analyse countries in isolation. To draw the best learnings and identify the best lessons, a comparative study is necessary.

2.1 The Mine Value Chain and its applicability to ASM

In the context of mining, the value chain represents a sequence of activities that the ore passes through from the time it is identified during prospecting and exploration to the time when it is sold to the consumer market (Baartjes, 2015). In the case of recyclable minerals, such as gold and platinum, some value chains could include a recycling stage. The value chain is applicable to the entire mining sector and all mining operations regardless of the size or scale of mining. It is important for mines to understand their value chain so that they know how to best optimise resource-to-market activities. A good understanding of the value chain also gives an upper hand in price and business negotiations. Figure 2.1 provides a high-level overview of a typical mine value chain.

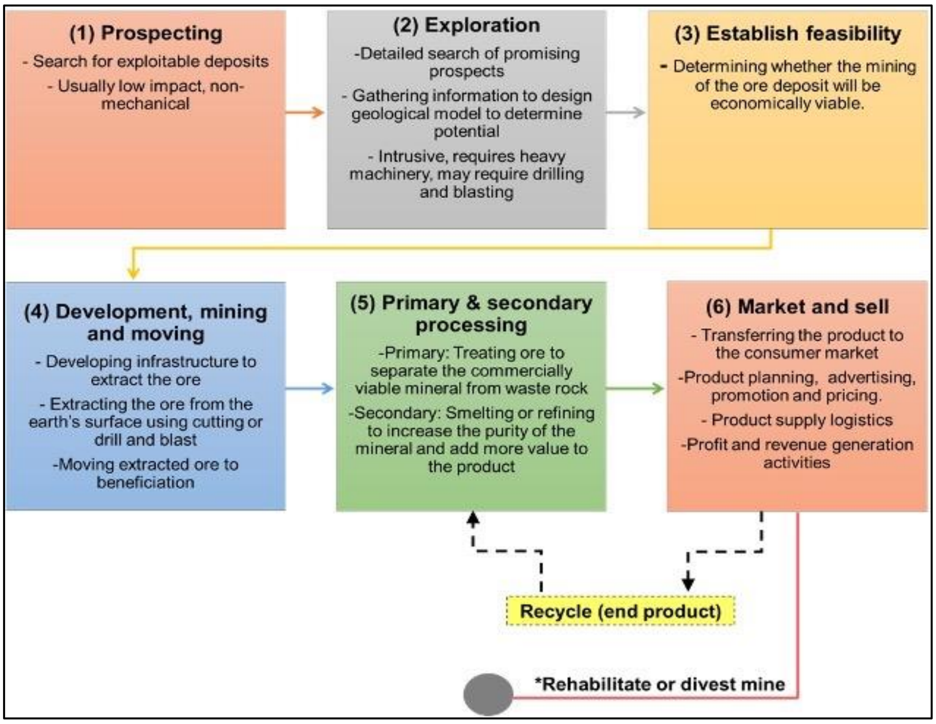

Figure 2.1: Overview of a Mining Value Chain. Source: Rajagopalan (2015)

Most of the literature that is available on the mining value chain focuses on large-scale mining. There is currently very little literature that is specific to artisanal and small-scale mining. A paper written by Page (2017) provided information about a typical value chain for ASM. This is illustrated in Figure 2.2.

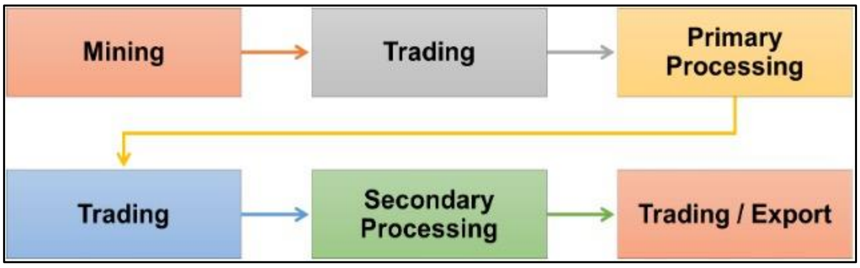

Figure 2.2: Typical ASM Value Chain. Source: Page et al. (2017)

According to Page et al (2017), most of the stages of the large-scale mining value chain are present in ASM. This literature also indicated that prospecting and exploration can be bypassed when establishing an ASM operation. The information also showed that the minerals that are mined in ASM can be traded at any time after they are extracted from the in-situ rock. This means that trading can occur during the very early stages or in the later stages of the value chain. According to the concept of the value chain, the stage at which trading occurs is very important because it determines the market value of the product. Mineral products that are traded after the more advanced stages of the value chain (such as after refining) are traded at a higher price than those that are traded during the earlier stages in their raw state. The premature trading of minerals within the value chain works against the notion of mineral-based economic development.

2.2 Country Analysis

The countries of Zimbabwe, South Africa, Brazil and Ethiopia were selected for this analysis based on the fact that they met 60% (or more) of the criteria as shown in Table 2.1. Although Pakistan only met 40% of the criteria, the country was selected because of its progressive ASM legislation, efforts to promote ASM, and development potential of the sector.

Table 2.1: Selection criteria of countries for the comparative analysis

		Zimbabwe	South Africa	Brazil	Ethiopia	Pakistan
Reason for selection	Significant gold ASM	✓	✓	✓	✓	
	Significant diamond ASM		✓	✓		
	History of gold or diamond mining	✓	✓	✓		
	High development potential for ASM sector	✓	✓	✓	✓	✓
	Commended mining legislation		✓	✓	✓	✓

2.2.1 Zimbabwe

According to a policy brief published by the Parliament of Zimbabwe in 2017, ASM is an important policy tool of poverty reduction in the country. The sector is estimated to have more than 500 000 direct employees, and over 3 million dependents. Although ASM has been practised since the 15th century, the activity increased significantly after Zimbabwe experienced recession in the year 2000, and hyperinflation in 2007. As a significant number of large companies downsized and closed, many small and medium sized enterprises (SMEs) emerged[10] (Gutu, 2017). The decline of the agricultural sector also saw farmworkers being driven into mineral extraction. Between the years 2006 and 2016, the ASM sector of Zimbabwe generated more than 50% of the foreign exchange earned. In the year 2016, the artisanal and small-scale gold miners produced 45% of the country's gold supply (Gutu, 2017).

a. The Definition of ASM in Zimbabwe

Zimbabwe does not have a clear or unanimous definition for ASM. According to Gutu (2017), the country's current legislation makes a poor attempt to define ASM and the sector is not satisfied with the brief definition. By analysing the country's Mining Act and existing literature, one can deduce that ASM has been split into the categories of small-scale mining and artisanal mining. The small-scale mining category refers to mining that involves individuals who *"own blocks of claims and may employ people"* (Pact, 2017). This includes small-scale mines that practise cost-efficient levels of mechanisation. The category of artisanal mining includes individuals or groups who *"do not own blocks of claims and mine on other people's claims or on land that is not registered for mining"* (Pact, 2017). It also includes

[10] SMEs make up between 40% and 60% of Zimbabwe's labor force and ASM makes up 8% of the SMEs in the country. About 85% of the SMEs in Zimbabwe are unregistered (Gutu, 2017).

small mines that mainly require manual labour and exploit shallow deposits. The participation of people in artisanal mining is driven by the conditions of other economic sectors, and it fluctuates with commodity prices, whereas participation in small-scale mining is mainly driven by the financial interests of the owners and the performance of the operation (Pact , 2017).

b. The Legal Framework

The ASM sector of Zimbabwe is governed by the Mines and Minerals Act (Chapter 21:05). This Act focuses on mining property and the rights over the property. There are also additional Acts[11] which regulate the environment, health and safety, explosives use and the trade of commodities. Some of the other Acts that are notable to this study are the Gold Trade Act and Precious Stones Trade Act. The Gold Trade Act and Precious Stones Trade Act regulates ownership, trade, and the movement of precious minerals further down the value chain (Ministry of Mines and Mining Development - b, 2016).

According to UNIDO (2018), the Zimbabwe mining legislation contains gaps because it does not make a distinction between large-scale mining and small-scale mining. The Act also appears to favour large-scale mining over small-scale mining, thereby encouraging a lack of compliance and illegal activities in the sector. Gutu (2017) wrote that the lack of recognition of ASM contributes to the increase of illegal operations. According to the Zimbabwe Miners Federation (2013), only 5% of the country's small-scale miners operated within the regulatory boundaries in 2013.

In Zimbabwe, all individuals and companies looking to acquire a mining claim follow a similar process regardless of the scale of mining. Some components of the

[11] Environmental Management Act, the Water and the National Water Authority Act, and the Explosives Regulations Act (UNIDO, 2018).

process may differ (but not significantly) depending on the type of commodity identified and the size of land of interest. There is no simplified version of registration for ASM operators. Figure 2.3 shows the general process that is followed by an individual looking to apply for a mining claim.

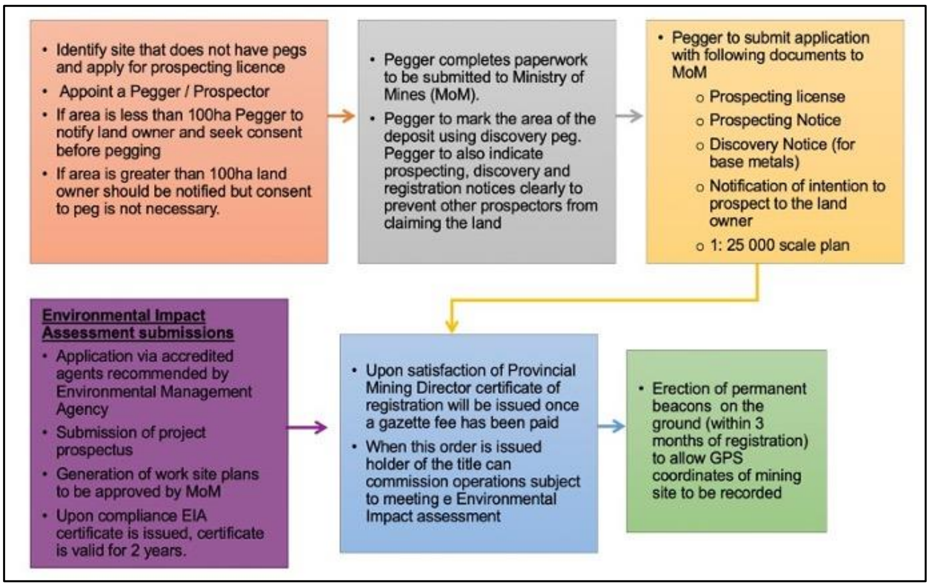

Figure 2.3: Process of acquiring an ASM licence in Zimbabwe. Source: Ministry of Mines and Mining Development (2016); Sibanda (2017).

The type of licence issued to artisanal and small-scale miners is called an ordinary mining licence. This licence covers areas that are less than 10ha containing any precious minerals. This type of licence is reserved for permanent Zimbabwean residents over the age of 18. Another mining licence, which is relevant to small-scale operators is the special mining licence, which covers areas less than 25ha containing commodities such as metal, stone and base metals. This licence can be issued to a company, which is legally registered in Zimbabwe. The licences are also issued instantly over the counter (Ministry of Mines and Mining Development, 2016a).

A challenge facing Zimbabwe's ASM sector is the poor management of the Mining Cadastre System. The current system in Zimbabwe is not computerised, which results in inadequate and delayed mapping of mining claims. The system of mapping concessions is manual (it is only done with pegs on the site). This often leads to artisanal miners trespassing on claims which are legally registered. The poorly managed cadastre system contributes to the mismanagement of payments and poor administration. The lack of computerisation and adequate systems prevents fairness, liability and transparency in the issuing of mining claims, (UNIDO, 2018).

c. The ASM value chain

The ASM value chain of Zimbabwe is the strongest in the prospecting, mine development and mining, marketing, and mine rehabilitation phases (as shown in Figure 2.4).

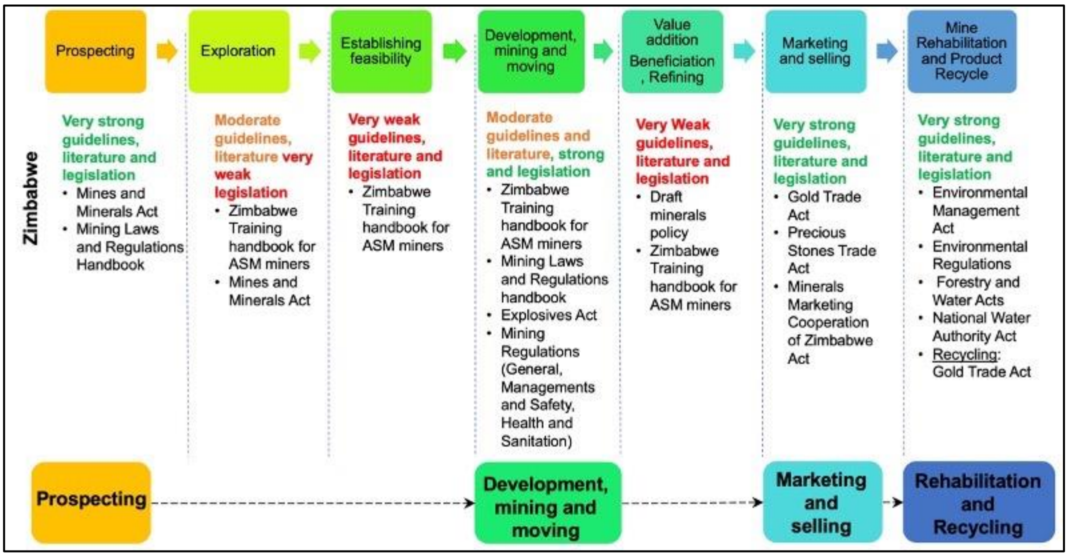

Figure 2.4: Strengths and weaknesses of the Zimbabwe ASM value chain (author's interpretation).

There is plenty of information (both literature and legislation) that supports these components of the value chain. However, there are gaps of information in the exploration stage, and there is very little information to guide operations on how to determine the feasibility. There is also a lack of value addition and beneficiation content in the legislation.

2.2.2 South Africa

Statistics published by the Intergovernmental International Institute for Sustainable Development (2017) showed that the South African ASM sector provides direct employment to about 20 000 people. However, it is believed that this estimate is highly inaccurate and could possibly exclude the large number of unregistered operations. Given the history of mining in South Africa (especially in the gold sector), the retrenchments of hundreds of thousands of mine workers must have driven a significant number of former miners into small-scale mining. These numbers would be difficult to estimate because of the hidden nature of the illegal operations. There is also extensive processing of tailings and waste dumps on the outskirts of old mining towns and cities. These examples combined with the inclusion of small-scale diamond, coal, platinum and base metal miners should surely put the figure of direct small-scale mining employees above 20 000. The number of people who are indirectly dependent on this sector is unknown.

a. The Definition of ASM in South Africa

A Minerals and Mining Policy White Paper published by the Department of Mineral Resources (1998) provides a definition for the South African ASM sector. ASM is defined as the smallest mining operation, ranging from artisanal mining where a subsistence livelihood is the key motivator, to bigger or more organised small mining companies, referred to as “junior” miners, that are motivated by commercial rather than subsistence factors. Artisanal mining is further defined as “*small-scale* *mining involving the extraction of minerals with the simplest tools, on a subsistence level"* (Department of Minerals and Energy, 1998). The broader category of small-scale mining is defined according to an operation's output, managerial structure or number of employees, and the amount of capital invested (see Table 2.2), and this differs from one commodity to another.

According to the South African National Small Business Act of 1996, ASM falls under the category of small business within the mining sector. The Act is more quantitative and it sub-divides the small mining businesses into the four categories that are shown in Table 2.2.

Table 2.2: National Small Business Act - Small mining business categories

Size	**Total full-time equivalent of paid employees**	**Total annual turnover (ZAR)** *Less than:*	**Gross asset value (excluding fixed property) (ZAR)** *Less than:*
Micro	5	30.0 mil	0.10 mil
Very small	20	7.50 mil	1.80 mil
Small	20	3.00 mil	4.50 mil
Medium	200	0.15 mil	18.00 mil

Source: (South African Government, 1996).

b. The Legal Framework.

The Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) is the principal legislation that governs the South African mining industry (Department of Water Affairs and Forestry, 2006). The MPRDA covers mining permit allocations and aspects of mineral processing and beneficiation. In addition to complying with the MPRDA, Mining companies are also required to comply with other laws which regulate health and safety, the environment, and explosives, among others[12] (Ledwaba & Mutemeri, 2017). The Precious Minerals and Metals Act of 2005 and

[12] The sector is supported additional laws such as the National Environmental Act, Mine Health and Safety Act, Air Pollution Act, Water Act, Explosives Act and the National Business Act.

the Diamonds Act of 1986 regulate the activities that take place beyond the processing stage (i.e., from refining to trading). This Act is administered by the South African Diamond and Precious Metals Regulator (SADPMR, 2013).

In South Africa, small and large-scale mines follow the same legislation and application process for a mining permit. According to the 2013 amendment of the MPRDA, a mining permit is issued for mines that operate on a surface area that is less than 5ha and this permit is valid for two years. After these 2 years, the permit can be renewed three times with each renewal being valid for 1 year at a time. Any mine that operates on a surface area that is larger than 5ha is granted a mining right, which is valid for a maximum of 30 years. The process that ASM operations need to go through when applying for a permit or right is shown in Figure 2.5.

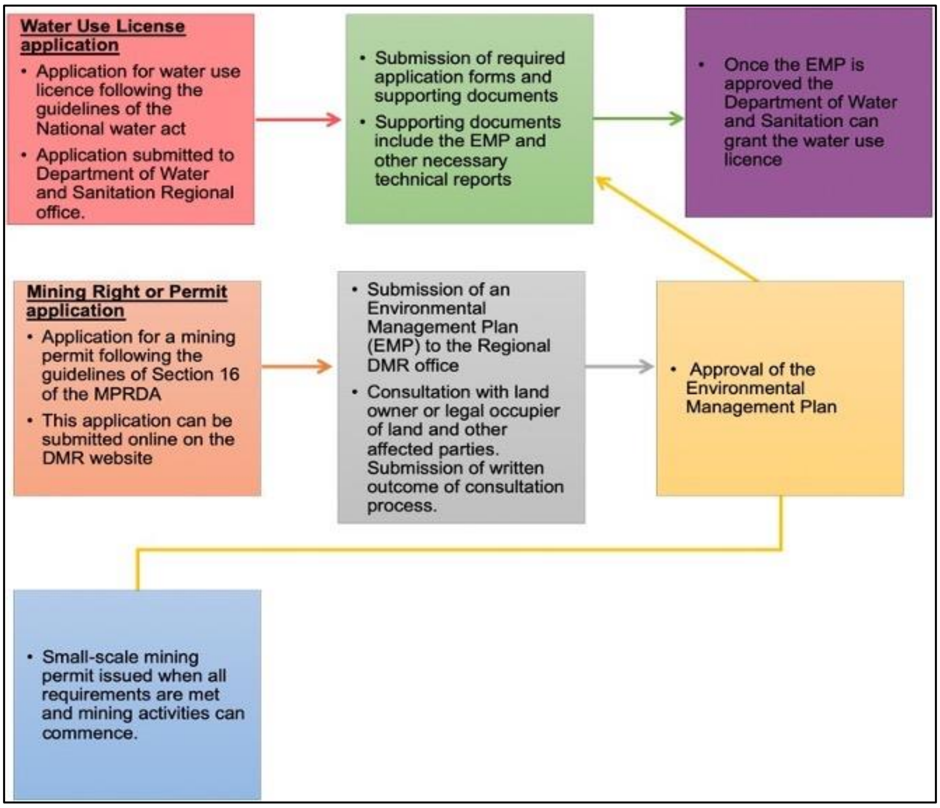

Figure 2.5: Process of acquiring an ASM licence in South Africa. Source: Department of Water Affairs and Forestry (2006); Ledwaba & Nhlengetwa, (2015)

Experts believe that South Africa falls short in the recognition of the ASM sector, and provision for the sector in the mining legislation. They express that the MPRDA is tailored more for large-scale mining, and there is no official legislation for ASM. Ledwaba & Nhlengetwa (2015) wrote that the MPRDA is structured to limit the growth of the ASM sector. They added that specifications of the 5ha of land permissible for ASM and the short validity of the mining permits stunt the growth of the sector. Hoadley & Limpitlaw (2002) also identified the same shortfalls in the legislation.

c. The Mining Cadastre

The South African Mineral Resources Administration System (SAMRAD) is the portal used to capture mining licence applications and the mining cadastre. During the time of this research, the author made several attempts to register as a user on the SAMRAD portal. However, the system was non-responsive. This gives an indication of poor functionality. The transparency of SAMRAD has been brought into question many times over the past years. In 2017, Creamer Media reported allegations of corruption and maladministration. This was revealed by an NGO called Corruption Watch. The SAMRAD system was identified as a weak link in the process of mining licence applications (Creamer, 2017). Kolver (2013) added that the South African mining cadastre system has had a negative impact on investment in the sector.

d. The ASM value chain.

Figure 2.6 shows that the weakest links of the South African ASM value chain are exploration and feasibility. The legislation of mining exploration can be found in the MPRDA. However, there is little to no information from other sources to guide ASM exploration and feasibility. The lack of information can cause ASM operations to bypass these stages.

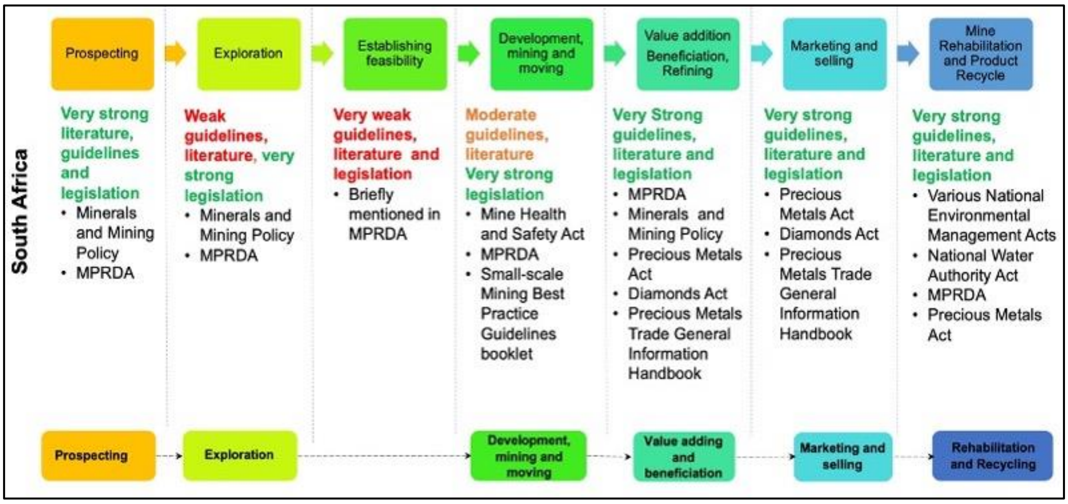

Figure 2.6: The ASM value chain for South Africa (author’s interpretation).

2.2.3 Brazil

Brazil currently contains the highest number of ASM operations in Latin America (IGF, 2017). The sector is concentrated in the Amazon region and is estimated to provide direct employment to about 467 500 people (MMSD, 2002; IGF, 2017). Gold is the most popular commodity in the Brazilian ASM sector as it accounts for 73% of the mineral revenue. About 43% of the workforce (approximately 200 000 people) are gold miners. The second largest commodity in production in the ASM sector are diamonds, which make up 11% of the mineral revenue. Diamonds are followed by cassiterite, a mineral used to produce tin, which makes up 10% of the mineral production (Sousa, et al., 2011).

a. The Definition of ASM in Brazil

The Brazilian mining legislation provides a definition for artisanal and small-scale mining. The country refers to ASM interchangeably as artisanal mining or small-scale mining (ICLG, 2019b). It does not differentiate between the two terms like Zimbabwe and South Africa. Brazil defines ASM as: *“a rudimentary form of mining carried out in deposits of a specific type by means of self-sustained individual* *labour only"* (Mathis, 2012). In the year 2008, the definition of ASM was broadened to include the following:

- Individual workers, family working groups, partnerships, labour associations and cooperatives; and
- Operations which conduct the processing of tailings deposits (Mathis, 2012).

b. The Legal Framework

The Federal Constitution of 1988 recognizes legal ASM operations as a formal economic activity and a lawful, valid sector in mineral exploitation. The sector is governed by The Mining Code (Act 227), which is administered by the Ministry of Mines and Energy. The country also has additional legislation that governs environmental compliance (Mathis, 2012). According to the Brazilian Mining Code, the mineral resources can only be exploited by Brazilian nationals or companies registered under the Federal Law (Olivera, 2014).

What stands out about the Brazilian Mining Law is that it has components that are tailored specifically for the ASM sector (Mathis, 2012). This legislation is known as the Garimpogen Law (Hentschel, Hruschka, & Priester, 2003). The law requires artisanal and small-scale miners to apply for a document known as an Artisanal Mining Permission, which was initially set up for mining cooperatives. In addition to this, the Federal Constitution created a system of demarcating Artisanal Mining Reserves. This system allows for specific surface areas to be set aside exclusively for ASM (Mathis, 2012). The process that needs to be followed to obtain a mining permit is shown in Figure 2.7.

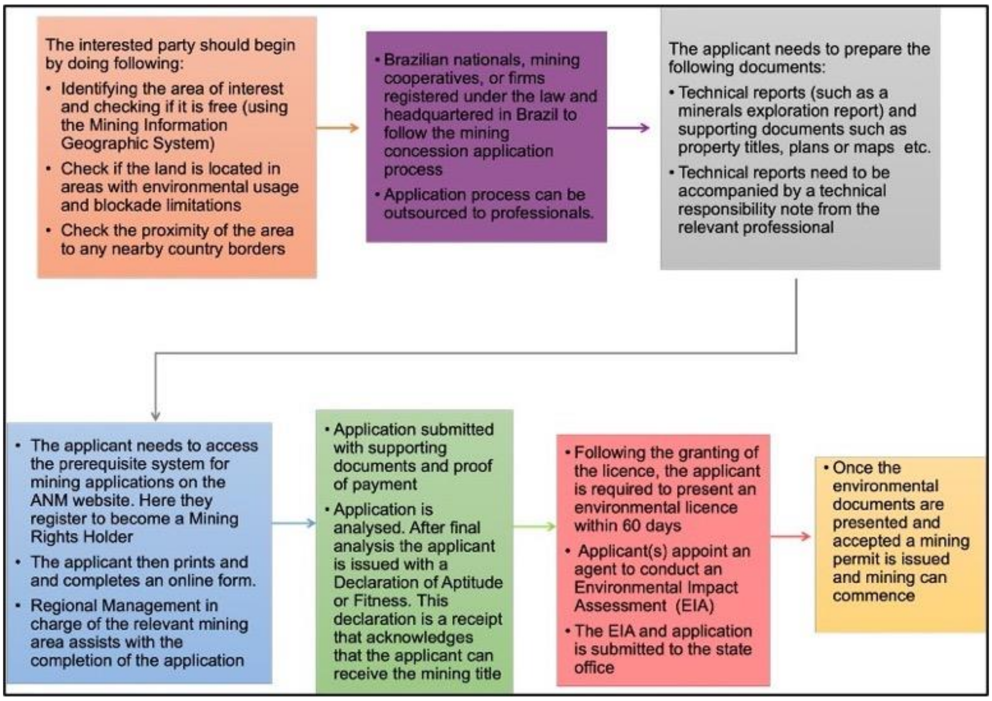

Figure 2.7: Procedure of acquiring an ASM permit in Brazil. Source: ICLG (2019b); Sousa R. et al., (2011); Olivera (2014); Agência Nacional de Mineração, (2020a).

In Brazil, the mining surface area for individuals is restricted to 50ha, whereas the area for cooperatives is unrestricted[13]. Mining permits are issued to ASM operators, these permits are valid for 5 years (for areas less than 50ha) and are renewable thereafter (Olivera, 2014; Mathis, 2012). The permits are issued on a first-come-first-served basis (Sousa, et al., 2011).

c. The Mining Cadastre

The National Mining Agency (Agência Nacional de Mineração or ANM) is responsible for regulating mining activities in Brazil. To facilitate the accesibility of mining information and legislation, the agency has created an electronic cadastre which can be accessed on the AMN website. The portal allows one to obtain spatial

[13] The Brazilian Federal Constitution Mining Law promotes cooperatives in the ASM sector. According to Olivera (2014), a maximum of 10 000 hectares is allowable for a mining claim depending on the type and location of the mineral deposit.

information about mining areas of interest (although the information is not updated in realtime). The ANM website is a well equiped ‘one-stop-shop’ for any potential investor or applicant. The website goes as far as providing detailed cost information about the application process, a practial guide for potential investors, as well as a registry of verified consultants that can assist interested individuals with the application process and technical work (Agência Nacional de Mineração, 2020a and b).

Although Brazil has many systems in place to guide ASM, the country has been criticized for lacking the capacity to execute the actions on the ground. According to Sousa (2011), the parties that are responsible for assessing and processing mining applications are so under 2resourced and understaffed that they are only able to issue tens to hundreds of permits out of the thousands of applications recieved on an annual basis. This backlog is one of the issues that discourage people from applying for licences.

e. The ASM value chain

Figure 2.8 shows that the Brazil ASM value chain is the strongest in the prospecting, mine development and mining, and rehabilitation phases. Although Brazil is well known for the promotion of mercury free gold processing, the country does not have specific Acts that govern the processing or beneficiation of minerals. There are also no specific regulations or guidelines on the marketing and selling of minerals. Brazil allows legally operating artisanal and small-scale miners to trade their products directly with the tertiary market without any special licences.

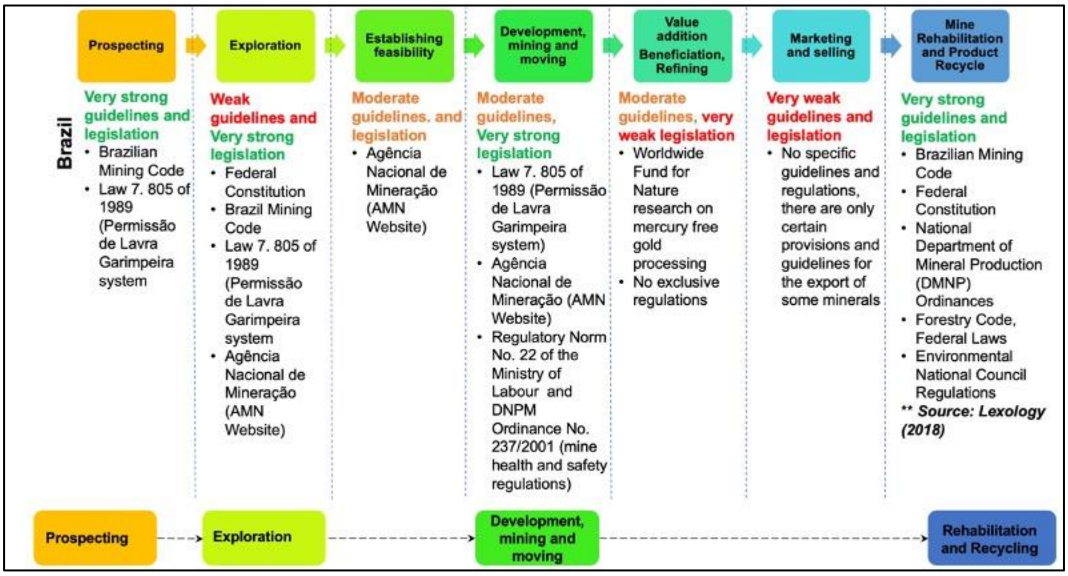

Figure 2.8: Strengths and weaknesses of the Brazil ASM value chain (author's interpretation).

2.2.4 Ethiopia

In the Ethiopian economy, the artisanal and small-scale miners are the biggest generators of mineral revenue. In the past, it was estimated to have produced 65% of the mineral revenue in the country. ASM is estimated to employ at least 1.26 million people directly and support the livelihoods of more than 7.5 million people[14] (EEITI, 2016). Approximately 60 to 70% of the artisanal and small-scale miners focus on the extraction of gold (IGF, 2017; Beyene, 2014). One of the positive aspects of Ethiopian ASM is that it does not make use of mercury or other harmful chemicals in the extraction of gold (Beyene, 2014).

[14] Some sources such UNECA indicate a lower number of direct employees. However, the Ministry of Mines and Energy provides a similar number (which is in the region of a million people).

a. The Definition of ASM

The Ethiopian Mining Proclamation provides three categories and definitions for ASM which are: artisanal mining, small-scale mining, and special small-scale mining. The Proclamation defines artisanal mining as *"any mining operation carried out by individuals or small micro enterprises that are mostly of a manual nature and does not involve the engagement of employed workers"* (ICLG, 2019a). On the other hand, small-scale mining opperations are required to fit into one of the below categories:

- Operations that produce an annual run-of-mine that is less than 100 000 m^3 for silver, gold, platinum, semi-precious minerals and other precious minerals;
- Operations with a production that does not exceed 75 000 m^3 for copper, lead, nickle and iron (metallic minerals); and
- Open pit and underground mines that do not produce more than 100 000 and 75 000 tonnes of ore respectively (Hindeya, 2012; ICLG, 2019a).

Special small-scale mining is described as a mining activity that is carried out by individuals working for, or owning, small and micro-enterprises. These individuals are required to be in possession of a valid ASM licence. They are also required to have adequate financial resources, and the ability to use modern mining technology (Beyene, 2014; EEITI, 2016).

b. The Legal Framework

The mining industry of the Federal Democratic Republic of Ethiopia is governed by the Mining Proclamation 678/2010. The government enacted the mining legislation through the Ministry of Mines and Energy, and government agencies such as the Ethiopian Geological Survey (FAO, 2010). The former is responsible for regulating the minerals sector and allocating licences, while the latter is responsible for conducting exploration activities, geological mapping, and other necessary activities that are related to geology. The government has also delegated Regional Licensing Authorities to assist with the administration of ASM concessions (Ministry of Mines and Energy, 2009a). The sector is required to abide by the country's health and safety, environmental protection, and mining tax laws[15]. The refining and trade of minerals is governed by the Transactions of Precious Minerals Proclamation (Ministry of Mines and Energy, 2009b; Ministry of Mines and Energy, 2009a).

Over the years, Ethiopia has made legislative changes to favour the development of ASM. Some of the most distinct amendments are the acknowledgement of women in mining, and the promotion of affirmative action in ASM. The government also established an artisanal and small-scale mining Directorate to administer all issues of ASM. Regional authorities have been set up across the country to give the sector legislative and licensing accessibility (Beyene, 2014; Ministry of Mines and Energy, 2010). Even though the government has put in great effort to transform legislation, there is the challenge of implementing the legislation on the ground (EEITI, 2016).

In Ethiopia, the people interested in conducting ASM can either apply for an artisanal mining licence or a small-scale mining licence. Artisanal mining licences are issued exclusively to Ethiopian nationals. They do not require the applicant to have financial resources or any technical and professional competency. However, small-scale mining licences require the applicants to demonstrate financial

[15] Additional laws are the Environmental Impact Assessment Proclamation, Mining Income Tax Proclamation (EEITI, 2016)

capability and the ability to commission the use of modern mining equipment. The licence application process is shown in Figure 2.9.

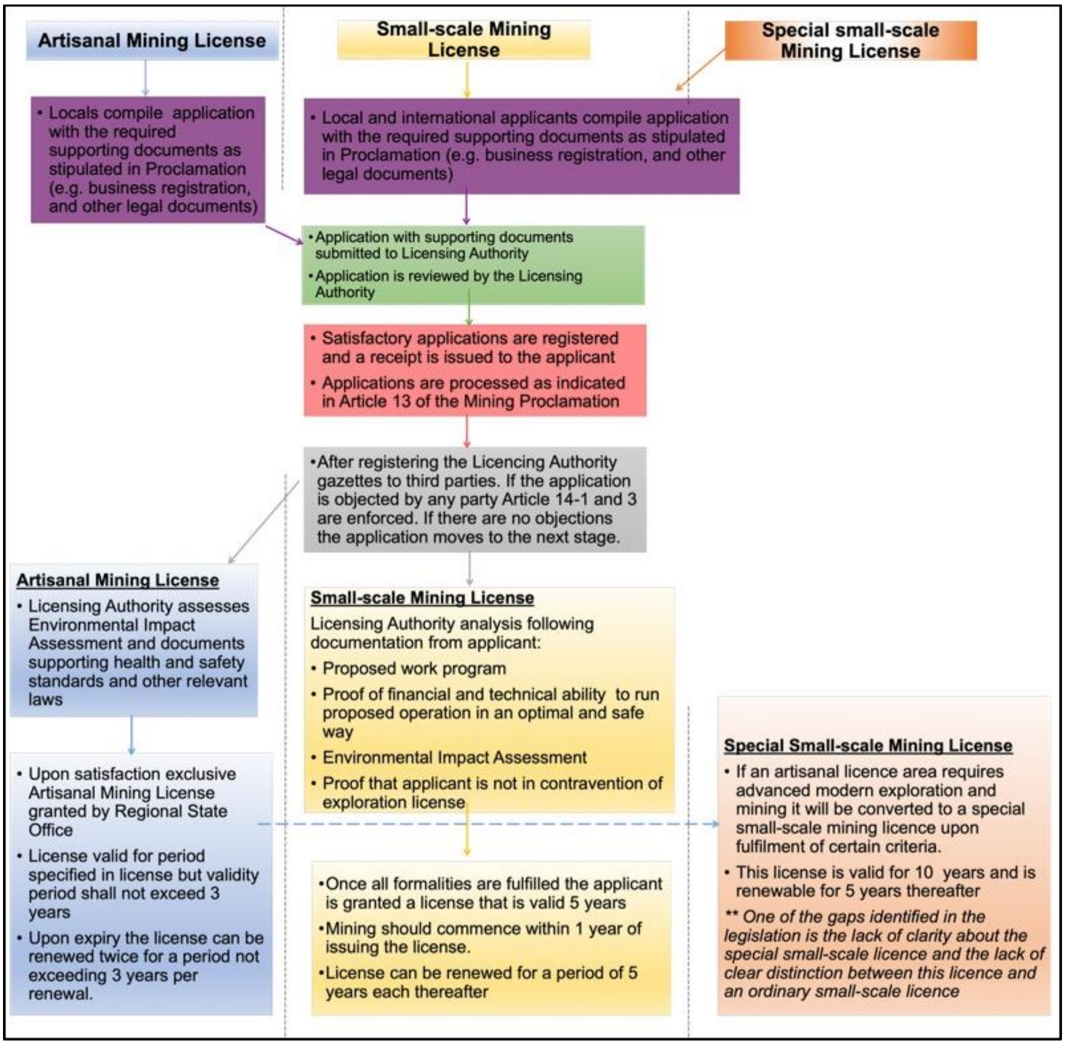

Figure 2.9: Procedure of acquiring ASM licences in Ethiopia. Source: Mining Operation Proclamation No.678/2010

In the current issuing of licences, small-scale mining takes preference over artisanal mining. The Licensing Authority reserves the right to revoke an artisanal licence at any time (with a 90-day written notice) if it views the deposit as one that requires advanced exploration and mining. In such a case, the Licensing Authority would allocate a new area for the artisanal miner and determine a fair amount of compensation for the loss incurred. If the artisanal miner can prove that they are able to explore and exploit the orebody using the advanced methods prescribed by the Licensing Authority, they will be given preference in the licensing process (Ministry of Mines and Energy, 2010). The Mining Proclamation does not specify the land area that is allocated for each licence, however, it does state that the maximum allowable area for a certificate of discovery is 1000ha.

c. The Mining Cadastre

The Mining Operation Proclamation of Ethiopia states that mining rights are registered on an electronic mining cadastre. The country uses the FlexiCadastre system which is a mineral rights management system that was developed in 2003 by a World Bank-funded project (IGF, 2017). This system is easily accessible and can be viewed on a user-friendly on-line portal. The opening page of this portal provides a step-by-step guide (that includes a video tutorial) on how to use the website. Information such as the mapping of licences can also be viewed without registering as a user.

d. The ASM Value Chain

The Ethiopian ASM value chain is weak in the phases of feasibility, mine development and mining (as shown in Figure 2.10). There are very few mining and safety regulations in the Proclamation. Like the other countries, even though legislation on exploration is sufficient, there is very little information and literature to guide the conduct of exploration and feasibility studies. Ethiopia has well thought-out marketing and selling strategies for the trading of gold. Some of the strategies include incentivizing regional traders who purchase gold from the ASM operations. This system was established to maximize transparency and curb the illicit trading of gold (Beyene, 2014; Ministry of Mines and Energy, 2010).

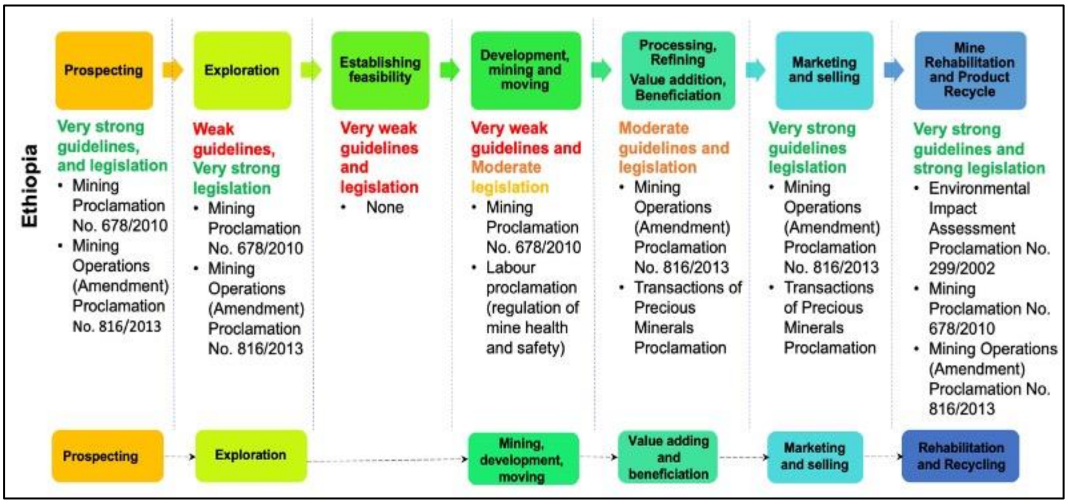

Figure 2.10: Strengths and Weaknesses of the Ethiopian ASM value chain (author’s interpretation).

2.2.5 Pakistan

In Pakistan the non-energy minerals considered to be the most valuable are gold, copper, iron, and gemstones (Shah, 2018). Gold is predominantly found inside rivers and on riverbanks in the form of placer deposits. Gold mining commonly takes place using basic methods such as panning (Rare Gold Nuggets, 2015).

In Pakistan, mining is largely carried out by the ASM sector (Ministry of Petroleum and Natural Resources, 2013). The country is estimated to have more than 50 000 mines, which operate as Small and Medium sized Enterprises (SMEs). These mines provide direct employment to about 450 000 people (Shah, 2018; IGF, 2017). Small-scale mining in Pakistan is conducted by individual entrepreneurs, partnerships, associations, and on some occasions, private companies (Ministry of Petroleum and Natural Resources, 2013).

a. The Definition of ASM in Pakistan

Pakistan is a Federal Republic that is made up of four provinces and applies a decentralized form of governance. The mining sector is complex because each province governs its mineral resources according to its own laws (Rare Gold Nuggets, 2015). This has resulted in different definitions for small-scale mining accross the provinces. This report focuses only on the legislation of the Punjab province because out of the four provinces, Punjab contains the most information, and offers the most learnings about the ASM sector.

In the Punjab Province, the Minerals Policy of 2018 does not explicitly define small-scale mining. However, it states that small-scale mining licences are only awarded to mining projects that have a capital investment that is no more than PKR 500 million (roughly USD 32 000). The Policy further states that this form of mining can either be mechanized or non-mechanized. According to Pakistan's mining Act , the maximum size of the areas that small-scale mines can occupy are as follows :

- 50 acres for precious and semi-precious gemstones;
- 200 acres for industrial minerals and dimension stones;
- 500 acres for fuel minerals and metallic minerals; and
- 3 000 acres for construction materials excavated for the cement industry (PAKP, 2017).

b. The Legal Framework

In Pakistan, the Mines and Oilfields Development Act of 1948 is the main legislation that governs the issuing and the management of mineral rights. The Constitution of Pakistan states that provincial governments control the mineral resources in their provinces except for nuclear gas and energy, nuclear minerals and oil, which are controlled by the central government (Ashraf, 2017). The provinces are responsible for administering this Act. In addition to the main Act the provinces can also develop their own mining legislation, regulations, and policies[16]. The provinces regulate the exploration, the development and the safety of the mineral resources via the Director General of Mines and Minerals (Maluka, 2017; Ashraf, 2017).

The National Minerals Policy of 2013 separates the mining titles of small-scale miners from those of large-scale operations. The titles applicable to small-scale mining opperations are mining permits or leases. Mining permits are issued on a first-come-first-served basis for small-scale mines. Small-scale mining is reserved for Pakistan Nationals but this also depends on the laws of the various provicial government (Ministry of Petroleum and Natural Resources, 2013).

The process of obtaining a lease usually begins with the application of a prospecting licence. This application is submitted at the Regional office. The prospecting licence can be converted to a mining permit at a later stage. A small-scale mining permit in Punjab is valid for 30 years. The Punjab Concessions Rules[17] outline the process (which is summarised in Figure 2.11). The Conssesions Rules document also shows the required application fees, and minimum bank balance that should reflect in the financial documents of the applicant.

[16] This often results in too much much legislation which is scattered around the country in the form of various public notifications (Ashraf, 2017).
[17] Procedure for grant of the Mining Concessions of Small- Scale Mining under Punjab Mining Concession Rules 2002.

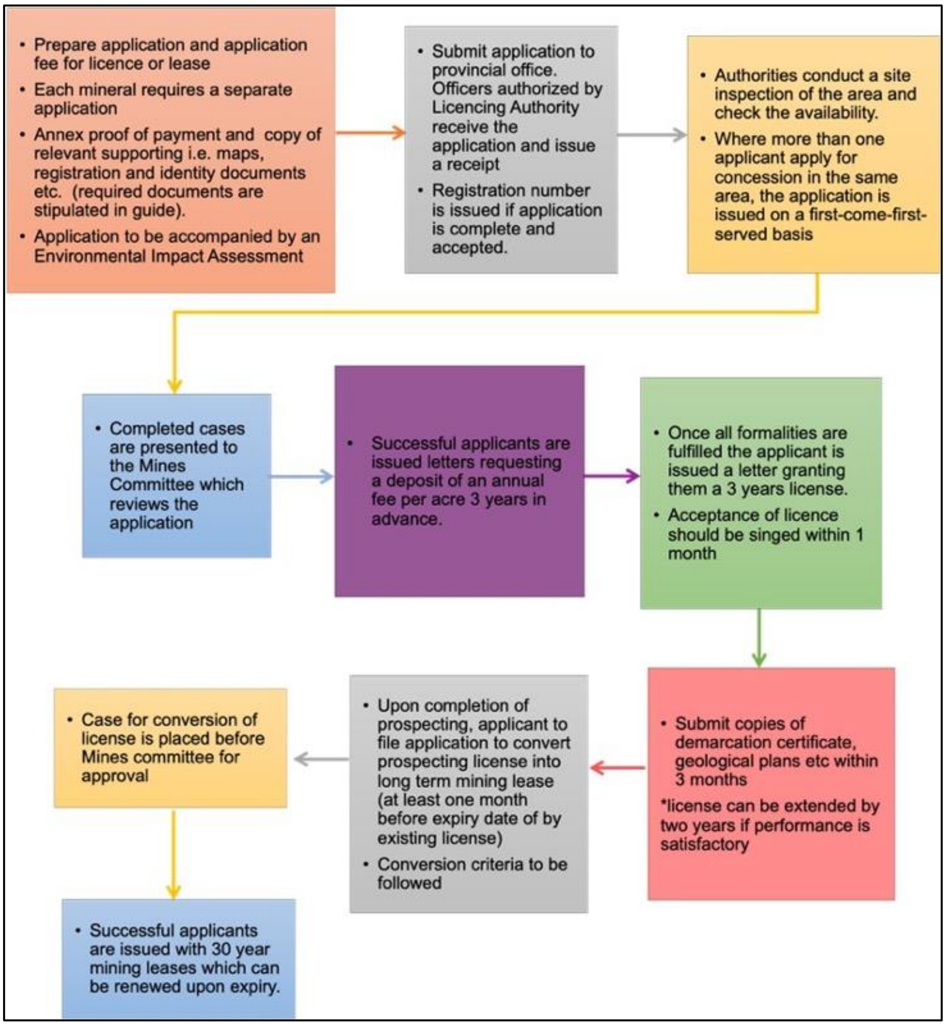

Figure 2.11: Procedure of acquiring a small-scale mining licence in Punjab - Pakistan. Source: Punjab Government (2002).

c. The Mining Cadastre

According to Ashraf (2017), Pakistan does not have a Mining Cadastre System. In his thesis, Ashraf developed a cadastre system for the country, and wrote about the requirements and importance of this system.

d. The ASM value chain

The strongest links in the Punjab ASM value chain are prospecting, exploration, and mining. Punjab province is leading in the exploration stage of the value chain. The province has a state-owned company, which promotes and assists with coal exploration. The province also has a mining exploration and development fund to assist the small-scale mining sector. The country does not have any clear-cut legislation related to the processing, beneficiation and sale of minerals

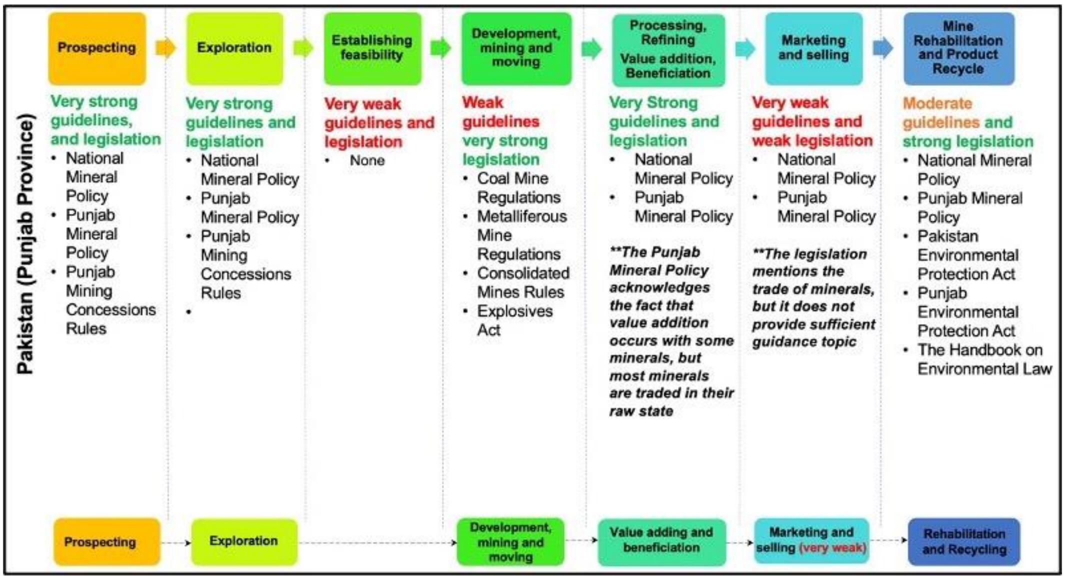

Figure 2.12: ASM value chain for Punjab province – Pakistan (author's interpretation)

2.3 Comparative Analysis

This section of the report compares the key findings from each country. It identifies lessons that can be drawn from the country definitions and legislations, it also identifies gaps that exist within the general ASM value chain. These comparisons are summarized in

Annexure 2 and Table 2.3.

2.3.1 Definition of ASM

Lesson 1: The separation of the artisanal mining and small-scale mining definitions, and the inclusion of these separate definitions in the mining legislation.

An important learning that was drawn from the country definitions was the separation of the terms artisanal mining and small-scale mining. Three out of the five countries (i.e., Zimbabwe, South Africa, and Ethiopia) have separated the two terms and given each a separate meaning. South Africa and Zimbabwe consider artisanal mining to be a subsidiary of small-scale mining. While Ethiopia has divided artisanal mining into further sub-categories. A second learning was the inclusion of these definitions in the mining legislation. Two of the 5 countries (i.e., Brazil and Ethiopia) include the definitions of artisanal mining and small-scale mining in the legislation.

2.3.2 ASM Legislation

Lesson 2: The recognition of ASM in main legislation and the development of subsidiary legislation exclusively for ASM.

Brazil and Ethiopia are the only countries that mention and officially recognize ASM in the primary mining legislation. These countries go as far as recognizing the sector and its importance in the federal constitutions. These countries have also developed auxiliary legislation that focuses only on ASM.

Lesson 3: (a) Different licences and licencing processes for LSM and ASM, (b) A clear distinction between the licences and licencing procedures of artisanal mining operations and small-scale mining operations

Lesson 4: The allocation of reasonably sized land for artisanal mining and small-scale mining, a clear indication of this information in the legislation.

Lesson 5: Realistic time frames for licence durations. A clear indication of this information in the legislation.

All five countries differentiate between the mining licences required by large-scale mines and small-scale mines. Each country has specific licences that are issued to ASM applicants. However, Ethiopia has gone further by differentiating between artisanal mining licences and small-scale mining licences. Artisanal mining applicants follow a more simplified application process and require fewer supporting documents compared to small-scale mining applicants. In this country, an artisanal mine can be converted into a small-scale mine by following a process specified in the Mining Proclamation. Ethiopia and Brazil provide the most realistic time (between 3 and 10 years) for the validity of ASM licences and the most reasonable land sizes (1000 ha and 50 ha respectively).

Lesson 6: User-friendly and resourceful electronic mining cadastre and repository systems with online applications, tracking and payment options.

Brazil and Ethiopia appear to have the most resourceful online mining cadastre and repository systems. A superior feature of Brazil's system is the database of verified professionals that can assist applicants with the necessary technical work. Ethiopia's system is outstanding because information accessibility is not limited by registration, and it provides a vast amount of useful information.

In most of the countries, the mining application forms can be found online, however these forms need to be printed, filled in and submitted manually to either regional or national offices. This physical process is a significant gap in this modern day and age, and it could also be a major bottleneck in the licence application process.

2.3.3 The Value Chain

This section compares the value chains of the 5 countries. It also discusses the gaps that were identified in the value chains. The comparative analysis is shown in Table 2.3.

Table 2.3: Comparative analysis of the artisanal and small-scale mining value chains

	Prospecting	Exploration	Establishing Feasibility	Developing, mining and moving	Processing, Refining Value addition Beneficiation	Marketing and selling	Mine rehabilitation and product recycling
Zimbabwe	Very strong	Very weak	Very weak	Very strong	Very weak	Very strong	Very strong
South Africa	Very strong	Moderate	Very weak	Very strong	Very strong	Very strong	Very strong
Brazil	Very strong	Moderate	Moderate	Very strong	Very weak	Very weak	Very strong
Ethiopia	Very strong	Moderate	Very weak	Very weak	Very weak	Very strong	Very strong
Pakistan (Punjab)	Very strong	Very strong	Very weak	Very strong	Very weak	Very weak	Very strong
Overall Profile	Very strong	Weak	Very weak	Moderate	Weak	Moderate	Very strong

The overall profile of the small-scale mining value chain shows that it is generally weak in terms of support and legislation. The following gaps were identified in the comparative analysis of the ASM value chains:

Gap 1: A lack of guidelines and information on how to conduct exploration, valuation or determine feasibility for ASM operations

In most of the countries, the knowledge and information gaps lie in exploration (with the exemption of Pakistan's Punjab province) and in determining the feasibility of ASM operations. The comparative analysis shows that ASM operations generally do not evaluate the quality and quantity of the deposits, and they do not determine the profitability of their projects. It appears that most ASM operations just identify the deposit, bypass exploration and valuation, and jump straight into mining. This can come at a significant disadvantage for small-scale miners who require financing or capital investment. Generally, there is very little to no guidance on deeper exploration or valuation techniques for ASM operations.

Gap 2: The lack of information to guide the physical development of artisanal mining and small-scale mining operations.

There is a lack of research about mining methods for ASM. Although Zimbabwe and South Africa have created ASM training handbooks that guide in mine development and the selection of mining methods, there is still a need for more information. The lack of tailored engineering methods and principles for the sector surely fuels the cowboy mining culture.

Gap 3: Lack of regulations to guide the day-to-day running of artisanal mines and small-scale mines.

Some of the countries have very few or no mining regulations to guide the day-to-day running of ASM operations (e.g., health and safety, explosives, transportation regulations etc.). Many of the regulations which exist were made for large-scale mines and they are copied and pasted (with very little to no modification) for ASM.

Gap 4: Lack of legislation that enforces local beneficiation and value addition and discourages premature trading of minerals.

The ASM value chain of the 5 countries is generally weak in the exploration, feasibility, and beneficiation or value addition stages. It is only South Africa (which has the strongest value addition legislation). Although countries such as Ethiopia and Brazil lead the world in the development of mercury-free gold processing technology, the countries do not have legislation that enforces the methods.

Gap 4: Poor trading and marketing of minerals (minerals being sold for less than their fair market price).

In many cases, minerals produced by ASM operations are traded before any value addition can take place. This deprives the local and national economies of revenue. Most of the countries that were analysed have sufficient guidelines on the marketing, selling and the recycling of minerals. Ethiopia's incentivised system of gold trading was identified as a potential leading practice. The final link of the chain (divesting, rehabilitation, and recycling) is one of the strongest as it has sufficient legislation and guidelines across all the countries.

2.4 Conclusion

Chapter 2 shows how different countries define, legislate, regulate, and guide the small-scale mining sector. Three out of the 5 countries that were analysed separate artisanal mining from small-scale mining. This distinction also reflects in the licencing process of some countries. The chapter shows that the mine value chain is applicable to small-scale mining, however, it is weak in the exploration, feasibility, and value adding stages. This chapter also touches on the importance of a modernized mining cadastre. Chapter 3 applies the international lessons drawn from this comparative analysis to Ghana (the country of study).

3 COMPARATIVE ANALYSIS: APPLYING THE INTERNATIONAL LESSONS TO GHANA

3.1.1 The Ghanaian Definition of ASM

Artisanal and small-scale mining in Ghana was initially defined in 1989 by the Small-scale Gold Mining Law (P.N.D.C.L 218). This legislation did not make any mention of the word "artisanal"; it only referred to small-scale gold mining, which it defines as *"the mining of gold by a method not involving substantial expenditure by an individual or group of people not exceeding nine in number or by a cooperative society made up of ten or more persons"*. The current legislation, the Minerals and Mining Act, 2006 (Act 703) does not provide a clear definition for small-scale mining. It vaguely describes the activity as *"a mining operation over an area of land in accordance with the number of blocks prescribed".* The main mining legislation also does not make any mention of the word "artisanal" when referring to the sector. It does not explicitly state the size of land that can be allocated to small-scale mining operations. However, the information about the land area was obtained from research conducted by Appiah (1998), and the ASM Handbook for Ghana (2017). This literature specifies that the maximum allowable area for a small-scale mining concession is 25 acres. Hilson (2001), who conducted extensive research about ASM in Ghana stated that licenced gold ASM operators usually employ 5 to 20 groups of people, and each group consists of 5 to 10 workers.

3.1.2 The Legal Framework of ASM in Ghana

The Ghanaian mining industry is primarily legislated by the Minerals and Mining Act 2006 (Act 703)[18] and the Minerals Commission Act 1993 (Act 450) (ICLG,

[18] This Act was amended in the Minerals and Mining (Amendment) Act 2015 (Act 900)

2019c). According to the Ghanaian Constitution and the Minerals and Mining Act, the minerals of Ghana are the property of the Republic, and they are bestowed upon the President. The legislation also states that small-scale mining is reserved exclusively for Ghanaian nationals, who are over the age of 18.

The Ghana Minerals Commission is the governing body that is responsible for administering the mining legislation, managing the country's mining industry, and coordinating relevant policies. The Minerals Commission conducts its responsibilities under the authority of the Ministry of Lands and Natural Resources. In addition to the Constitution and the Minerals and Mining Act, the following laws have been enacted to regulate the small-scale mining sector:

- The licencing, compensation and settlement, explosives, health safety, technical and general mining regulations, which regulate the establishment and the day-to-day running of the operations (ICLG, 2019c);
- The Precious Minerals Marketing Corporation (PMMC) Law, which regulates the trading or sale of precious minerals (i.e., diamonds and gold) sourced from small-scale mining (Minerals and Mining Policy of Ghana , 2014);
- The Mercury Law, which regulates the use of mercury in the small-scale gold mining operations (Eshun & Okyere, 2017);
- The Water Resources Act and the Water Use Regulations (Minerals and Mining Policy of Ghana, 2014) 7;
- The Environmental Protection Agency Act 1994 (Act 490) and the Environmental Assessment Regulation, which are administered by The Environmental Protection Agency (Akafia, 2019).

The country currently does not have legislation that focuses explicitly on the small-scale mining sector. The Minerals and Mining Act is applicable to both large and small-scale mining. Ghana does however have an ancillary guideline or strategy for the small-scale mining sector. It exists in the form of the Minerals and Mining Policy (published in November 2014). This policy focuses on supporting and encouraging the sustainable development of the small-scale mining industry.

According to the Minerals Commission, there are five different types of mineral rights which are issued in Ghana. Amongst them is the small-scale mining licence, which is reserved exclusively for Ghanaian nationals (Minerals Commision Ghana, 2019). Figure 3.1 shows the process that is followed to acquire a licence for small-scale mining.

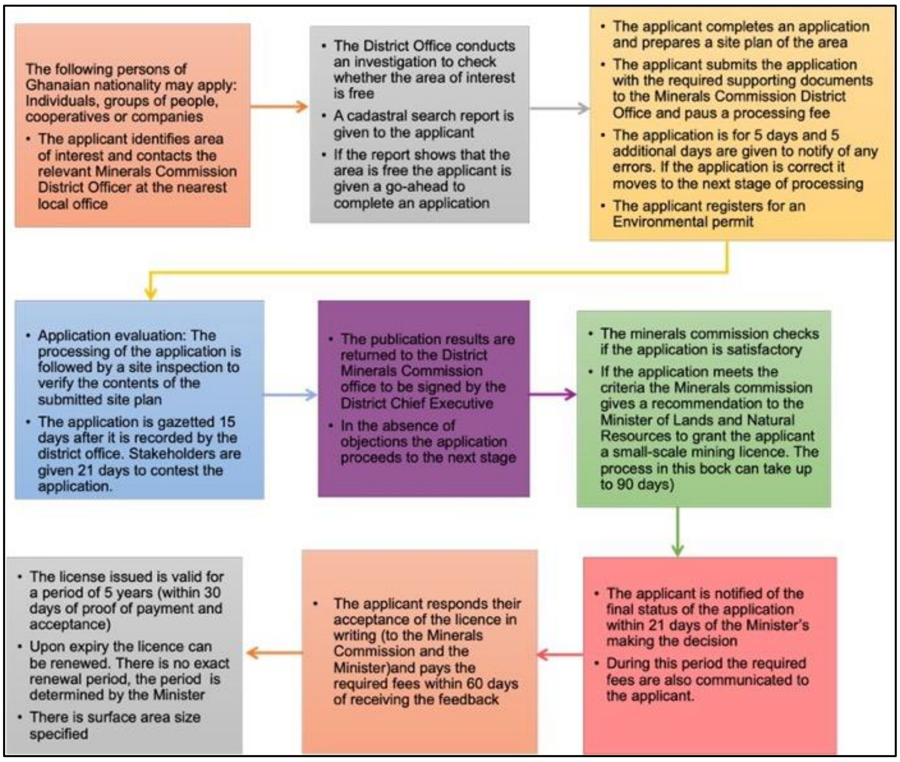

Figure 3.1: Process of acquiring a small-scale mining licence in Ghana. Source: Ghana News Agency (2016); Minerals and Mining Act 2006 (Act 703); Minerals Commision Ghana (2019); Tychsen, et al., (2017)

Figure 3.1 shows that small-scale mining licences are issued by the Minister of Lands and Natural Resources by the recommendation of the Minerals Commission. To make licensing and regulations accessible to the locals, the Minerals Commission assigned district offices to the various mining areas to assist with the applications. However, despite Ghana's efforts to decentralize the application process, most operations continue to function outside the regulatory framework. It is said that this is due to the difficult, expensive, and time-consuming process of obtaining a licence (IGF, 2017). According to Debrah et.al (2014), just over 300 operations are registered with the Minerals Commission. On the 8th of February 2020, the Ghana online Mining Repository showed that only 211 small-scale licences had been issued, of which 47 are active. The system also showed that 213 small-scale mining applications had been submitted as of the 8th of February 2020 (as shown in Figure 3.2). This information verifies the fact that only a small fraction of Ghanaian small-scale miners operates within the legal boundaries.

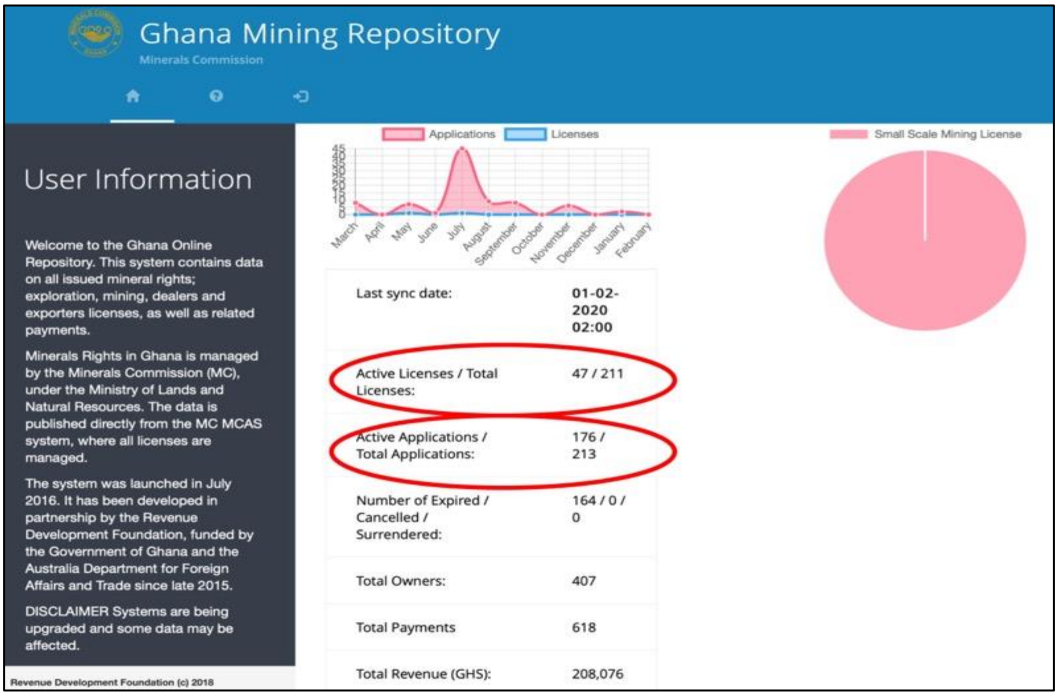

Figure 3.2: Number of small-scale mining licences and applications in Ghana. Source: Ghana Minerals Commision (2020)

Ghana currently utilizes an online web-based portal (shown in Figure 3.2), referred to as the Ghana Mining Repository, to report the data that is captured in the Mining Cadastre. The system is user friendly and easily accessible. Basic information, such as the number of licences issued, can be obtained by unregistered users whereas more detailed information requires user registration. The administration system allows one to conduct a cartographic search of registered large and small-scale licences and permits. It also allows for the online registration of mineral licences and the tracking of applications. The system was launched in the year 2016 with the objective of improving transparency, compliance, efficiency and reducing conflict and corruption related to mineral tenure (Geospatial Media, 2016).

Unfortunately, despite all these efforts, Ghana has been criticized for the inadequate enforcement of small-scale mining legislation on the ground. According to a report published by the International Institute for Sustainable Development (2017), one of the main regulatory issues in the small-scale sector is the Minerals Commission’s lack of enforcement.

3.1.3 The Small-scale Mining Value Chain in Ghana

A positive aspect about small-scale mining in Ghana is the amount of valuable literature that has been written about the sector. The literature on the Ghanaian small-scale mining is significant and more than most of the countries that were analysed in Chapter 2. The mining legislation, regulations, the PMMC laws and the mining policy paint a good picture of the legislative components of the small-scale mine value chain. The Artisanal and Small-scale Mining Handbook of Ghana, which was published in 2017, is a good source of guidance as it gives one a high-level theoretical understanding of how-to setup a small-scale mining operation. The above information enables one to have an idea of the strengths and weaknesses of the small-scale mining value chain of Ghana (as shown in Figure 3.3).

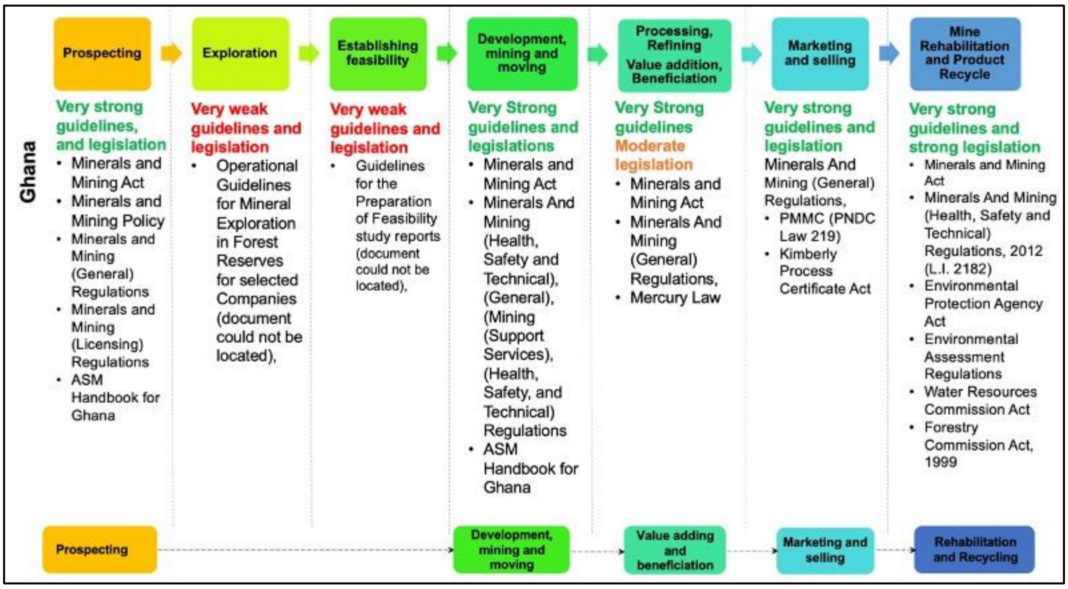

Figure 3.3: Overview of the small-scale mining value chain of Ghana (author’s interpretation).

Like most of the countries that were analysed in Chapter 2, the biggest gaps in this small-scale mining value chain lie in the exploration and feasibility stages. What is unique about Ghana is that the chain is strong in the mining and mine development phase. The country has detailed regulations to guide the day-to-day running of the small-scale mines, it also has good guidelines on small-scale mining methods. Unfortunately, the value chain is quite weak in the value addition or beneficiation phase. This is mainly because the legislation does not enforce local value addition, and it does not discourage the premature trading of minerals. Although the marketing and selling phase appears to be strong, a weak link was identified because the small-scale miners tend to trade their minerals prematurely at any time in the value chain, and they often trade at a lower market value.

3.2 Comparative Analysis

Table 3.1 and Table 3.2 provide a comparative analysis between Ghana and the countries that were analysed in chapter 2. The analysis looks at Ghana’s alignment with the lessons and gaps that were identified in the previous chapter.

Table 3.1: Ghana’s alignment with international lessons learnt.

Definition and Legislation		
Lessons Learnt	**Ghana’s Position**	**Ghana's alignment to international lesson learnt.**
Lesson1: The separation of the artisanal mining and small-scale mining definitions, and the inclusion of these separate definitions in the mining legislation.	Ghana's legislation only refers to small-scale mining. Although Minerals and Mining Policy refers to artisanal and small-scale mining it does not provide a definition for the term. Although both documents provide a definition for small-scale mining, the definition is very vague. The term is very poorly defined compared to the other countries.	Poorly aligned
Lesson 2: The recognition of ASM in main legislation and the development of subsidiary legislation exclusively for ASM.	The primary legislation in Ghana acknowledges small-scale mining but it does not recognize artisanal mining. The country does have subsidiary guide (i.e. the Minerals and Mining Policy) that focuses on the small-scale mining sector.	Partially aligned
Lesson 3(a) Different licences and licencing processes for LSM and ASM.	Ghana issues a small-scale mining licence, which is different from that of LSM.	Well aligned
Lesson 3(b) A clear distinction between the licences and licencing procedures of artisanal mining operations and small-scale mining operations	No. The primary legislation and the Minerals and Mining Policy do not recognize the word "artisanal".	Poorly aligned
Lesson 4: The allocation of reasonably sized land for artisanal mining and small-scale mining; as well as realistic time periods for licence durations. A clear indication of this information in the legislation	The primary legislation, and the Policy do not clearly state the size of land that is allocated for small-scale mining. They only mention a prescribed number of blocks. According to literature, the maximum allowable landsize for small-scale mining in Ghana is 25 acres.	Poorly aligned
Lesson 5: Realistic time periods for licence durations and renewals. A clear indication of this information in the legislation	According to the legislation, small-scale mining licences are valid for 5 years. However, the number of times the licence can be renewed is not specified and it lies at the discretion of the Minister.	Partially aligned
Lesson 6: User friendly and resourceful electronic mining cadastre and repository systems with online applications, tracking and payment options.	Ghana has an online mining cadastre and repository system. The system is the same as that of Sierra Leone. Although this is a great effort, it is not in the calibre of some of the other countries such as Brazil and Ethiopia. More work can be done to improve this system.	Partially aligned

Table 3.2:Ghana’s alignment to the ASM value chain.

ASM Value Chain		
Gaps Identified	**Ghana's Position**	**Does the gap exist in Ghana**
Gap 1: A lack of guidelines and information on how to conduct exploration, valuation or determine feasibility for ASM operations	Similarly to the other countries, Ghana does not have sufficient literature to guide small-scale mines on how to conduct exploration or establish feasibility. The Minerals and Mining Policy document makes reference to two guide lines i.e. the *"Operational Guidelines for Mineral Exploration in Forest Reserves for selected Companies, 1997" and "Guidelines for the Preparation of Feasibility study reports, 2009",* but this these documents could not be located for verification during the literature review for this study.	Yes
Gap 2: The lack of information to guide the physical development of artisanal mining and small-scale mining operations.	Ghana has published an ASM handbook that serves as a guide to aid potential small-scale miners to develop and run their operations. The handbook is a good source of information, however, it is the only source of literature that is available.	Partially
Gap 3: Lack of regulations to guide the day-to-day running of artisanal mines and small-scale mines.	Ghana has impressive legislation and literature to guide the day-to-day running of a small-scale mining operations. The various mining regulations as well as the ASM handbook appear to provide great assistance. Ghana is superior to the other countries when it comes to literature, information and regulations about running a small-scale mining operation.	No
Gap 4: Lack of legislation that enforces local beneficiation and value addition and discourages premature trading of minerals.	Like some of the countries mentioned in Chapter 2, Ghana has developed guidelines to aid in local processing and beneficiation. However, the law does not enforce local value addition.	Yes
Gap 5: Premature trading and poor marketing of minerals (minerals being sold for less than their fair market price	The trading of minerals is regulated by the PMMC. However, due to desperation, the lack of knowledge and the lack of value addition, minerals tend to be traded poorly, below their market value, at the disadvantage of the miners and the local economy.	Partially

3.3 Conclusion

Chapter 3 reveals that Ghana has made significant effort to legislate and guide the small-scale mining sector. However, the country is still not fully aligned to some of the identified international lessons. The chapter also shows that Ghana is experiencing challenges like those of the other countries with the ASM value chain. The value chain is the weakest in the exploration, feasibility, and the value addition phases. A weak link was also identified in the marketing and trading phase. Ghana appears to be stronger than some of its peers when it comes to the development and day-to-day running of the mining operations.

Chapter 4 examines the rationale behind ASM by looking at the application of mining engineering principles to the sector.

4 THE APPLICATION OF MINING ENGINEERING PRINCIPLES TO ASM.

Chapter 4 examines the application of mining engineering principles and theory to ASM[19]. It does this by looking at the steps that are involved in setting up and running a mining project and relates them to the ASM sector. The chapter looks at the activities across the entire mining value chain, and conducts this analysis according to the sequence of events in the chain. Each section begins by giving a theoretical explanation and background of the activity or step. It then moves on to explaining how the activity is conducted in (or should be applied to) ASM.

This chapter is important because it gives a holistic understanding of how ASM should be conducted in theory. It also examines the engineering logic or rationale behind ASM. The information in this chapter is based on existing literature.

4.1 Identifying the mineral deposit

4.1.1 Prospecting

Prospecting is the first step of a mining project, and a component of mineral exploration. Hustrulid (2020) defined it as the *"search for economically exploitable mineral deposits"*. It is the identification of areas which have the highest potential to bare economic mineral resources.

Prospecting can be conducted via conventional methods or modern methods. Prior to the twentieth century, conventional prospecting methods were used to search for indications of mineral deposits. These methods, which are still being practised today, required people to walk around certain areas searching for specific soils,

[19] Mining engineering is the practice of planning and overseeing the extraction of minerals from the ground. This includes evaluating or assessing whether the mineral can be mined profitably and developing techniques to increase the safety and efficiency of mines (Jobs and skills, 2022).

weathered zones, outcrops, and rock types. Today, such inspections still take place, but with the aid of modern techniques and remote sensing equipment (Hustrulid, 2020). Figure 4.1 shows the different conventional and modern prospecting methods that can be used to identify gold and diamond bearing areas.

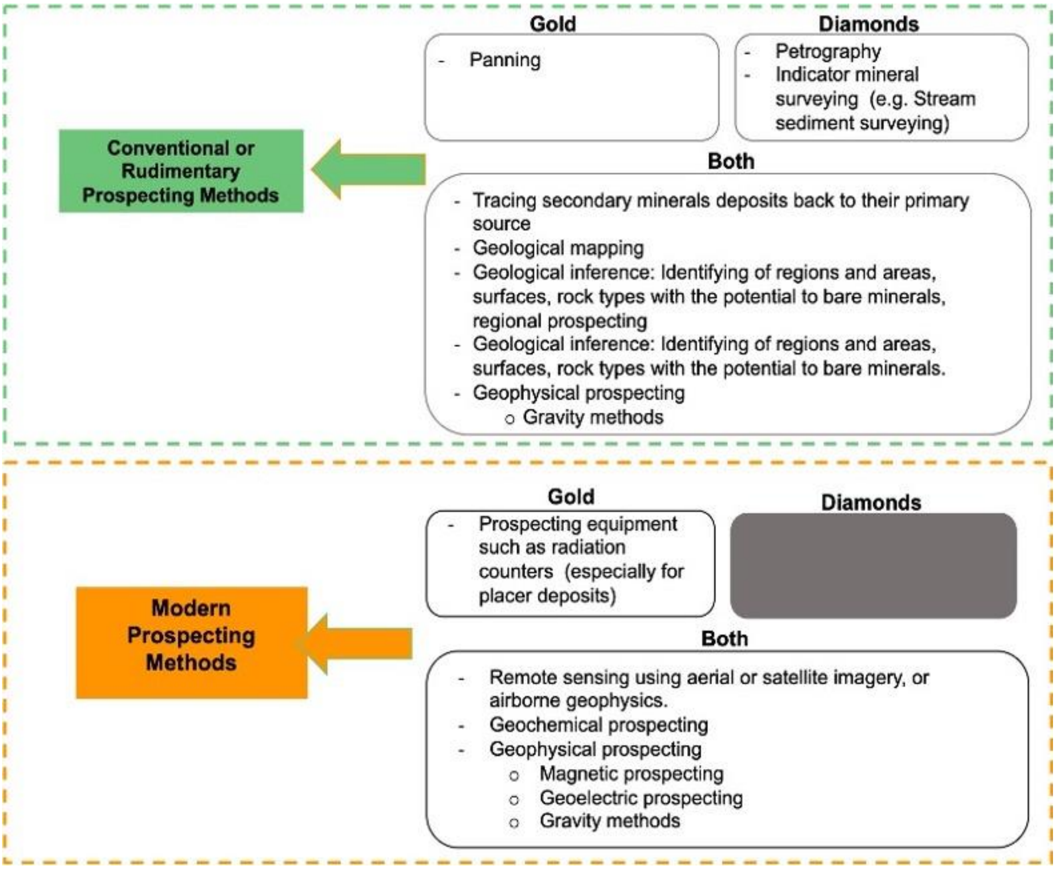

Figure 4.1: Rudimentary and modern prospecting methods. Source: 911 Metallurgist (2017); Shodhganga (2009)

a. The Application of prospecting to ASM.

The emergence of artisanal and small-scale mines in certain areas is usually a sign of mineralisation. ASM miners typically target high unit value minerals that are easily accessible. Areas with high ASM activity draw people and companies, who prompt for further exploration, to the mineralised areas.

The IGF (2017) report on ASM stated that it is common practice for junior miners to follow the trail of artisanal miners. After junior miners locate the mineralized areas, they apply for mining licences. In most cases, once the licence is issued, the junior miners either evict the artisanal miners or force them to mine marginal areas within the concession (IGF, 2017). Figure 4.2 shows the dense concentration of ASM operations trailing for many kilometres west of Obuasi in Ghana. These ‘informal’ kind of trails usually become targets for ‘formal’ prospecting.

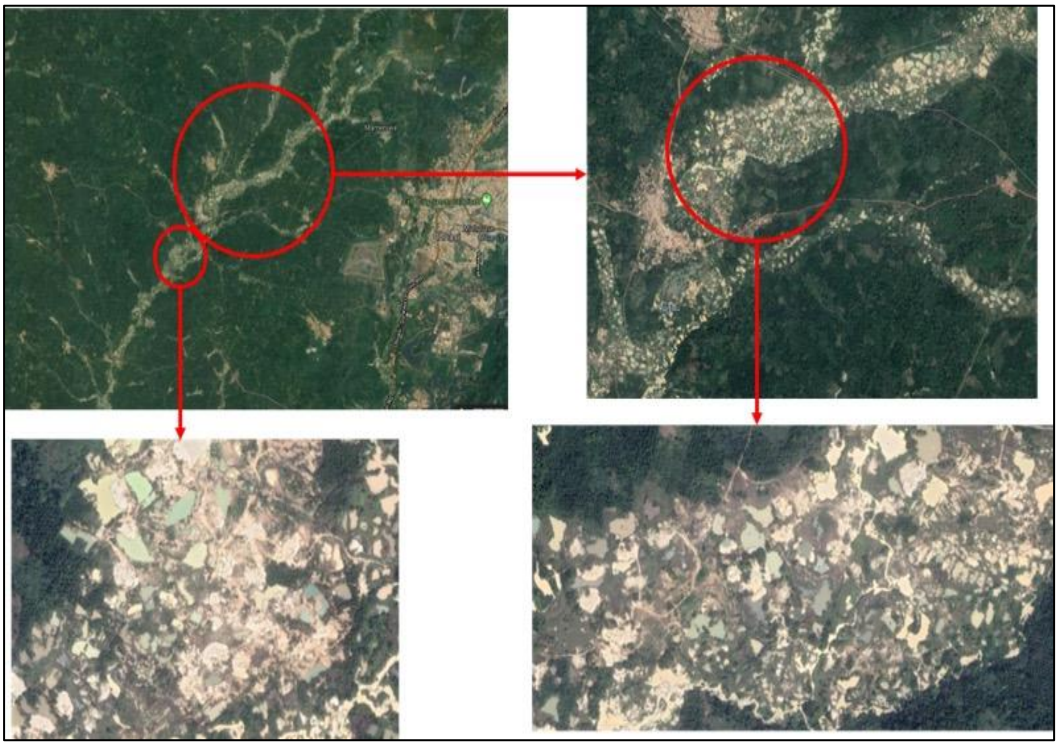

Figure 4.2: Satalite imagiry of ASM mining west of Obuasi (Ghana). Source: Google Maps (2020)

The information in this section shows that in ASM, there is a much larger overlap between mining and prospecting. Also, unlike formal operations, there is no clear distinction between the two phases of the mining value chain in reality.

4.1.2 Exploration

Exploration is the process of collecting high quality geological information to determine the location, extent, and the quality of a mineral deposit (Mero & Clark, 2017). Exploration data enables the project to accurately verify the extent, distribution, orientation, geometric characteristics, and grade of the mineral deposit. Exploration is an important step in establishing a mine, in fact, it is the foundation of any mining project. It produces information that enables the project to determine whether it should continue with feasibility studies and eventually, production (New Pacific Metals, 2018). Without proper exploration, there will be limited knowledge and evaluation of the orebody. This will lead to ineffective projects, and plans that do not deliver the desired outcomes; it will also affect the operation's accessibility to funding[20] (Wits University, 2015).

There are different types of exploration methods available to the mining industry. The method used depends on the type of mineral deposit being pursued and the budget available. Figure 4.3 provides a schematic of the available methods, it also indicates the methods that can be applied to ASM.

[20] To acquire legitimate funding for a mining operation, there needs to be technical information that proves that the operation will be profitable.

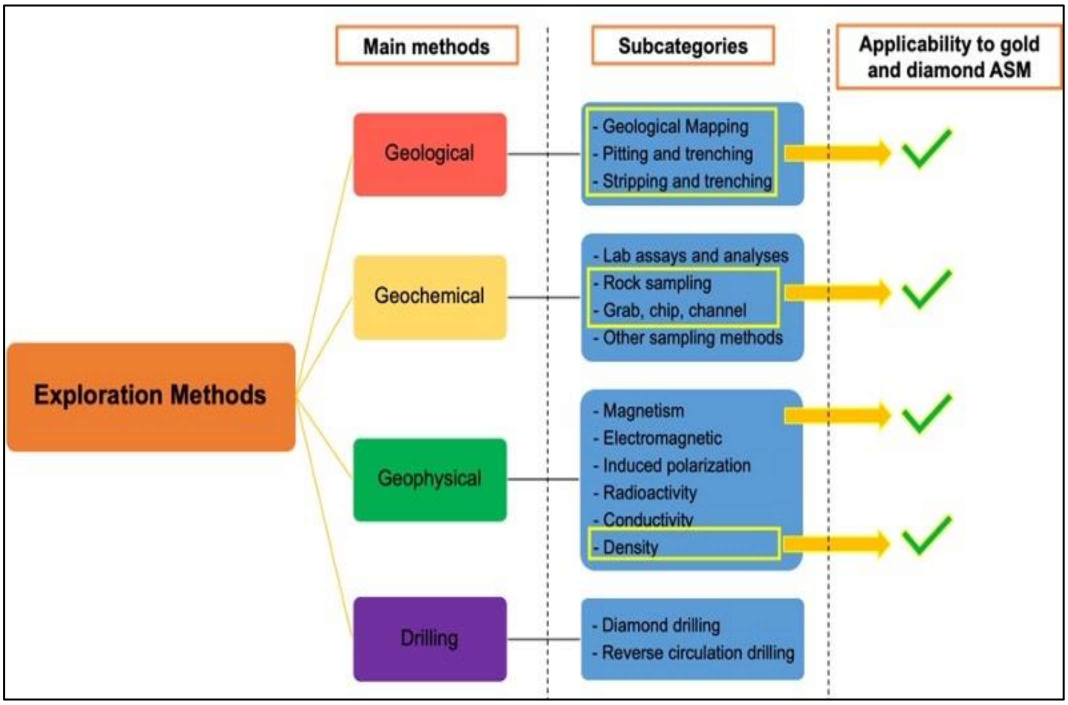

Figure 4.3: Mineral exploration methods. Source: New Pacific Metals (2018)

a. The application of exploration methods to ASM

According to the Artisanal and Small-scale Mining Handbook for Ghana (2017), most informal ASM operators do not conduct exploration and they leave the discovery and value estimation of the minerals to chance. Zimbabwe's Training Handbook for Artisanal and Small-Scale Miners (2019) states that exploration in ASM is limited because it is costly. Exploration is common amongst formal small-scale or junior mining companies. The small-scale miners and junior miners usually lean towards less expensive techniques such as pitting (shown in Figure 4.4), and trenching (shown in Figure 4.5).

Pitting exploration entails digging a series of test pits in a pattern (as shown in Figure 4.4). These test pits are used to collect rock and soil samples, which are analysed either in the field or the lab. Pitting is mostly applicable to shallow lying, flat orebodies, especially placer deposits (Geology Hub, 2017). Whilst this is standard practice for the formal sector during the exploration phase, the ASM sector tends to do it at the reconnaissance stage. Such early physical exposure of the orebody is a strength, and it is little wonder that formal prospecting programmes follow the ASM target identification practices.

Figure 4.4: Pitting Exploration method. Source: Volcanic Goldmines Inc. (2017); Unity Global Mines Group Inc. (2019).

The trenching technique (shown in Figure 4.5) involves the stripping of overburden, followed by the digging a of a trench to expose the underlying bedrock. This method is applicable to dipping orebodies that are located close to surface. Samples of rock are collected from the trench, and once the ground has been exposed, the rock surfaces are mapped to determine the extent of the ore horizon as well as the lithology, structural geology, and other parameters (New Pacific

Metals, 2018). Both the pitting and trenching methods can be conducted using either manual tools, explosives, or mechanical excavators (Geology Hub, 2017).

Figure 4.5: Trenching exploration method. Sources: Force Commodities (2018); CSE Landscape Architect (2012); Geology Hub (2017).

Some ASM operations also apply geological mapping, which is a simple and low-cost exploration technique. It entails a geologist (or someone with adequate geology knowledge and experience) conducting fieldwork to delineate ore bearing rock types, identify structures, and describe the lithology and morphology of the outcrops (Brimhall, Dilles & Proffett, 2005).

Modern geophysical exploration has also been developed and applied to ASM projects. Researchers from the University of São Paulo have made efforts to develop more simplified and inexpensive geophysical exploration methods for small-scale operations. These methods have been successfully applied to some small-scale mines in Brazil (Tichauer et al, 2014).

4.1.3 Sampling

Sampling is another important step in the exploration phase of a mining project. It entails the collection of representative rock samples from the ore horizon to identify likely zones of mineralization. Sampling helps the project to determine the grade and the assay values of the mineralized zones (Ralph, 2005; Pact , 2017; Pramoda, 2017). Figure 4.6 shows the types of sampling methods that are used in the mining sector. It also shows the methods that can be applied to ASM.

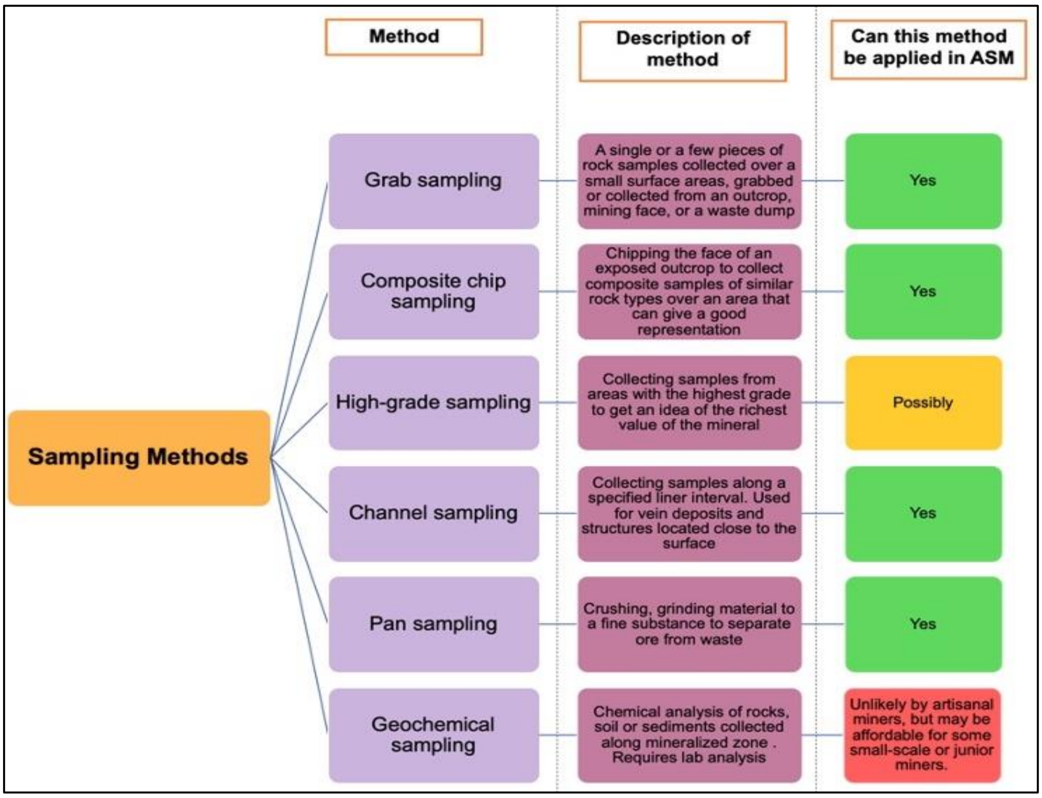

Figure 4.6: Sampling methods and their applicability to ASM. Sources: Pact (2017); Ralph (2005).

a. *The application of sampling to ASM*

Rock samples can either be collected by hand, chipping, or drilling. Hand taken samples are most common in ASM because they are simpler and cheaper. The ASM sector also leans towards sampling techniques that can be conducted in the field rather than in a laboratory. Figure 4.6 shows that almost all the sampling methods can be simplified and applied to ASM.

Sampling requires a certain level of technical knowledge, especially because it involves the application of mineral evaluation principles. According to Mischuad (2016), sampling can be complex because of its reliance on interpretation. This is mainly applicable to high-value placer minerals, which are commonly mined in ASM. The difficulties are introduced by a phenomenon called the nugget effect[21], which can give rise to significant sampling errors (Mischaud, 2016).

The processing of sampling data does not have to depend on technology. There are first principle methods that can be used to conduct basic evaluation calculations, and these can be done by hand. A few examples are average grade calculation, pay limit, and impact of dilution on grade. These calculations have been tried and tested. They are taught to mining engineering students in universities, and they are also used by samplers in mines. The techniques can be taught to any person, who has a basic understanding of mathematics. Although these methods have a low level of confidence, they can be surprisingly accurate, and they can be enough to justify proceeding to the next stage of the mining project.

[21] A nugget effect is a situation where a sample contains a nugget of high-grade material, distorting the value to one higher than the true average (Rapth, 2005). Such errors can be resolved by increasing the amount of samples taken to counterweigh peculiarities within the orebody, taking ‘check samples’, and making adjustments based on experience.

In the process of sampling, the rock types that bear metallic minerals, such as gold, are sent for assaying. In assaying, ore is analysed to determine the composition, purity, and weight of the mineral of interest (Augustyn et al., 2019). Assaying is a highly technical process, and for it to be accurate, it needs to take place in a controlled environment such as a reputable commercial or field lab. While junior miners or formal small-scale mining companies may be able to afford lab analysis, typical ASM operators most likely lack the resources. Those who attempt to assay resort to the old process of panning, crushing, and using mercury amalgamation to separate the ore for weighing (Mischaud, 2016). For the companies that can afford lab assaying, finding an accredited lab can be challenging (ALS Chemex, 2012).

4.1 Feasibility Studies

4.1.4 Resource Modelling.

The data collected from exploration is used as input for the construction of the geological model, the resource or orebody model and other relevant calculations. A resource model is a fundamental requirement for a mine feasibility study, mine design and future planning (Wits University, 2015). The model can be constructed using software or older modelling techniques. The interpretation of exploration data and inputting of the results into the model requires a high level of technical knowledge, professional training, and experience. In many cases, large-scale mining companies source professionals who specialize in resource modelling, which comes at a very high cost. This is a luxury that artisanal and small-scale mines cannot afford. There is currently no simplified method of resource modelling for the ASM sector, and this step is bypassed.

4.1.5 Determining Feasibility

A feasibility study is an evaluation that technically establishes whether the resource can be mined profitably[22] (Ushakov, 2017). It considers the mining, metallurgical, marketing, economic, social, political, legal, and environmental factors (known as modifying factors) that may affect the profitability of the project (SAMREC, 2009). A feasibility study is the source of motivation when seeking for investment and financial support for any mining project[23]. It is important for it to be well prepared, objective, and informative. Once the feasibility study proves that a mineral deposit can be mined profitably, the mineral resource is classified as a reserve[24]. Even though a mineral resource can be classified as a reserve, it can move back to the resource classification. This can be caused by modifying factors, which change over time. The resource and geology models, geology, geotechnical, and hydrological models, as well as modifying factors are used to conduct the feasibility study of the mining project.

b. The application of feasibility studies to ASM

Chapter 3 showed that feasibility studies are the weakest link in the ASM value chain in terms of legislation, literature, and guiding material. The absence of feasibility studies is one of the reasons why ASM operations struggle to attract and acquire legitimate funding. According to Hentschel et al (2003), the lack of low cost assistance with the preparation of feasibility studies is one of the typical problems

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[22] In some cases, a full feasibility study is preceded by a prefeasibility study. A prefeasibility study determines whether or not the project should proceed with a full feasibility study. It also estimates the amount of money that will be required to commission the project, and it determines whether the money can be spent or not (Wits University, 2015). Some projects mention a bankable feasibility study.

[23] A feasibility study that can be presented to potential financiers and investors is referred to as bankable feasibility study.

[24] The SAMREC Code (2016) defines a mineral reserve as *"the economically mineable part of a Measured and/or Indicated Mineral Resource".*

experienced in the ASM sector. Feasibility studies are hardly covered in ASM research, training books and other guidelines. Like resource modelling, these studies are highly technical and expensive. Even though this is the reality, some countries require ASM projects to present a feasibility study in the process of licence applications. This is probably one of the reasons why some operators opt for the illegal route.

The reporting of exploration results, mineral resources and reserves is guided by international mineral codes such as the JORC and SAMREC. Some of the mineral codes contain guidelines that mining projects can use to guide the reporting of mineral exploration and evaluation results. An example of this is the South African Minerals Code (SAMREC), which contains tabulated step-by-step guidelines on how to report exploration and evaluation results as well as a simple assessment template (located in pages 28 to 61 of the Code). Even though some of the codes have such tools, they cater specifically for large-scale mining. Codes such as the JORC and SAMREC tend to overkill and make reporting so expensive that it becomes out of reach for ASM. There is a need to create simple reporting codes and guidelines for the ASM sector. This separation is necessary because companies in ASM generally do not have the intention to list on a public exchange, but they still need other types of finance.

4.2 Mine development and mining

After conducting a feasibility study, the project moves into a stage of mine development. This stage entails the physical preparation of the mining site for production. The value chain analysis in Chapter 3 showed that mine development and mining are one of the strongest links in the ASM value chain. This is because of the following reasons: Firstly, all mines must go through some sort of site preparation to gain access to the mineral deposit and extract it. Secondly, there is a significant amount of literature and legislation available to guide mine development and mining for ASM operations.

4.1.6 Mine development

The first step in developing a mine is the selection of a mining method. This is the technique that will be used to extract the mineral bearing rock type from the in-situ rock. The fundamental goal of a mining method is to maximize the profit and get the highest ore recovery in the safest possible way (Bitarafan & Ataei, 2004). Mining methods vary from one operation to another. The selection depends on several economic and technical factors[25] (Harraz, 2016; Okubo & Yamatomi, 2009). The selection of the wrong mining method can end the project even before it begins.

During mine development, the required infrastructure is erected, and the necessary machinery, equipment and labour are sourced. Mine development also includes the assembly of processing and refining facilities and equipping the site for movement of the ore from the primary extraction area to the processing and smelting areas. For large-scale mines, mine development requires the excavation of inclines, drifts, tunnels, adits and shafts, or the mass removal of overburden to access the orebody. The development of ASM operations is not as long and as extensive as that of large-scale mining. In many cases, ASM production starts almost immediately. Regardless of how simple the mining development may be, the project still needs to have some resources or capital to enter production. Figure 4.7 shows the categories of mining methods for surface and underground mines[26].

[25] Such as the type of mineral deposit, the depth and geometric properties, topography, grade, and the mechanical properties of the surrounding rock types

[26] The research does not analyze underground ASM because of the dangers of the activity.

The methods that are most applicable to the ASM sector are enclosed by the red blocks.

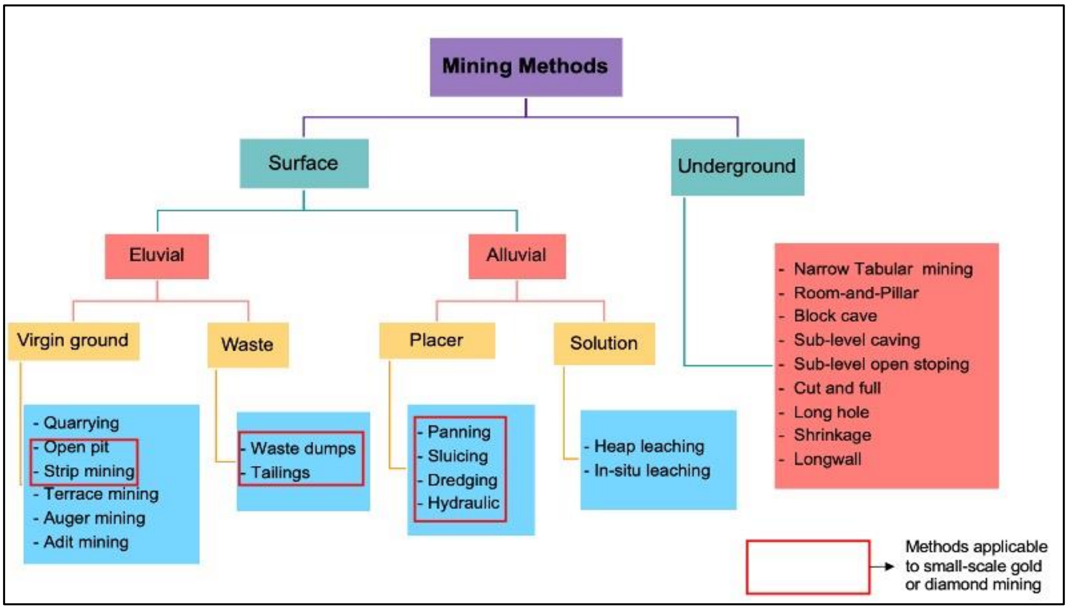

Figure 4.7: Surface and underground mining methods. Source: Harraz (2016); Okubo (2009); DWAF (2006)

c. The application of mining methods to ASM

According to the Zimbabwe ASM Training Handbook (2017), ASM operations are less likely to select or follow a particular mining method. The book adds that the operations just tend to follow the mineralization without applying a particular sequence or methodology. Although this point is valid, this research shares a different view. In the author's opinion, the ASM operators (especially surface miners) select and follow a particular mining method, even though the method may be applied in its most basic form. However, the methods applied lack adequate planning or sequencing. This causes haphazard mining, which has a negative impact on the environment, productivity, and sustainability[27]. In some cases, it can be difficult to classify some of the mining methods used (especially those that occur

[27] The overlap between prospecting and mining (that is discussed in section 4.1.1) also contributes to the haphazard appearance of the ASM operations.

underground). On the other hand, formal small-scale mines or junior miners tend to undergo the process of formally selecting a mining method and mine planning.

The surface mining methods that are commonly used in ASM are: open pit and strip mining, hydraulic mining and dreging. The applications of these methods are shown in Figure 4.8, Figure 4.9 and Figure 4.10.

Figure 4.8 shows a gold dredging operation that is located in a river in the Western Region of Ghana. This dredge is locally refered to as a “Galamsey vessel”.

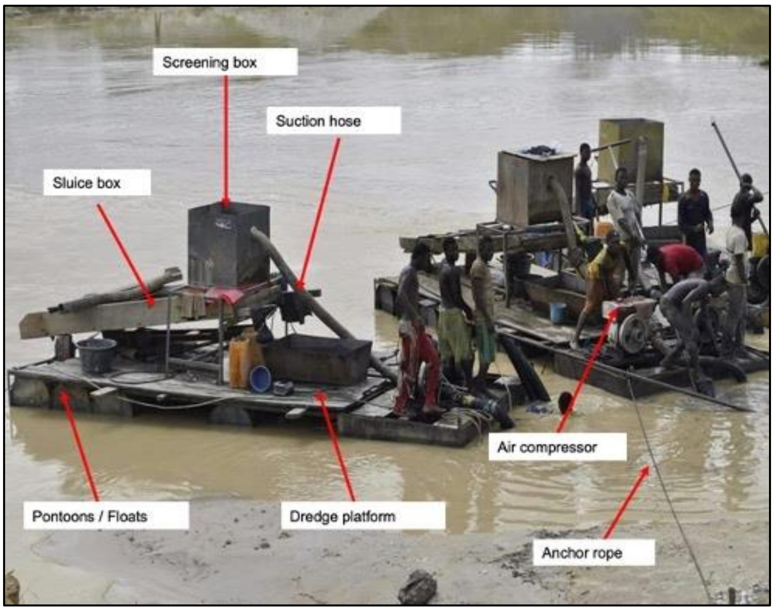

Figure 4.8: The application of mining engineering to an ASM dredging operation. Source: Dokosi (2017); Bokako (2020); Michaud (2015).

Figure 4.9 shows an open pit ASM operation that is located in an Eastern province of the Democratic Republic of Congo, and Figure 4.10 shows a hydraulic ASM operation located in the town of Paramaribo in Brazil.

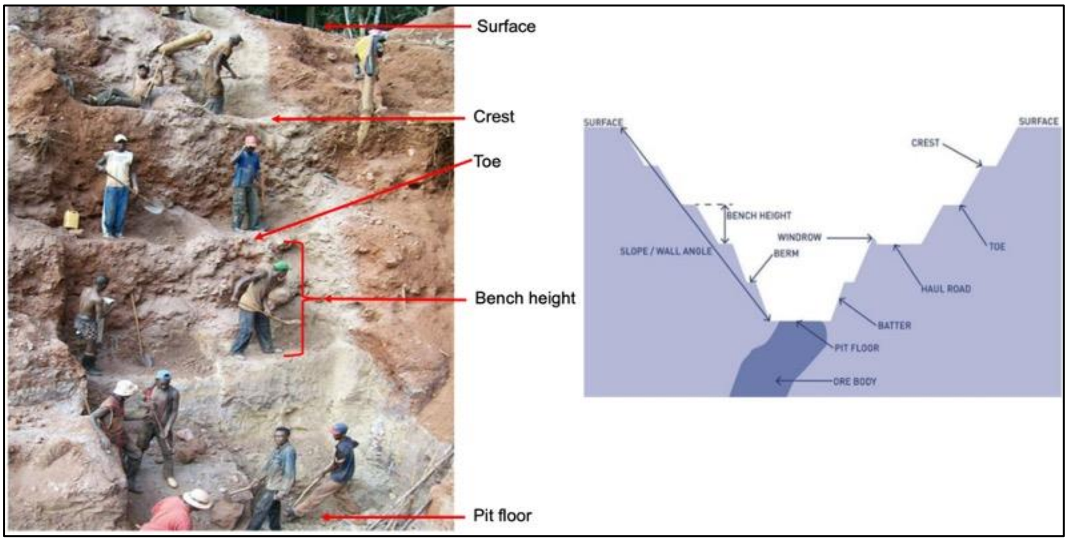

Figure 4.9: The application of mining engineering to an ASM open pit design. Source: Harraz (2016); Lüthje, Kranz, & Schoepfer (2014).

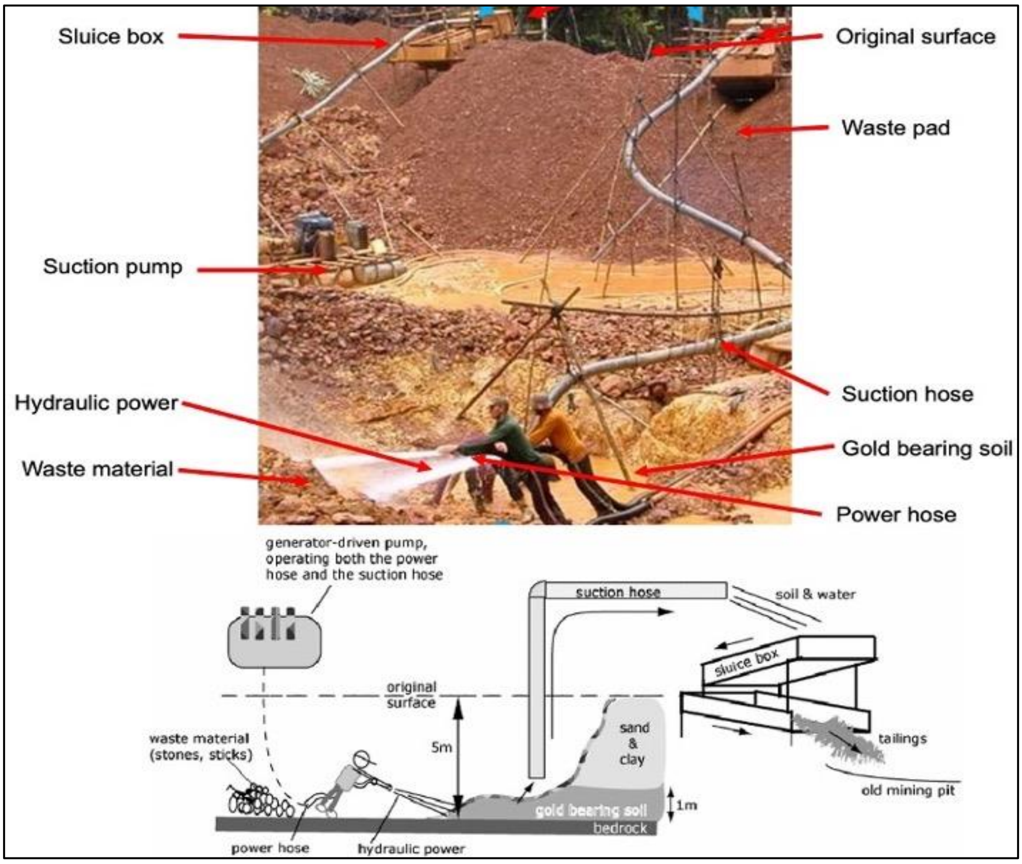

Figure 4.10: The application of mining engineering to a hydraulic ASM operation. Source: Legg, Ouboter & Wright (2015); Kooye & Heemskerk (2003).

These images show that ASM projects apply mining engineering methods (and to some extent design) to their operations, even though the applications occur in the most basic form. The level of application that is shown in the images is impressive given the fact that the majority of ASM operators are informal and they lack education and technical training. The pictures also show that ASM operations device plans to develop their own technology (e.g., the dredge shown in Figure 4.8) using basic tools. This practice also includes the fabrication of hoisting or conveyance systems and the assembly of basic processing plants (Economic Commision for Africa, 2009).

4.1.7 Mining and the daily operation mining projects.

Once there is sufficient infrastructure and access to the orebody, the mine moves into the stage of production. In many operations (both large and small-scale), mine development and production occur concurrently. The day-to-day running of mining operations is guided by regulations, standards, and procedures. These mechanisms are put in place to ensure that the mine adopts a safe and systematic way of production. Countries usually have mining regulations that guide the development of operational standards and procedures on the individual mines. They also have regulatory bodies that conduct inspections to check if the mines are operating within the regulations.

a. The application of mining regulations to ASM.

The literature reviews in Chapters 2 and 3 included a brief examination of the regulations that various countries have in place to guide the daily operation of mines. In all the countries that were analysed, there were no regulations that were made specifically for ASM. In each country, the ASM sector is guided by the same regulations that guide large-scale mining. This is understandable because the operating principles are the same for both large and small-scale mining.

This research considers the countries of Zimbabwe, South Africa, and Ghana to have some of the best mining regulations which can be easily applied to the ASM sector. Table 4.1 provides a summary of the different mining regulations for the above-mentioned countries. It also gives a high-level overview of the operating factors covered by each regulation.

Table 4.1: Operational activities covered by mining regulations

Regulation	Country	Operational activities covered by regulation
Mining (Managements and Safety) Regulations	Zimbabwe	*Competencies and training, *Appointments * Mine management *Ventilation *Tramming *Surveying, mine planning *Outlets *Engineering (electircal, mechanical) *Investigation of incidents and accidents *Applicable to surface, underground and coal mines. *Fees and penalites
Mining (Health and Sanitation) Regulations		*Occupational health and safety *Sanitation issues
Explosives Act		Drilling and blasting
Mine Health and Safety Act No. 29 of 1996 and Regulations	South Africa	An all encompassing document that provides health and safety regulations go guide the daily operation mines. The 8 chapters of the MHSA cover the following: *Appointments and administration, *General mine health and safety *Engineering (electricity, tramming, machines and equipment) *Outlets *Explosives, fires and explosions *Health and safety structures *The inspectorate *Occupational health *Rescue first aid emergency preparedness and readiness, *Survey mapping and mine plans *Tripartite institutions *Incident reporting *Fees (examination, certification, licence and permit application) *Penalties and fines for non compliance to regulations
MPRDA		*Social Labour Plan *Environmental regulations during mine production *Pollution control and waste management regulations

Regulation	Country	Operational activities covered by regulation
Minerals And Mining (General) Regulations	Ghana	*Recruitment and training *Local procurement *Export, sale, disposal of minerals *General operation of a mine * Record keeping and reporting compliance of mining projects *Small-scale mining obligations
Minerals And Mining (Health, Safety and Technical) Regulations		*The inspectorate *Operating plans and permits *Incident and accident inspections, investigations and enquiries *Reporting on returns, accidents, notices and appointments *Management of mines *Mine plans *Large-scale mining (Surface and underground) *Ventilation and dust *Illumination *Processing *Auxiliary mine surface facilities *Tailing storage *Rehabilitation and closure *Engineering (electrical, conveyance, mechanical) *Sections that tailor some of the above regulations specifically for underground and surface ASM *Functioning of attributors *Duty of owners *Mine safety *First aid, mine rescue, fire protection
Minerals And Mining (Health, Safety and Technical) Regulations		*Registrations, *Service provision *Benefits *Environmental obligations *Records and reporting *Offences and fees

Source: ILO-a (2020); MHSC (2018); MPRDA (2002); DMR-b, (2017).

Table 4.1 shows that several operational factors, such as health and safety, conveyance, environmental obligations, appointments, engineering, mine planning etc. are covered by mining regulations. These regulations are enough to guide the ASM operations.

4.3 Value addition

Value addition is primarily defined as the additional processing or conversion of commodities from their primary state to an intermidiate or final state. This describes the further enhancement of a product before delivering it to the market, which has specific requirements on the level of processing and purity. Value addition is done with the purpose of deriving maximum value from the product (Mabuwa, 2014). According to the Uongozi Institute (2017), over the recent years, the definition of value addition has graduated beyond the notion of processing and refining minerals. It is now also defined as obtaining maximum economic value from the mining industry and subsidiary sectors linked to mining. This definition includes strengthening local supply chains and empowering local content. It requires the sector to encourage local content in the secondary and tertiary sectors linked to mining.

In the long, term taking full advantage of the activities that are further down the value chain helps to decouple the local economy from its reliance on the primary production of minerals (Uongozi Institute, 2017). When the local economy becomes less dependent on mining, it is more likely to achieve sustainable economic growth and development.

According to Amoako-Turrour et al (2015), value addition benefits the following four main pillars of the economy: "*Local employment and in-country spending; Procurement of local goods and services; Technology and skills transfer; and Local participation through equity and management"* (Amoako-Tuffour, Aubynn, & Atta-Quayson, 2015).

a. The lack of value addition in ASM.

The lack of value addition is a major challenge for the ASM sector. The minerals that are produced can be traded at any stage of the value chain – provided that there is a buyer for the production. Artisanal and small-scale miners tend to trade their products in rawer (or impure) form during the early stages of the value chain. This works against the four main economic pillars. It puts the local economies at a great disadvantage because when the minerals are traded prematurely, jobs and potential revenues are lost. Research conducted by Wacha (2012) on the ASM sector of Uganda revealed that artisanal and small-scale miners trade prematurely because they often lack the value addition knowledge, capacity and resources. The operators are also desperate for income, and they have great difficulty in accessing the markets due to complex, costly and restrictive marketing regulations.

4.1.8 Mineral Processing (Beneficiation)

Mineral processing is defined as follows: *"the treatment of ore to concentrate their valuable contstituents (minerals) into products (concentrate) of smaller bulk, and simultaneously to collect the worthless material (gangue) into discardable waste (tailings)"* (Balasubramanian, 2017). In simple terms, mineral processing is the cleaning of ore to separate substances that do not have value from the economically valuable mineral. Mineral processing is the first step in extractive metallurgy. Figure 4.11 provides an overview of the sequence of events that take place in mineral processing.

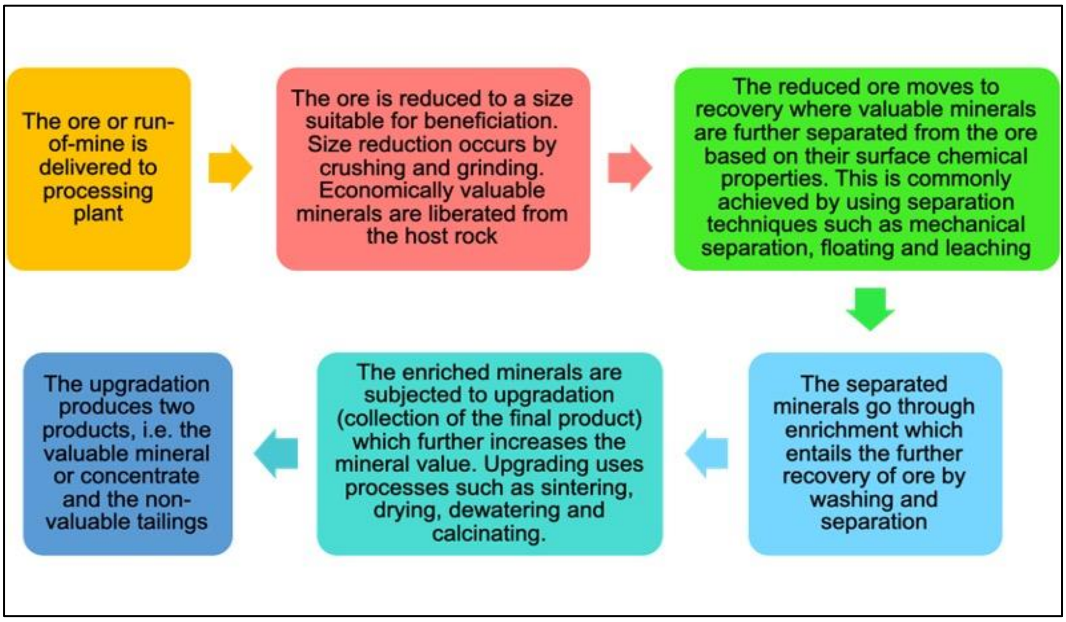

Figure 4.11: The steps involved in mineral processing. Source: Balasubramanian (2017).

a. *The application of mineral beneficiation to ASM*

There is a significant body of literature that provides information about mineral processing for ASM, especially for the gold and diamond commodities. Some of the notable literature is the ASM Handbook for Ghana, the Training Handbook for ASM in Zimbabwe and a paper on sustainable gold processing by Mukono et al. (2018). The handbooks show how various ASM operations apply the process shown in Figure 4.11. Similarly to the selection of mining methods, mineral processing techniques depend on the type of mineral deposit being exploited, and ASM operations follow the most basic form of the processing methods. In many countries, operations require additional licences to conduct mineral processing, smelting and refining. According to Mukono et al. (2018), individual ASM operations often do not have their own processing plants due to the extensive requirements of setting up and operating a plant. The miners therefore rely on localised custom milling plants to process and refine their minerals at a fee.

The processing of ASM diamonds is simpler compared to gold. With diamonds, the gravel that is mined is just washed and screened to remove the waste, and the diamonds are picked using hands (Tychsen et al., 2017). In the case of gold ASM, the mineral concentration step (i.e. the last step in Figure 4.11) includes amalgamation. Amalgamation entails mixing the enriched mineral with mercury to cause the gold to attach to the mercury and the barren material to separate from the gold (Kubach, 2012). The amalgam is then heated at a high temprature to burn off the unwanted slag. This produces a gold concentrate which is similar to a doré that can be refined for further purification. Some ASM operations do not use amalgamation to extract gold, but instead they smelt the concentrate to burn impurities and leave the gold produce (Tychsen et al., 2017). In many cases, the ASM gold is sold before it reaches the refinery stage and the diamonds are sold without being polished. This lack of further value addition causes the minerals to fetch a lower price in the market.

4.4 Marketing and Selling

This section focuses on the marketing and selling of ASM gold and diamonds. To understand how these ASM products are traded, it is important to first have knowledge of the general flow of high value minerals in the global market. This will assist one to gauge the alignment of the ASM sector to legitimate trading. Figure 4.12 shows the flow of gold according to the World Gold Council, and Figure 4.13 shows the flow of diamonds into the global market.

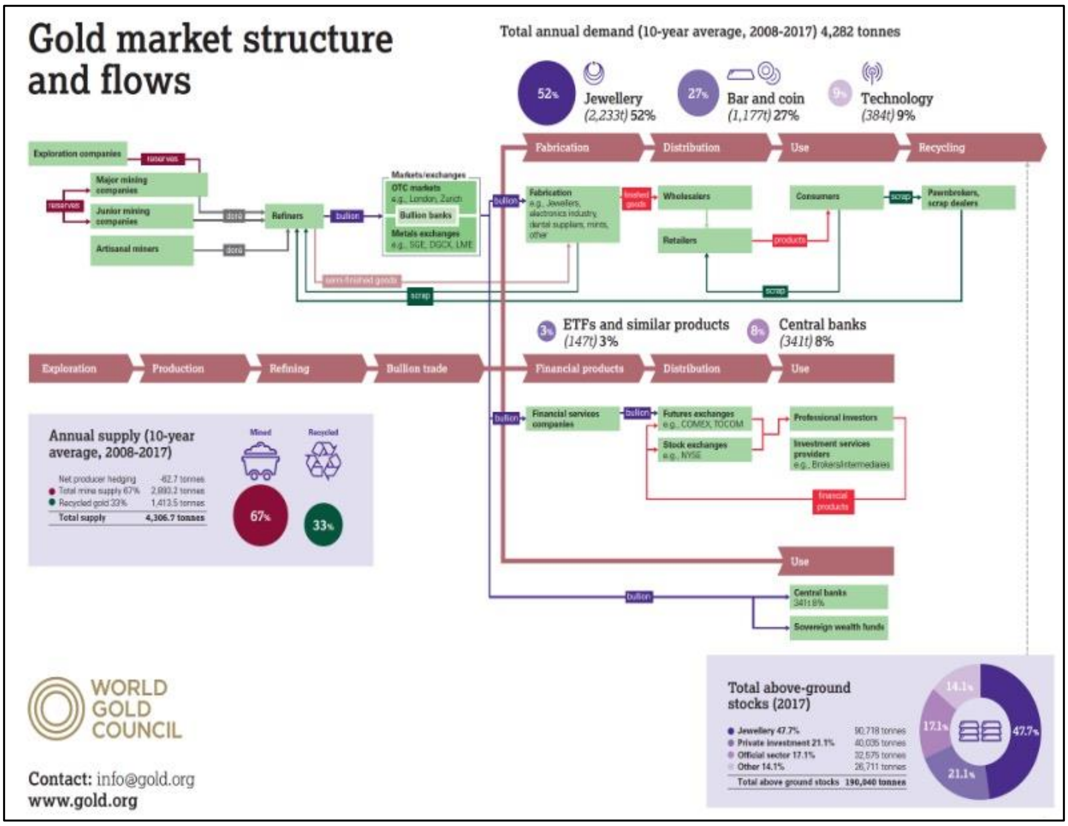

Figure 4.12: The flow of gold in the global market. Source World Gold Council, (2017e).

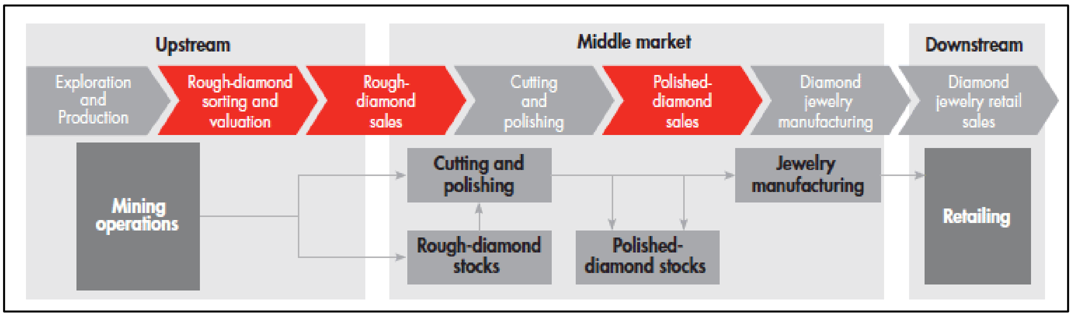

Figure 4.13: The flow of diamonds into the market. Source: Spektorov et al. (2013).

In the main flow, gold leaves the processing site as a doré (i.e., processed gold that still contains metal impurities) and it enters the refinery, where it is purified further and converted to bullions. After this step, the bullions are sold to bullion banks or placed on the global stock exchange, where they are sold to various industries. Figure 4.12 shows that in other cases, the gold enters the mainstream (mainly fabrication) right after the refining stage.

In the case of diamonds, all diamonds that enter the market need to receive the Kimberly Process Certification. The certification validates that all diamonds that enter the export market are conflict-free. The Kimberly Process also helps to ensure that the diamonds that reach the jewellery market can be traced back to ethical mining operations (Kimberly Process, 2020). Figure 4.13 shows that the rough diamonds that are produced by the mines are sold to the middle market, where they are polished and used to manufacture jewellery. After this, they are sold to the consumer.

4.1.9 The marketing and selling of ASM products

In ASM, each country has its own system of regulating the flow of gold and diamonds into the mainstream market. In some countries, like Brazil, licenced ASM operators can trade their minerals directly to the tertiary market without applying for any trading permits or licences or going through licenced brokers or dealers.

However, in most countries, the trade of high value minerals is facilitated by licenced dealers. Figure 4.14 shows the market flow of ASM gold and diamonds in the countries of Tanzania, Ethiopia, and Zimbabwe. Ethiopia was selected because it is considered to have one of the best ASM marketing systems. Tanzania and Zimbabwe were selected because of the amount of information available on the marketing systems.

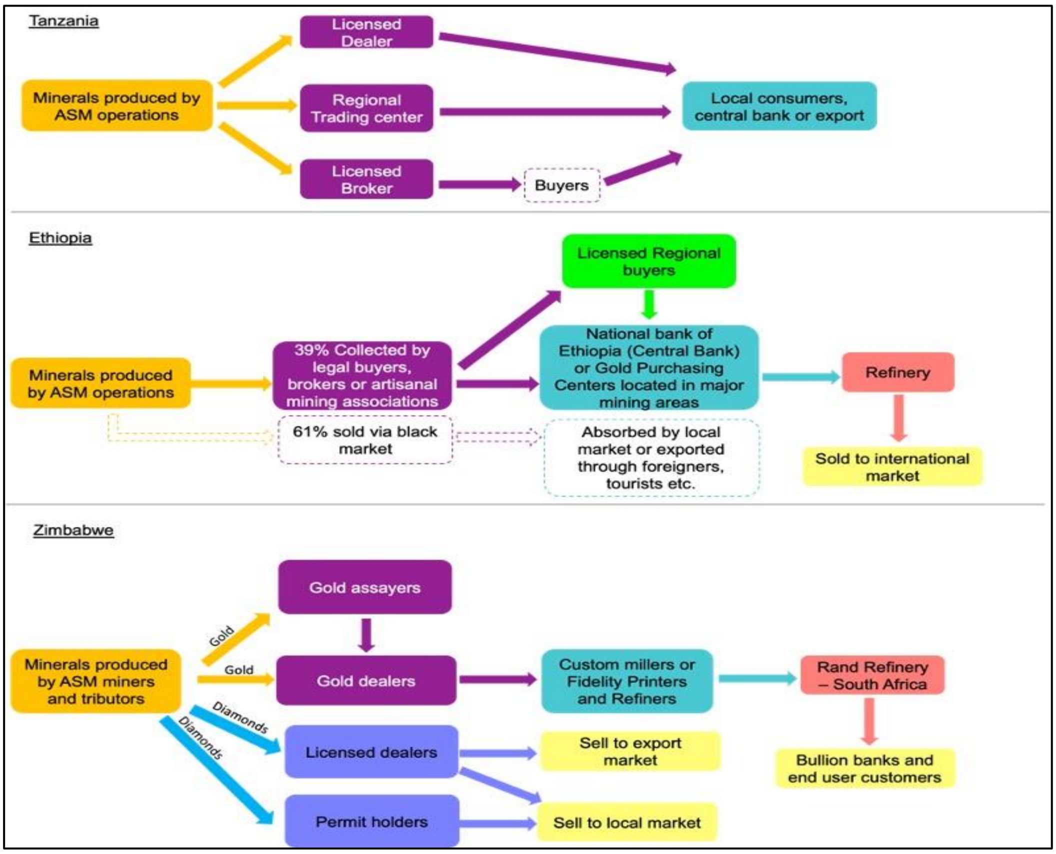

Figure 4.14: The market flow of ASM minerals in Tanzania, Ethiopia, and Zimbabwe. Source: Ministry of Mines and Energy, (2009b); Ministry of Mines and Mining Development (2016a); Ministry of Energy and Minerals (2021).

Figure 4.14 shows that the flow of lawfully traded ASM gold and diamonds aligns with the global flow. The general flow is from the operator to the licenced trader, to a bank, and then to the refinery or consumer. The details about the licensing and the regulations that accompany the marketing structures of the three countries are provided in Annexure 3.

The marketing and selling of high value minerals in ASM can be complex. In many cases, trading is illegal, and it lacks transparency. According to the African Mining Vision (2011), the informal and unregulated nature of ASM leaves the sector very susceptible to illegal trading. According to the IGF (2017), ASM operators commonly sell on the black market to avoid paying taxes and royalty fees associated with legitimate transactions. They also sell out of financial desperation created by the need to sustain their livelihoods. This desperation coupled with the lack of marketing knowledge and poor access to the markets puts the operators at a great disadvantage. Another issue that emerged from the literature was the influence of ASM sponsors in the trading of minerals. ASM operators are usually tied to a sponsor (i.e., a financier who provides the capital for mining) and this sponsor sets the selling price for the minerals. This often prevents the ASM operators from getting a fair share of the mineral revenue (African Mining Vision, 2011).

4.5 Mine rehabilitation and restoration of the environment

Mining environmental rehabilitation refers to restoring land that has been damaged by mining back to its initial or similar condition. This is normally mandated by environmental assessments and management plans which are prerequisites to obtaining mining permits or licences. These plans require the mining project to evaluate the likely impact that the activity will have on the physical and socioeconomic aspects of the environment. Mining operations are also usually required to develop mitigation strategies to manage the impact.

According to a publication by the Austrailian Government (2016), environmental rehabilitation depends on the desired end use of the land that was affected by mining. It is important for mines to begin a project with the end in mind. This is done by planning for rehabilitation early in the life of mine and incorporating these strategies into the short and long term mine planning (Austrailian Government, 2016). According to the Minerals Council South Africa and Coaltech (2007), rehabilitation needs to be effective, which means that it should offer long term sustainability under regular management. Environmental rehabilitation should also be ecologically viable, which means that it should include the following:

- Technical rehabilitation, which comprises of waste management, topsoil preparation, filling of voids, grading and reprofiling of the topography etc; and
- Biological rehabilitation, which comprises of topsoil management, collecting and distributing the seeds of the local vegetation (Bolormaa, 2019).

In addition to the above, environmental rehabilitation should be affordable and socially accepted (especially in the ASM sector). Social acceptance means that the relevant community and stakeholders should buy into the desired end use of the land and their desires should also be incorporated into the rehabilitation plans (Bolormaa, 2019). Land rehabilitation should align to the development strategies of the local communities (Minerals Council South Africa and Coaltech, 2007). They should seek to empower the affected local communities and provide them with improved and lucrative alternative livelihoods.

4.1.10 The application of mine rehabilitation and environmental restoration in mining.

Most ASM operations generally do not fulfil their environmental management or rehabilitation responsibilities. This is because the tasks require significant skills, time, financial resources and sometimes technology. The current nature of the sector does not allow for operators to achieve the same rehabilitation levels as large-scale mines. Another possible reason for the non-compliance is that most environmental rehabilitation laws and guidelines are made specifically for large-scale mines. In cases where the ASM operators are willing to comply, they face the hurdle of complicated and unrealistic regulatory requirements (Stevens, Duthie, & Ranieri, 2017). ASM operators often ignore the environmental regulations and opt for the informal or illegal route because of these requirements and the lack of environmental knowledge (African Mining Vision, 2011). Some countries have addressed this challenge by simplifying Environmental Impact Assesments (EIAs) for ASM (African Mining Vision, 2011).

4.6 Conclusion

Chapter 4 shows that artisanal mining, in its nature, is a form of prospecting. The chapter also demonstrates the application of mining engineering principles to ASM. It identifies the techniques that are simplified for ASM (e.g., exploration, sampling, beneficiation), as well as those that need to be simplified for the sector (e.g., resources modelling, feasibility etc.,). Chapter 4 shows that despite its informality, there is logic to artisanal and small-scale mining. The sector applies basic forms of mining engineering even though, in many cases, the applications may lack proper planning and sequencing.

Chapter 5 focuses on the field work that was conducted in Ghana (the country of study). The chapter investigates how artisanal and small-scale mines operate.

5 CASE STUDIES OF SMALL-SCALE MINING IN GHANA

Chapter 5 documents the case studies of two Ghanaian ASM operations. It provides field observations of how Ghanaian artisanal and small-scale mines operate in the real world[28]. Chapter 5 also aligns these field observations with the mining theory and principles discussed in Chapter 4.

It is important to note that the site observations that were conducted for Chapters 5 to 6, as well as the stakeholder engagements in Chapter 7 were conducted in line with the ethics code that is stipulated by the University of the Witwatersrand. Observing the code of ethics ensured that the researcher and participants were not exposed to any exploitation or danger, and that the research engaged with participants willingly. To protect the identity of the stakeholders (in line with the Wits University code of ethics), most of the feedback is reported in a generalized format.

5.1 Background of the ASM case studies

The initial research plan was to conduct case studies for both the gold and diamond small-scale operations. However, the field investigation of diamond mining could not take place due to the difficulty of identifying a mine that was willing to participate in the research. The research however successfully documented the activities of 4 gold mines, which are grouped into 2 case studies. The first (case study A) focuses on 2 unregistered small-scale gold mines, which operate illegally, and the second (case study B) focuses on 2 registered gold mines that operate legally. The Ghana Minerals Commission assisted with the identification of the legal operations that were used for this research.

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[28] During the fieldwork exercise, the legal mines provided the research with production data. However, this data is discussed in the next chapter (Chapter 7).

5.2 Location of the ASM case study areas

The Minerals Commission recommended the mining town of Dunkwa for the case study due to its high level of ASM. Dunkwa (also known as Dunkwa-on-Offin) lies 97 km Southwest of the metropolitan city of Kumasi, and 33 km South West of the popular mining town of Obuasi. The case study areas are located on the North-West outskirts of the mining town, along the Offin river[29]. These locations are shown in Figure 5.1.

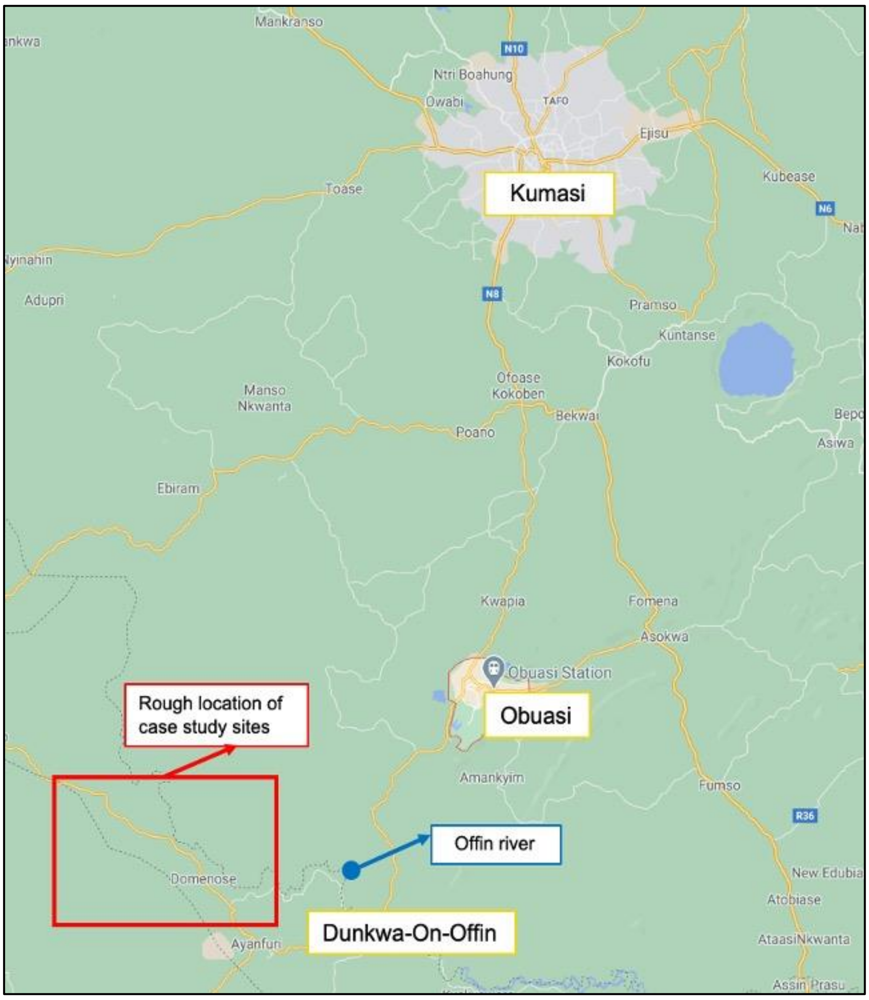

Figure 5.1: Location of mining sites used for case studies. Source: Google Maps (2021).

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[29] Coincidentally, this is the mining area that is shown in the prospecting satellite image in Figure 4.2

5.2.1 Location of the case study areas relative to water bodies and major infrastructure.

Figure 5.2 and Figure 5.3 show the location of the case studies (and their rehabilitated areas) relative to major infrastructure and water bodies. The device that was used to take the photos in the field automatically pinpointed the images to a geographical location.

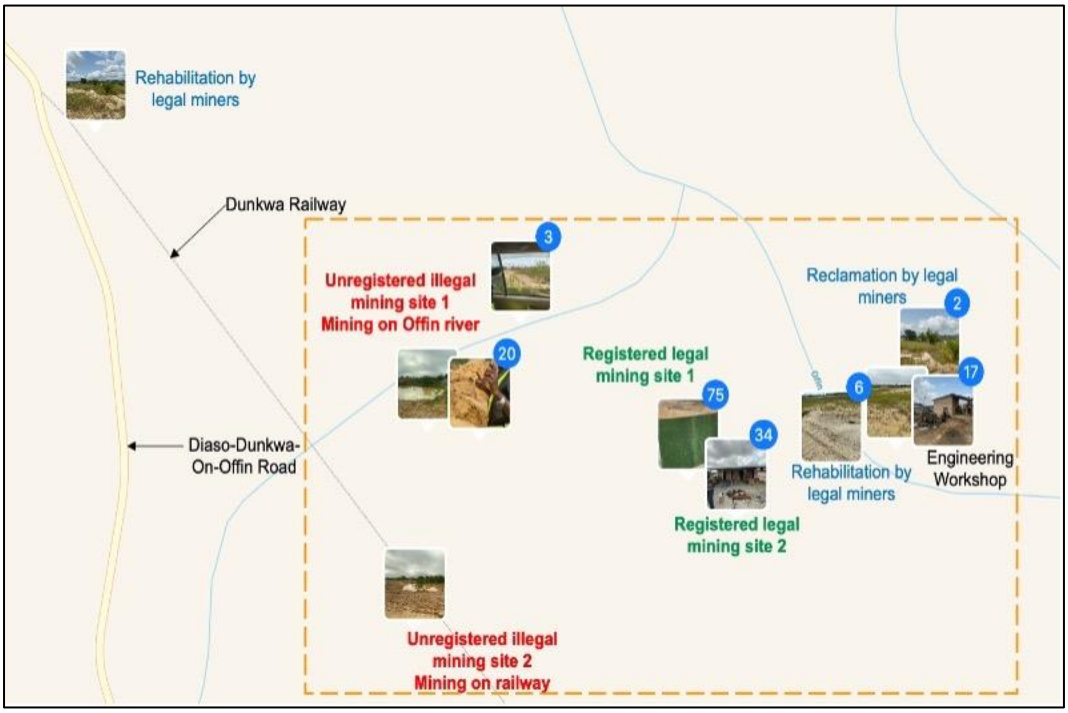

Figure 5.2: Map of the mining and reclamation sites. Source: Apple Maps (2021).

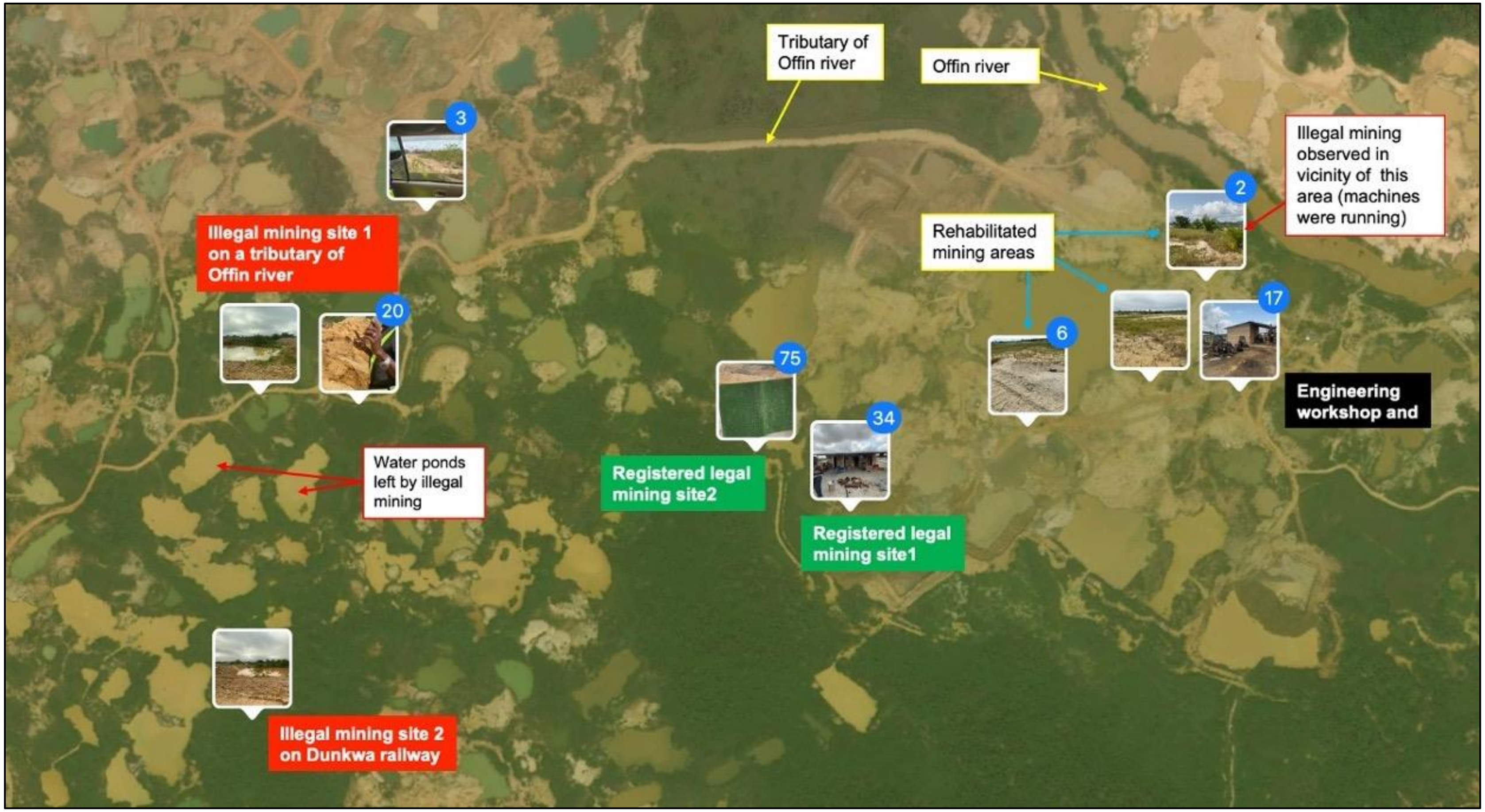

Figure 5.3: Satellite imagery of case study areas. Source: Google Maps (2020).

5.3 The Background of the Dunkwa Mineral Deposits

Dunkwa has a very long history of gold mining. The locals have been mining in the area for centuries, and the documentation of modern gold mining dates to the early 1900s (Boaduo, 2017). Figure 5.4 shows images of the dredges that were used to mine gold in Dunkwa-on-Offin in the early 1900s.

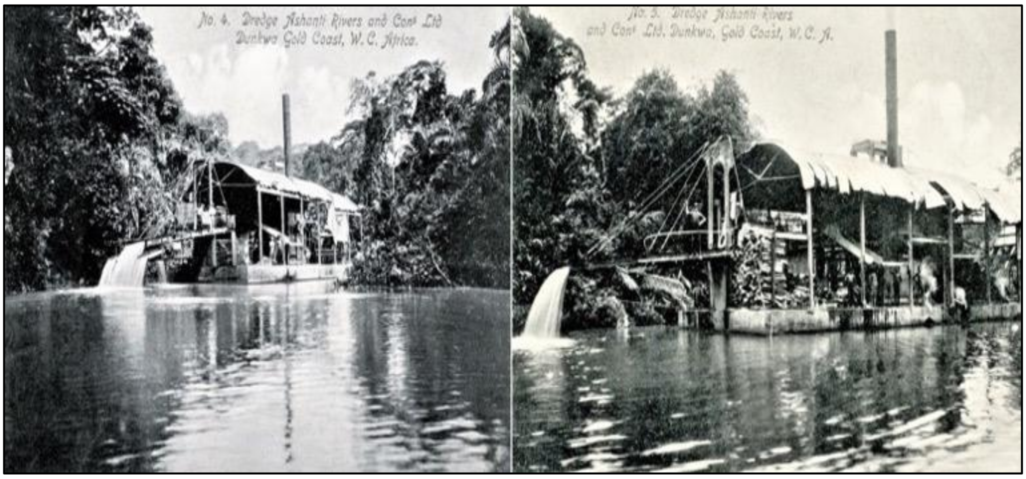

Figure 5.4: Dredgers mining gold in Dunkwa in 1910. Source: Mindat.org (1985)

5.3.1 The Geological setting and mineralisation

Dunkwa lies on a portion of the Ashanti gold belt, which contains alluvial placer deposits (mindat.org, 1985). The location of mining activity in the area indicates that the gold can be sourced from either terrace or stream placer deposits. Figure 5.5 provides a schematic of the different types of placer deposits that can be found in nature. The above-mentioned placers are secondary and tertiary deposits that are created by gold that has been displaced from its original source

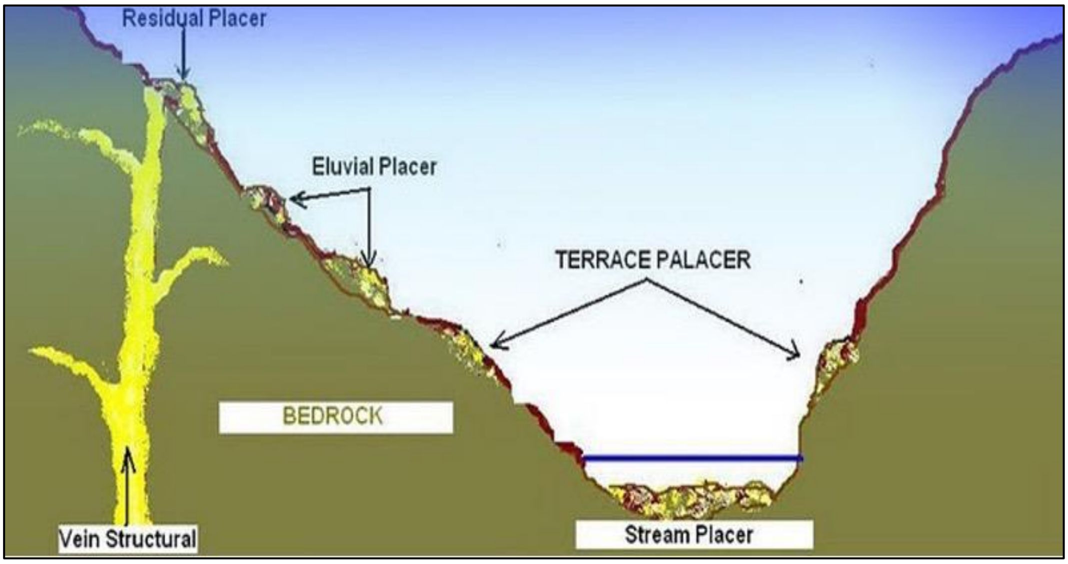

Figure 5.5: Schematic of the different types and the origin of placer deposits. Source: Michaud (2017).

According to Tychsen et al. (2017), placer deposits in Ghana originate from the Birimian veins and lodes. The gold is displaced from these primary sources by hydraulic action (water) and gravity (rocks). During the transportation process, the gold-bearing rocks disintegrate, erode and weather. This together with other natural chemical processes causes the gold to become liberated. In due course, the gold-bearing rocks, nuggets or particles are deposited at favourable destinations such as near water bodies and inside riverbeds, where they become stratified and concentrated placer gold deposits located along streams are embedded in gravel and surrounded by heavy minerals. These heavy minerals appear as bands of black rock or sand (Michaud D. , 2017a). This was observed at the legal small-scale mines, and is shown in Figure 5.15.

5.3.2 The quality and grades of the Dunkwa deposits

The intensive small-scale mining and the presence of large-scale companies in Dunkwa gives one an indication of the high mineral wealth in the area. The areas of high mineral value in Dunkwa are primarily occupied by large mining companies such as Golden Star Resources and Persus Mining, while the lower grade areas are occupied by small-scale miners. The registered mines that were used for the case study are both located on a concession that was previously owned by Goldfields. After determining that mining on a large-scale would not be feasible, the company returned the concession to the government which made the area available for small-scale mining.

The picture of the mineral wealth in Dunkwa is clarified by reports produced by large-scale mines occupying the area. According to a publication by Golden Star Resources (2016), the company was granted rights to mine the Mampon deposit in Dunkwa. The publication describes the Mompon deposit to be very rich because it contains high grades and oxides. The deposit was estimated to contain about 45 000 ounces of gold valued at 4.6 grams per tonne. In a statement made by Sam Coetzer (2017), the President and CEO of Golden Star Resources, the Mampon mineral reserves were estimated to reach exceptionally high grades of 14,02 g/t. The Mampon deposit would be used to help strengthen the cash-flow of Golden Star in the short term (Golden Star Resources Ltd, 2016).

5.4 Observations made at the illegal mines (Case Study A)

5.4.1 The location of the illegal small-scale mines

A large presence of illegal mining operations was observed along the route to the registered small-scale mines. These mines were mainly concentrated along the banks of the Offin river. Illegal mining was also observed on an old railway line passing through the town. The satellite image in Figure 5.3 [30]as well as the site photos in Figure 5.6 and Figure 5.7. show the proximity of illegal mining to the main water bodies.

[30] It is important to note that all the images that are presented in Chapters 5 and 6 form part of the authors' collection of photographs that were taken during this research.

Figure 5.6: Illegal mining taking place near the Offin river

Figure 5.7: Pollution of Offin river tributary caused by illegal mining.

According to the legal miners, the Offin river is supposed to be the main source for water supply in the Dunkwa mining community. However, the community has resorted to using ground water because of the heavy river pollution.

a. The Riparian Buffer Zone Policy for Fresh Waterbodies

The Riparian Buffer Zone Policy for Fresh Waterbodies guides the required distances between economic activity and waterbodies. Riparian buffer zone regulations are also designed to protect major infrastructure such as railway lines, high tension powerlines etc. (Tychsen et al., 2017). The policy for waterbodies was formulated to protect the riparian vegetation and preserve the integrity of the water body and the stability of the riverbanks (Ministry of Water Resources, Works and Housing , 2013). Table 5.1 shows the riparian buffer zones that are stipulated in the Policy.

Table 5.1: Riparian buffer zone distances

Zone	**Recommended riparian distance**
Municipal reservoir shoreline protective Buffer	60 to 90 meters (e.g., Weija dam, Lake Bosomtwe)
Major perennial rivers/streams	10 to 60 meters (e.g., Volta, Tano, Offin)
Minor perennial streams	10 to 15 meters
Important seasonal streams	10 to 20 meters
Streams within forest reserves	10 to 50 meters
Wetlands	30 meters
Areas with steep slopes of between 15 to 30% within proximity to the river	Buffer may be adjusted by adding an extra 20 meters

Source: Ministry of Water Resources, Works and Housing (2013).

Table 5.1 shows that there should be a 10-meter to 60-meter buffer zone (plus an additional 20 meters due to steep pit slopes) between all mining activity in Dunkwa and the Offin river. However, the illegal mines operate inside the river. The consequences of non-adherence to the buffer zone were seen in the pollution of the Offin river, and the disturbance of vegetation along the riverbanks. The removal of this important natural catchment is leading to soils and other sediments being washed into the river. This affects the purity, depth, and the ecosystem of the main river, and it also destabilizes the riverbank. This makes the surrounding areas more prone to flood damage (Clacherty & Moodie, 2004). The extent of damage was evident in the numerous riverbank collapses that were seen around the illegal mining areas.

5.4.2 Mining infrastructure and camp facilities

On the illegal mining operations, the only infrastructure that was observed was the dredging equipment. No sign of any other infrastructure or camp facilities was observed. The machinery and equipment on the mines appeared to be in very poor working condition. The mining also appeared to be more labour intensive.

5.4.3 Mining methods applied by illegal miners

Observations of the illegal mines were limited because the areas were unsafe to enter. From the observations that were made at a safe distance, the researcher could determine that the illegal miners use dredging, sluicing and panning as mining methods (as shown in Figure 5.8). The dredging activity that was observed in the field is the same as the Galamsey vessel shown in Figure 4.8 (Chapter 4).

Figure 5.8: Unstable slopes surrounding Galamsey vessels

The methods used by the illegal miners looked hazardous to health and safety. Figure 5.10 shows a miner swimming in the contaminated water to access the workings. The lack of technical knowledge, caution, and safety principles was observed. Figure 5.8 shows that the vessels were surrounded by and anchored on unstable slopes. The anchoring exacerbates the already dangerous geotechnical conditions.

The legal miners alluded to the fact that the galamsey operators do not plan their mining activity, and they recover gold at very low grades. They attributed this to the inconsistency in workflow, the lack of a structured organizational system, and the lack of freedom to operate (the illegal miners constantly stop and hide from the regulators). Production information to verify these statements could not be obtained because the illegal miners were not willing to engage with the researcher or disclose their information.

5.4.4 Poor environmental management

The environmental impacts of illegal mining in Dunkwa are glaring. The illegal operations are surrounded by heaps of unstable waste rock, and abandoned pits (or hollows) filled with polluted water. Some of these heaps and hollows are located very close to roads that lead to the registered mining sites. Figure 5.9 shows a photo of the environmental conditions that surround these operations.

Figure 5.9: Poor environmental conditions surrounding illegal mines

The water ponds not only make the area unattractive, but they also pose health and safety risks to people, vehicles, and animals passing by. This water is the perfect breeding ground for malaria mosquitoes and other dangerous bacteria. The legal miners indicated that the ground water table in the area is quite shallow, and it is normal to intersect it during mining. They explained that one of the consequences of the water ponding is that the unclean water seeps into the ground water causing contamination. This can create significant problems because in surrounding rural communities, boreholes are the main source for water supply.

5.4.5 Poor wastewater management

In addition to the above, the illegal mines pump the contaminated wastewater back into the Offin river or into the abandoned pits and the surrounding environment. Figure 5.10 shows the wastewater being discharged into the surrounding working environment.

Figure 5.10: Illegal miners discharging wastewater into the (river) workings

Poor wastewater management causes problems not only for the surrounding communities, but also for people living in further areas. Clacherty & Moodie (2004) wrote that contaminated sources such as discharges from tailings and mercury use etc. can join major pathways (streams and rivers) and find their ways downstream to receptors (people and other living creatures). Test samples conducted by Golow & Adzei (2002) showed signs of Persistent, Bioaccumulative and Toxic substances[31] (PBTs) as well as extremely high quantities of mercury in soil, grass, fern and acquiculture around farms located in the Dunkwa-on-Offin area.

The Ghanaian government has been criticised for its inability to adequately enforce penalties for water pollution. Over the years, there have been calls for the strict

[31] PBTs are described as toxic long lasting chemicals or substances that break down slowly in the environment and build up in humans, other species and the food chain. They are known for causing adverse damage to the ecosystem and human health (Golow & Adzei, 2002).

monitoring of compliance to water policies, as well as the imprisonment of individuals and companies that violate these policies (Ghana News Agency, 2020).

5.5 Observations made at the legal mines (Case Study B)

5.5.1 The location of the legal mines relative to the Offin river

The Offin river was observed North of the legal mines. The mines are closest to the river in the North-Easterly direction. In the field, the river or its tributaries could not be seen or heard anywhere in either direction. This is shown in Figure 5.3, and in Figure 5.11, a photograph that was taken in the shortest direction to the Offin river. The researcher also attempted to walk from the legal mines to the river, but it could not be reached because of the riparian vegetation which spanned for more than 1km in all directions.

Figure 5.11: Photograph taken at the legal mines in the shortest direction towards the river.

5.5.2 Mining infrastructure and capital

The mining infrastructure, machinery and equipment on the legal mines appeared to be in very good condition. The operations were semi-mechanized with machinery and equipment comprising of excavators, skid steers, loaders, large pipes, engines, crushers, and pumps. The legal mining site also had an engineering workshop which was equipped with technicians as well as maintenance and repair tools. The camp contained a canteen with a kitchen and a cook to meet the nutritional needs of the mine workers. These facilities are shown in Figure 5.12. In such an environment, nutrition is important because of the work intensity and the long hours on the mine. Office, accommodation, sanitation and ablution facilities (which are necessary for health and safety purposes) were also observed. The site management explained that while most of the workers commute to the site daily, a few workers stay onsite (on a shift rotation) for logistical and security reasons.

The site also contained a scrapyard, which housed damaged or inefficient machinery and equipment. An old gold mining trommel was also observed in the scrapyard. The miners explained that in the past, the mine attempted to use a gold mining trommel, however, the trial proved to be inefficient because the gold recovery was low. The scrapyard also contained machines that were damaged because of a raid that took place in 2017, when the government placed a temporary ban on small-scale mining.

All the large excavation machinery and spare parts used on the operation are imported from China. However, the hydraulic system (or washing plant) is produced locally.

Figure 5.12: Camp facilities observed on legal mines

According to one of the site managers, the minimum start-up capital for a basic semi-mechanized small-scale gold mining operation can be very high. The manager indicated that it could range from hundreds of thousands to a few million Cedis. The amount of required start-up capital depends on whether the mine plans to buy or rent machinery. It also depends on whether they purchase new or second-hand equipment and machinery. The miners added that access to this kind of capital is difficult because of the nature of the business and the perception of the industry.

The legal mines also had personal safety systems in place. Although there is room for improvement, almost all the workers were seen wearing safety boots, some were wearing reflector vests, helmets, and branded overalls.

5.5.3 The organisational structure

The legal mines have clear organizational structures. The two concessions in this case study are owned by one individual who is located off-site (the miners indicated that some owners prefer to be on site). In this case, the Concessions Owner has appointed a site manager for each operation. The site managers are responsible for the day to day running of the operations. Each site manager employs a foreman and supervisor, who oversee the production. Most of the time, the roles of foreman and supervisor run parallel, but normally the supervisor reports to the foreman. The manager also appoints the workers (i.e., technicians, supporting staff and production workers) who maintain the camp, its infrastructure and work in the pit. The organogram of the legal mine used in the case study is shown in Figure 5.13

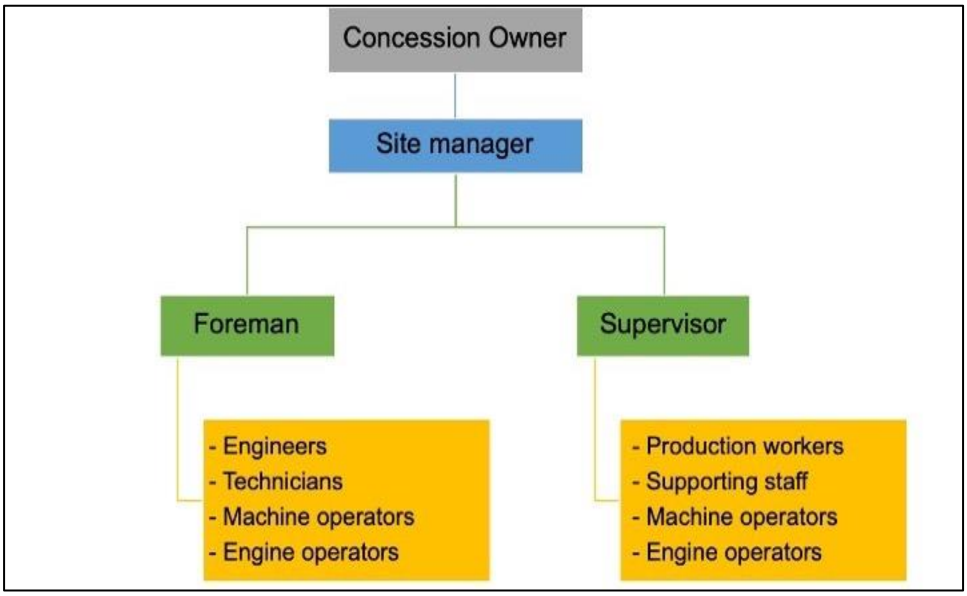

Figure 5.13: Organogram of the legal mine.

5.5.4 Determining the areas to mine

When asked how they determined which areas to mine, the legal small-scale miners explained that they rely on intense sampling, experience, and knowledge of the area. They emphasised that field experience is important for the ability to identify high and low value areas.

The miners have a general idea of where the high-grade deposits are located. They normally buy land that has gold-bearing potential (or they give recommendations to potential concession owners). After this, they conduct exploration, which consists of digging a series of pits (as explained in Chapter 4). In many cases, the pits produce either trace (zero) values or high values. The small-scale miners understand that the values obtained in one pit do not provide a general representation.

The miners have their own practical and flexible ways of sampling, interpreting results, and deciding on where and how to begin mining. The logic that was explained aligns with the sampling methods and techniques that are described in the literature written by experts such as Michaud (2016d). Sampling is conducted ahead of the face (as shown in Figure 5.14). This is done to estimate the grade that lies ahead, and to help assign values to the different mining 'blocks'. The grade is estimated by calculating the amount of gold recovered per volume (cubic metre) of gravel and waste moved. This is shown in the production data provided in Chapter 6. Sampling occurs at small and regular intervals because of the gold nugget effect.

To determine the mining areas, the miners divide the active mining area into small sections (shown in Figure 5.14) and assign a value to each block based on the sampling data. According to the surveyor, these bock values are verified by the grade of gold produced, volume of rock mined, and gravel depth of each section.

This together with the sampling that is conducted ahead helps the operation to estimate the amount of gold that should be produced in a specific week. The mine also measures the face length and advance on a weekly basis. The production information for the legal small-scale operation is shown in Table 6.1 in Chapter 6.

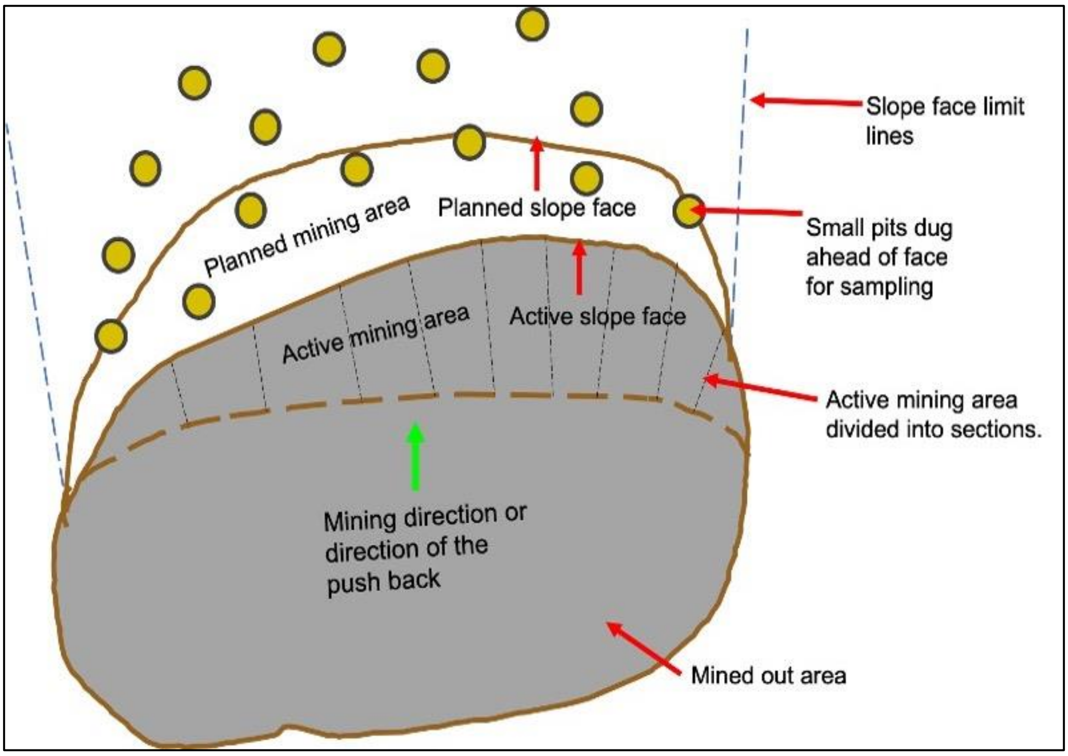

Figure 5.14: Rough sketch of mining plan explained by miners (author's interpretation)

Figure 5.14 shows a rough illustration of the informal mining plan as explained by the miners. The type of planning that legal miners conduct seems appropriate for their scale of mining. Although they apply first principles and do not use technical terminology, their way of thinking aligns with mining engineering principles. The mine understands the concepts of pit and slope design, mining blocks, mining direction, and they plan future production advances (specifically for the following week). The production data for this case study is provided in Chapter 6.

5.5.5 Mining methods applied by the legal miners

The two legal mines that were observed use a combination of open pit, hydraulic mining, sluicing, and panning. To begin mining, the operations construct an open pit by stripping the topsoil and mining through the hanging wall waste to expose the ore zone. The miners explained that they know they have reached the ore horizon when they pass clay overburden and intersect black gravel as shown in Figure 5.15.

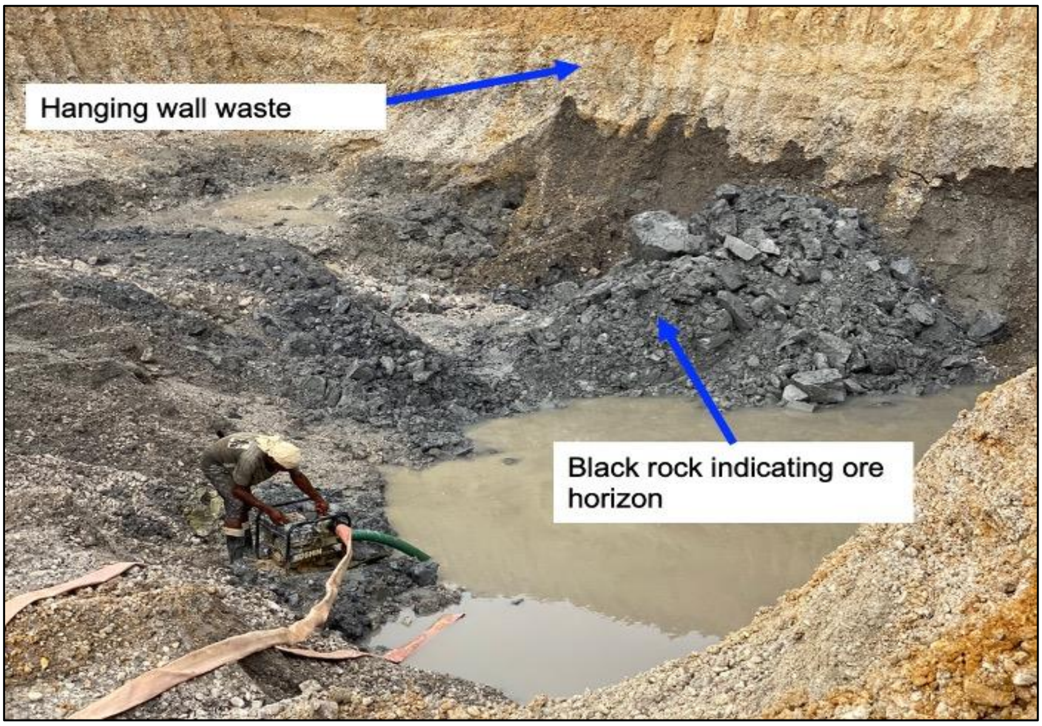

Figure 5.15: Mineralised zone indicated by black gravel

The method that the miners use to identify the mineralized zone aligns with Michaud's (2016d) description of the mineralization of gold placer deposits in section 5.3.2.

In the process of exposing the overburden, the mines ensure that they dump waste strategically to avoid rehandling, and to make it easy to backfill the pits in the future. The mine applies geotechnical principles to ensure the stability of the high wall. In the past, the miners used to experience slope failures. The experience has taught them to excavate the highwalls at an angle to ensure stability and minimize the risk of slope failures. This application is shown in Figure 5.16 .

Figure 5.16: Geotechnical engineering principles observed on one of the legal mines

Once the ore zone is exposed, a mining starting point is established with the help of a surveyor. After determining the starting point and projecting the mining faces, the miners construct a paddock where the hydraulic mining equipment is to be installed. The miners also understand the concept of pushbacks and open pit shells. They determine pit limits, and they push the hanging wall back to a projected limit to advance production. Figure 5.17 shows the hydraulic mining method that is used on site[32]. This hydraulic system also doubles as a washing plant.

[32] The miners refer to the entire mining system as a washing plant.

Figure 5.17: Hydraulic mining as conducted by the legal miners

Inside the pit, an excavator is used to load the broken ore into the top board or first washing tray. In this tray, hydraulic power is applied to wash or separate the rocks and create a slurry that moves to a primary sluice box.

5.5.6 Mineral processing

The sluice box shown in Figure 5.17 is lined with a prospecting mat. This mat is used to trap or recover any gold particles or residue released during the process (the gold particles sink into the prospecting mat due to their high density). The tailings from the primary sluice box are then pumped to a secondary sluice box that is used to catch any remaining gold. At the end of the working day, the miners take the prospecting mat and wash it to liberate all the recovered gold particles. In this operation, the prospecting mat is washed every four hours. The recovered gold is washed and processed using panning and controlled mercury amalgamation. The amalgamation process produces a concentrate, which is recorded and stored for tallying. The values of the amount of gold that is recovered on an average week are shown in Table 6.1 (Chapter 6).

The site manager tallies the recovered gold amalgam on the Tuesday[33] of every week. He back-checks the recovery against the values that were projected. This back check helps the mine to verify the validity of the sampling and the survey data; it also helps to identify whether gold has been stolen on the operation. According to the miners, their method of back checking works for them, and it has been improved over time. They say it produces reliable results and they are confident in the values they get.

5.5.7 Environmental Management

a. Land Rehabilitation

The legal small-scale mines are surrounded by pits that have been backfilled and levelled with waste rock (as shown in Figure 5.18). It was evident that the legal miners rehabilitate as they work. The replacement of topsoil was also visible on the land. The miners indicated that they store the topsoil when they excavate so that they can return it during rehabilitation. Vegetation was also seen growing on the rehabilitated areas. According to the Minerals Commission (2022), registered small-scale miners are provided with seeds (such as palm kernel seeds that produce palm trees) to replant the lost vegetation. The legal miners expressed that they rehabilitate because it is a legal obligation. They also feel that it is 'the right thing to do', and legal operators would like to see the land being used for other economic activity. Even though they try their best to rehabilitate, they are aware that there is room for improvement.

[33] In Ghana, gold is tallied on Tuesdays. This is because in some areas, Tuesdays are revered for cultural reasons. On this day, all economic activities that disturb the land (such as farming, fishing, and mining) are paused, and employees use the day to conduct repairs, maintenance of equipment and tallying of their produce.

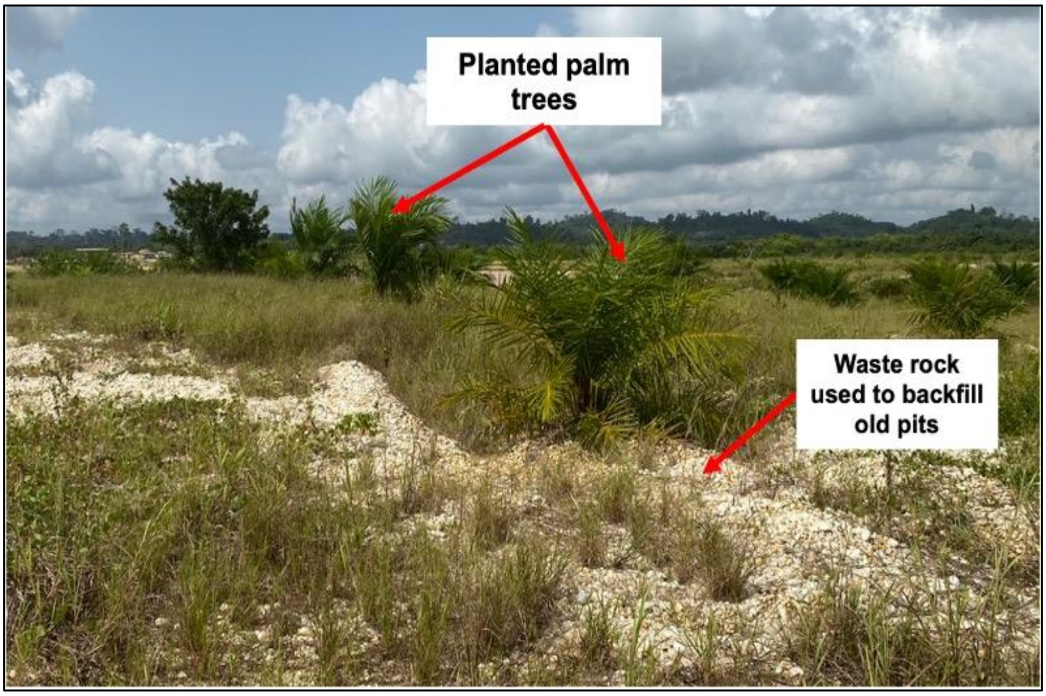

Figure 5.18: Rehabilitated land with backfilled pits and vegetation

b. Waste Water Management

The legal miners have systems in place to manage wastewater that is discharged. The main supply of water is the ground water table. They employ a 3-pond system, which recycles the water to optimize water usage, and prevents contaminated water from entering the environment or main water bodies. The 3-pond system involves the construction of water ponds and a series of catchment berms, which direct the water away from rivers and streams. Figure 5.19 provides an illustration of how the water recycling system works as explained by the miners and as written by Tychsen et al (2017).

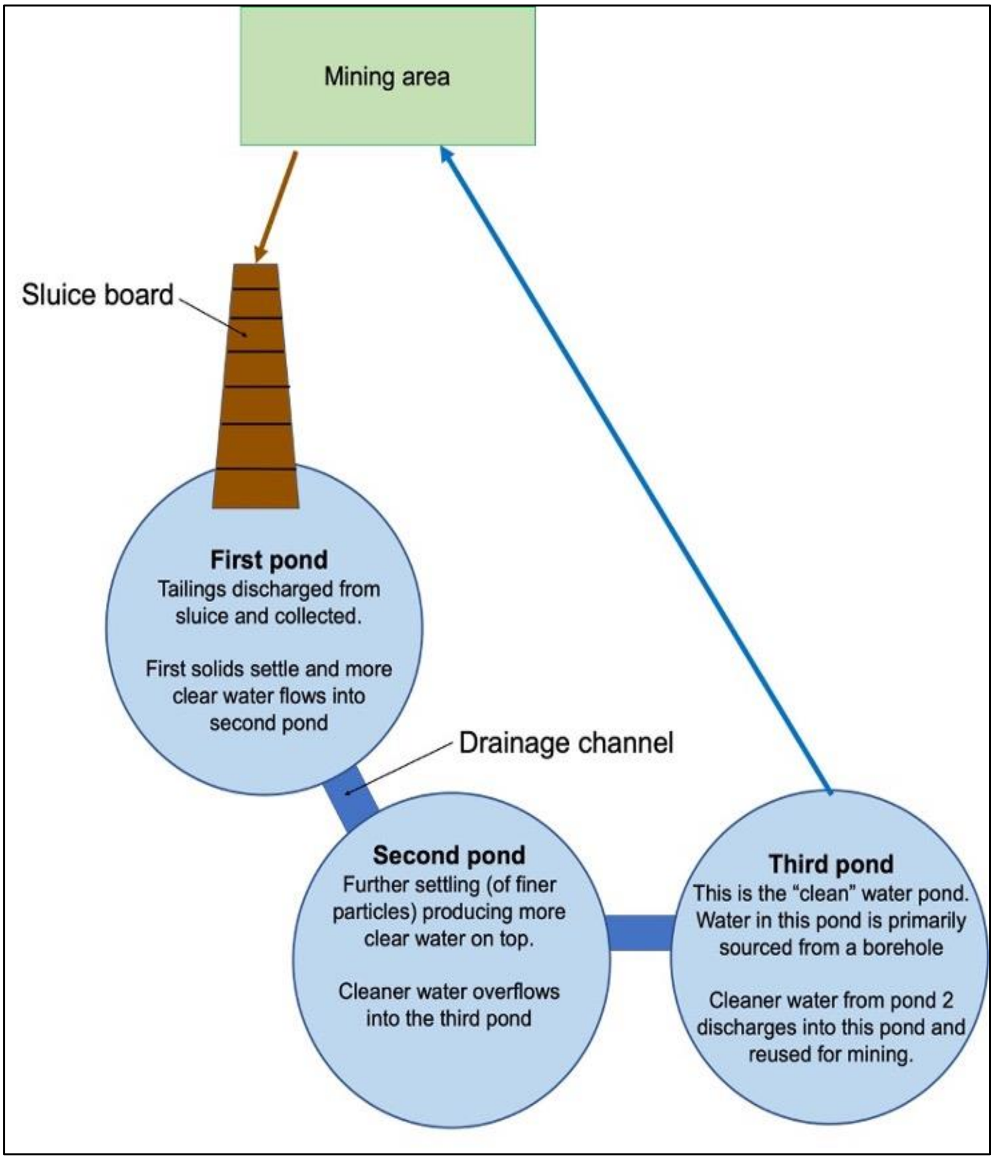

Figure 5.19: Illustration of the 3-pond water purification system (author's interpretation).

As shown in the diagram, the tailings from the secondary sluice box are discharged into the first water pond, where the first settlement of the solids occurs. The solids settle at the bottom of the pond and the cleaner water overflows into the second pond. In the second pond, finer particles are given a chance to settle and the purer water on top discharges into the third pond. The third pond is used to catch the purified water and store water from the borehole. The water in this pond is pumped back and reused in the mining activity. A photo of the 3-pond system used on the legal mining site is shown in Figure 5.20.

Figure 5.20: The 3-pond water purification system on the mine

The mine also has a pit dewatering system to ensure all excess water is pumped out of the working areas. A storm water drainage system (drainage humps, berms, and furrows) was also observed on the mine. The system was developed to direct rainwater around and away from the excavations. The storm water drainage is essential because of the high rainfall that is experienced during the rainy season.

The differences between the illegal and legal small-scale operations prompted a comparative analysis, which is provided in Annexure 4

5.6 Conclusion

Chapter 5 shows that legal and illegal small-scale operations work in different ways. Legal mines are better capitalised, organized, and are more likely to comply to mining and environmental regulations. The legal miners have a very good understanding of mining engineering principles, and they apply mining techniques. The importance of registering a mining operation is also very well understood by the legal miners. The legal mines function properly because they put more resources on the line, and because of this, they have a bigger commitment to produce and comply to rules and regulations. Observations made at the illegal mining area show that working conditions are unsafe. They also show that the mines are not well managed or equipped. These mines do not abide by any environmental, safety or mining regulations.

Chapter 6 analyses the production data provided by the legal mine in case study B to gain an understanding of the financial viability of small-scale mining projects.

6 PRODUCTION ANALYSIS AND FINANCIAL VALUATION OF THE LEGAL SMALL-SCALE MINING PROJECT

Chapter 6 investigates the application of financial valuation to small-scale mining. In this chapter, the research uses the production data provided by the legal small-scale mining operation (Case Study B) to conduct a probabilistic analysis of different gold production scenarios. It then uses this information, as well as cost estimates, to generate discounted cashflows for the scenarios.

6.1 Production data provided by the legal small-scale operation

The legal mines presented in Case Study B keep a production logbook that records the weekly gold recovery. One of the mines provided the researcher with production data for one week, which is shown in Table 6.1.

Table 6.1: Weekly gold production data for the legal small-scale mine

Date and workday (Year - 2020)	Frequency of washing prospecting mat (hours)	Total daily hours worked	Total 'cooked' gold (g)
Wednesday, 19 February	4	16	205
	4		248
	4		237
	4		311
Thursday, 20 February	4	16	315
	4		338
	4		332
	4		347
Friday, 21 February	4	16	315
	4		274
	4		351
	4		354
Saturday, 22 February	4	8	261
	4		126
Sunday, 23 February	4	16	186
	4		251
	4		183
	4		94
Monday, 24 February	8	8	210
Total		**80**	**4938**
12% of gold recovered due to miner (g)			*593*
88% of gold recovered due to sponsor (g)			*4345*

According to this data, the mine produced 4.3 kg of gold between the 19^{th} of February and the 24^{th} of February 2020 (i.e., in one week). The mine operates for six days a week (i.e., from Wednesday to Monday) and it runs on two 8-hour shifts per day. The table shows that the miners collect the gold from the washing plant regularly during the shifts. They do this by washing the prospecting mat every four hours. They then amalgamate the gold and weigh the final product. The miners refer to the amalgam product as ‘cooked gold’, however, the technical term is sponge gold (Tychsen et al., 2017).

6.1.1 Probabilistic analysis of the production data

Table 6.1. shows that production was interrupted on Saturday and Monday. According to the miners, this was due to the breakdown of one of the excavators. The miners explained that their production efficiency depends on the following factors:

- The grade of the deposit;
- The efficiency of the machinery and equipment (i.e., the excavator and the washing plant);
- The nature of the gravel being washed (sometimes the gravel is thick, and it takes longer to wash); and
- The weather (production decreases during the rainy season).

To account for these factors, the report uses the data provided in Table 6.1 to conduct a probabilistic analysis of the gold production per shift. The aim of this is to estimate the worst, most likely and best-case scenarios for gold recovery in one shift. Table 6.1 shows the input parameters that were used to conduct the analysis.

Table 6.2: Input parameters used for probabilistic analysis

	Gold produced every 8 hours (g)
Lowest production value	210
	277 387 437 453 548 589 653 679
Highest production value	705
Mean value[34]	493,8
Standard deviation[35]	170,0

The data in Table 6.2 shows that the least amount of gold recovered during the week was 210g, the highest was 705g and the average was 493.8g. This data was used to generate the normal distribution curves shown in Figure 6.1 and Figure 6.2.

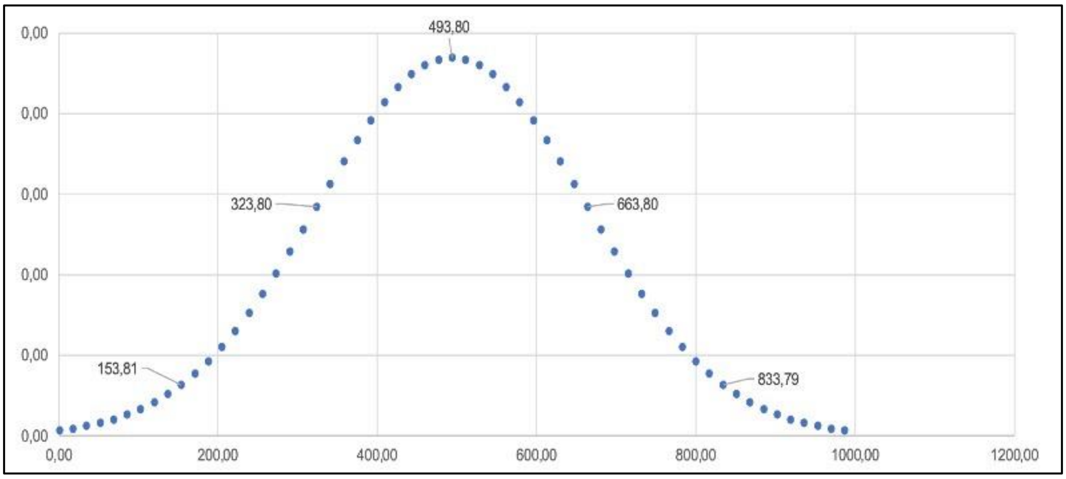

Figure 6.1: Normal distribution curve for small-scale gold production per shift

[34] The mean is the average value of the data provided.

[35] Standard deviation refers to the spread of the data about the mean.

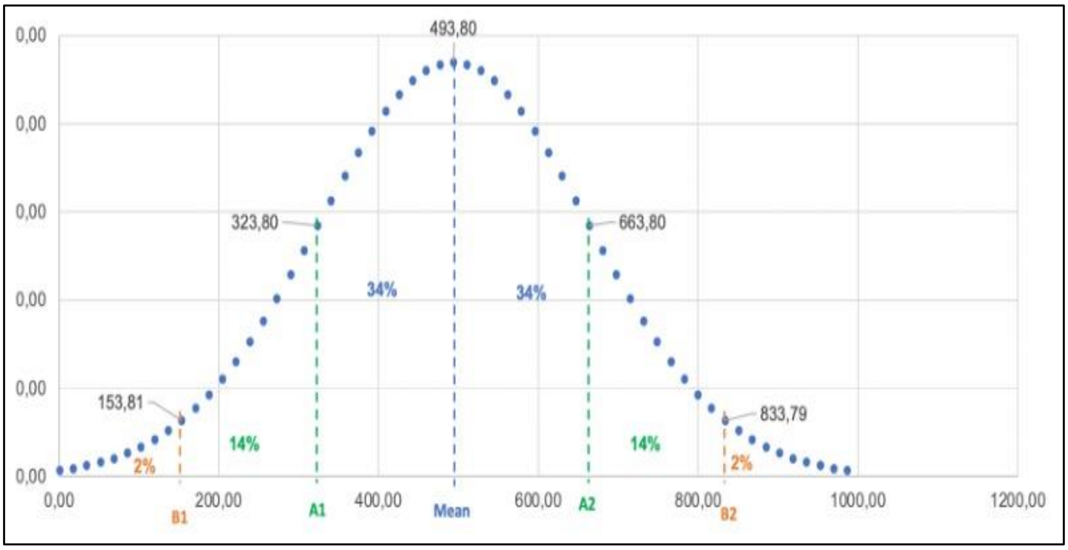

Figure 6.2: Normal distribution curve for shifts indicating probabilities of gold production.

Points A1 and A2 on Figure 6.2 represent the mean less one standard deviation and the mean plus one standard deviation respectively. Points B1 and B2 show the mean less and plus two times the standard deviation. The area underneath the graph indicates the probability of producing a certain amount of gold in one shift. In total, this area amounts to a probability of 100%. The probability decreases as the curve approaches infinity (Frost, 2021).

This graph can therefore be interpreted as follows:

- **Between points A1 to mean, and A2 to mean:**
  - Each area represents a 34% probability. This indicates that the mine has a 34% probability of producing between 323.8g to 493.8g of gold. There is also the same probability of producing between 493.8g to 663.8g of gold in one shift.
  - Most of the gold production will lie between the ranges of A1 and A2 because this is where the curve has the biggest area (68%).

- **Between points A1 to B1 and A2 to B2:**
    - The mine has a 14% probability of producing 153.81g and 323.8g of gold. It has the same probability of producing between 493.8g to 833.79g of gold per shift.
- **From points B1 and B2 to infinity**
    - The last area shows that there is an even lower probability (2%) of the mine producing less than 153.81g or more than 833.79g of gold in one shift.

The shift production values shown in Figure 6.2, (i.e., the values at the second and third standard deviations or 3 inflection points) were used to estimate the range of possible weekly production. These production numbers were multiplied by the total weekly hours shown in Table 6.1. This resulted in the generation of the weekly production figures shown in Table 6.3.

Table 6.3: Estimated weekly production figures

	Estimated Gold production per week - 80 hours (kg)
Lowest possible value	0,00646
	1,54 3,24 4,94 6,64 8,34
Highest possible value	9,87
Mean	4,94
Standard deviation	3,59

The information in Table 6.3. corresponds with the feedback that was given by the miners. They indicated that on an unproductive week, gold production can be as low as 1kg or 2kg, and in a good week, production can exceed 6kg. The 4.9kg gold production recorded in the mining logbook (Table 6.1) falls within the range of average. The production figures in Table 6.3 were used to create a normal distribution curve for the weekly production (shown in Figure 6.3) and a probability analysis (shown in Figure 6.4) for the weekly gold production. The x-axis represents the gold production in kilograms, and the y axis represents the values that normalize the data.

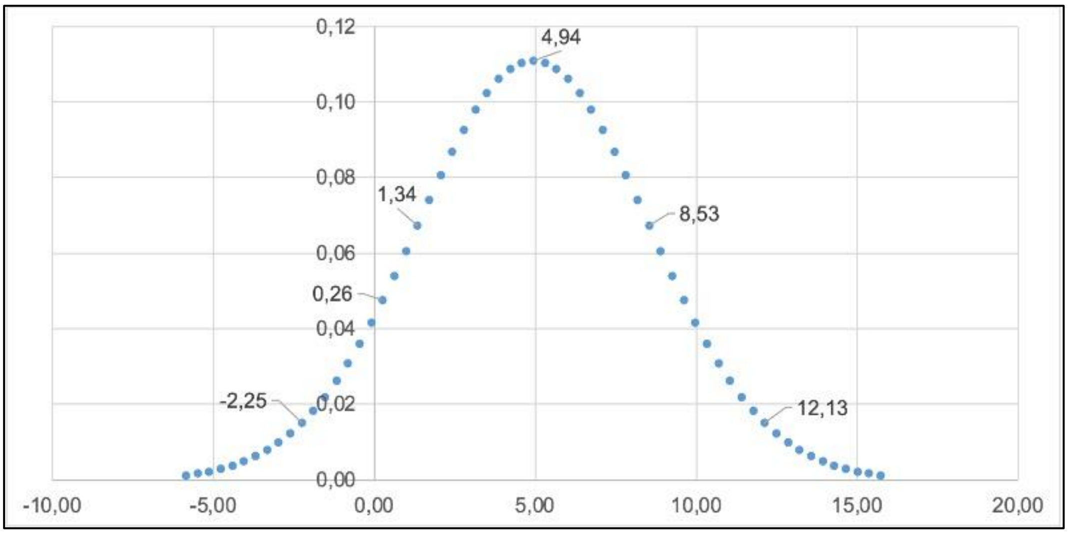

Figure 6.3: Normal curve for weekly gold recovery

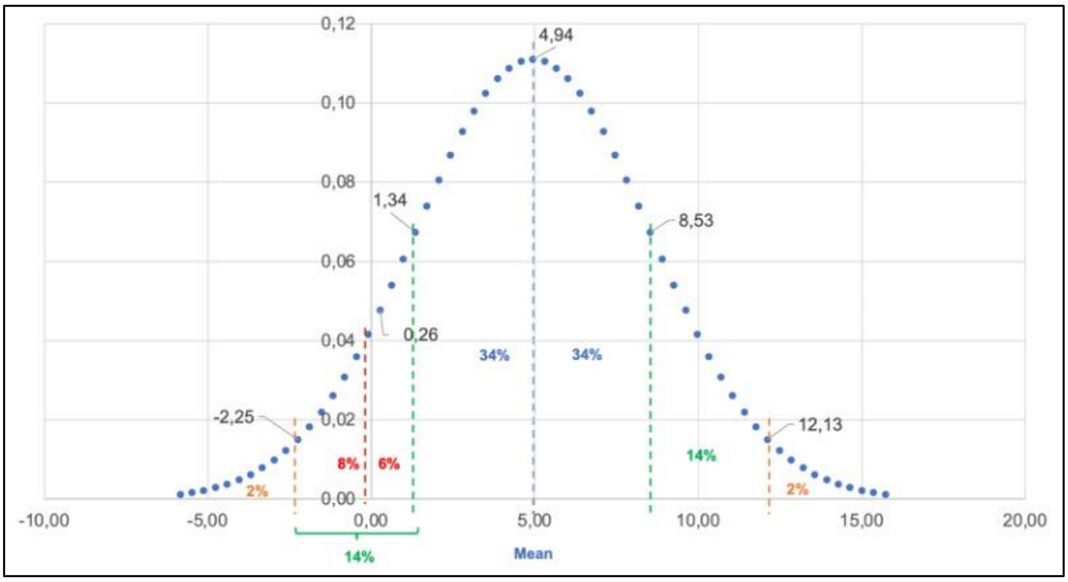

Figure 6.4: Normal distribution curve for weekly gold production indicating probabilities

The following observations can be made from Figure 6.3 and Figure 6.4:

- There is a 68% probability that the mine will produce between 1.34kg and 8.53kg of gold in one week;
- There is a 14% probability that the mine will produce between 8.53kg and 12.13 kg of gold in one week;
- There is a 2% probability that the mine will produce more than 12.13kg of gold in one week.
- The curve moving into the negative X axis indicates the probability of zero gold production during the week. The area under this portion of the graph was calculated to be 10%. Therefore, one can assume that there is a 10% probability that the mine will produce zero gold during the week.

The interpretation of Figure 6.4 gives the research enough information to create different production scenarios for the mine. Table 6.4. shows the production values that will be allocated to each production scenario.

Table 6.4: Scenarios based on distribution of weekly gold production

Production Scenarios	**Weekly gold production**
Worst case 1	0,26 kg
Worst case 2	1,34 kg
Most likely case	4,94 kg
Best Case	8,53 kg

6.2 Gold recovery on the operation.

6.2.1 Reporting the recovery of placer gold deposits.

According to Clay & Shumaker (2004), the recovery of gold placer deposits is reported in grams per cubic meter (g/m^3). This reporting denotes the dry in-situ volume of the material mined. The volume of rock mined is the sum of the gravel that is treated, and the overburden removed[36]. The production scenarios shown in Table 6.4 were converted to this configuration using the process shown in Table 6.5.

Table 6.5: Recovery values (g/m^3) of the placer gold deposits for the four production scenarios

	Scenario / Units	Worst case 1	Worst case 2	Most likely case	Best Case
	g	265	1 343	4 938	8 532
Gravel treated	m^3	278	278	278	278
Overburden mined - Clay	m^3	998	998	998	998
Total material moved	m^3	1 276	1 276	1 276	1 276
Gold grams per unit volume	g/m^3	**0,21**	**1,05**	**3,87**	**6,69**

The gold grams per unit volume in Table 6.5 were used as input data to simulate discounted cashflows for the 4 production scenarios.

6.2.2 Trading of the recovered gold

The small-scale mine sells the sponge gold to a licenced buyer on a weekly basis. The buyer then assays the gold using a specific gravity testing machine and method to determine the purity and the corresponding gold price. Figure 6.5 shows the testing equipment used to determine the gold purity. The process of determining the purity of the gold, as explained by the buyer, is summarised in Figure 6.6.

[36] The miners indicated that even though they keep a record of the amount of waste mined, they do not focus much on the volume of waste moved or gravel washed. Their primary focus is rather on the amount of gold that is produced daily and weekly.

Figure 6.5: Gold assaying equipment used by buyer.

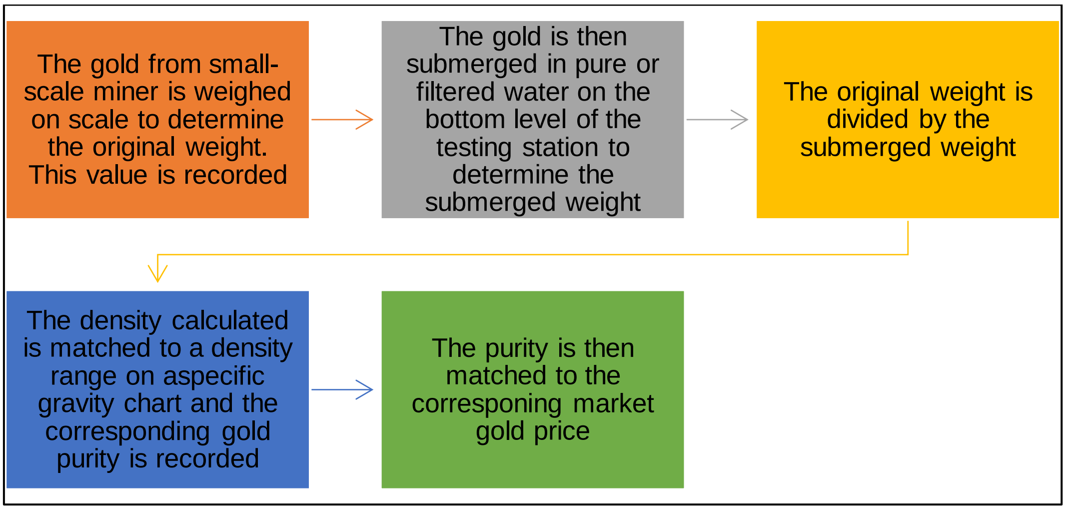

Figure 6.6: Process of calculating gold purity (author’s interpretation).

To increase the accuracy of the assay, the gold is submerged into a measured amount of pure or filtered water (as shown in Figure 6.5). The specific gravity of the gold sold in the week of study was calculated to be 11. This value corresponds to a gold content of 25% (i.e., 6K gold) . This gold content and karats were determined using the charts provided in Annexure 5. On the 24th of February 2020, the price for 24k gold (99,99%) was USD1672,4/oz, and the price of 6k gold was USD418,10/oz (Goldprice.org, 2020). The buyer explained that he monitors the gold price on an hourly basis to negotiate a good buying and selling price. In this case, the buyer has negotiated to purchase the gold from the mine at USD33 (GHC200) less the market value. This is done to cover the buyer's overhead costs. This means that for the week of study, the mine sold the gold that was recovered for USD385,10/oz.

After purchasing the gold from the mine, the buyer purifies it further by smelting it in a crucible using oxygen as shown in Figure 6.7. A portion of the smelted gold is used to create jewellery, which is sold locally, and most of the gold is sold to the Ghana Precious Minerals and Marketing Company (PMMC).

Figure 6.7: Gold smelting method used by licenced buyer

Although the benefit of registering a small-scale mine is great in the early stages of the value chain, further down, the registration status does not appear to count. All of the gold that is produced (from both the legal and illegal operations) is delivered to the (same) local refineries, and it enters the mainstream market.

Although the gold refinery that was observed in this study accepts only legal gold, in the local town there are several other shops that receive gold from illegal mines.

6.2.3 Estimated revenue for one week.

For the week shown in Table 6.1, the operation sold their gold at USD385.10/oz and collected a revenue of USD67, 077.88 as shown in Table 6.6. The revenue from the gold sale is divided between the Site Manager (who takes 12%) and the Sponsor (who takes 88%). This split ratio varies from one operation to the other. In this mine, the sponsor is responsible for all the operating costs.

Table 6.6: Revenue generated from weekly production

Item	Units	Weekly values
Gold recovery	**g**	4 938
	kg	4,94
	oz	174
Gold Price ***25% - 6K gold on 2020/24/02*	**USD/oz**	418.10
Gold Price used to purchase from small-scale mine *** 6k price less USD33*		385.10
Total Revenue	**USD**	67 077.88
	GHS	355 512.76
Revenue due to miner (12%) ***compensation that miner receives*	**USD**	8 049.35
	GHS	42 661.53
Revenue due to sponsor (88%) ***compensation for the sponsor. Also used to cover the mine operating costs*	**USD**	59 028.53
	GHS	312 851.23

6.3 Estimation of costs incurred by the small-scale gold mine

6.3.1 Capital costs and direct costs

To buy equipment and machinery that is in good condition, the operation would need at least 500 000 Cedis (depending on the size of the mine) to a few million Cedis. According to the legal small-scale miners, the lower range applies to operations that rent or purchase second-hand machinery and equipment, and the higher range applies to operations that buy brand new machinery and equipment.

In addition to this, the mines are required to pay once-off crop compensation to the farm owners of the land, which can range between 25 000 to 30 000 Cedis for every acre of land disturbed by mining. There is also a compensation that is given to the traditional authorities of the mining area to maintain a cordial relationship with the community leaders.

A shortcoming that was observed in the field was that the mine does not keep a good record of the operating costs. An informal record is kept of the amount of diesel used, but there is nothing for the maintenance and running costs of the machinery and washing plant. Although a record could not be provided for the costs, the miners indicated that the daily cost of renting an excavator was about GHS4000 (USD634) per 8-hour shift. This amount excludes fuel and labour.

The inability to obtain accurate cost information resulted in the research estimating both the capital and operating costs. The estimations were based on mining engineering knowledge, information from machinery and equipment suppliers, and literature. Although the estimations are not accurate, they give an idea of the costs incurred in a typical semi-mechanized small-scale gold mine. Table 6.7 provides an inventory of the capital goods that were observed onsite and the associated costs (excluding labour).

Table 6.7: Estimation of capital costs and direct costs

Item	Description	Quantity	Purchase cost plus 12,5% VAT (USD)	Operating cost ($/hr)	Operating cost ($/m^3)
Excavator	*CAT 336 Hydraulic Excavator*	2	529 816	27.00	1.37
Water pump	*Diesel water pump - 12inch Diesel Water Pump with Outflow 800m^3/H*	2	6 750	2.34	0.15
Washing plant equipment	*50 to 150 tph washing plant*	2	30375	0	0
	Sluice box	2	1688	0	0

Source: Kompareit (2021); MarketBook (2021); Supplier Directory (2021); 911 Metallurgist (2021).

The cost estimates were based on new machinery and equipment. The Excavator purchase costs were sourced from an online advert of a new medium-sized excavator. The Diesel pump, washing plant and sluice box costs were sourced form supplier websites. The 2020 Ghana diesel price was used in the calculations. All the machinery and equipment prices show in Table 6.8 include VAT.

6.3.2 Variable costs

As discussed earlier, the wages of the mine employees depend on the weekly gold recovery and gold price. This means that they are variable costs. The miners were able to give rough estimations of the labour costs (which are shown in Table 6.8). The labour costs for this operation are also the responsibility of the sponsor. The sponsor first pays the site manager his portion of the revenue (12%), and thereafter pays the workers. Table 6.8 shows that the estimated weekly labour costs of this operation amount to USD12355, which is roughly 18.4% of the gold revenue for the week of study.

Table 6.8: Estimated labour costs.

Job category	Number of employees	Weekly Earnings (% gold revenue per employee)	Weekly cost (USD)
Pit workers - Production workers, engine operators	7	0,36%	1 688
Site Manager	1	12%	8 040
Pit Supervisor Engineering Foreman	2	0,8%	1 072
Excavator operators	2	0,6%	831
Workshop Technicians	2	0,36%	482
Supporting staff	2	0,2%	241
Totals	**16**	**18,4%**	**12 355**

The legal small-scale miners added that the workers earn an income that is more favourable than other economic activities such as farming.

6.3.3 Indirect costs

Small-scale mines in Ghana are required to pay a royalty rate of 5% of the revenue earned (Tychsen et al., 2017). The country currently does not have a tax system that is made specifically for the small-scale mining sector. According to a the ASM framework published by the Minerals Commission (2015), taxing small-scale mining operations in Ghana is very difficult. To make it easier to collect taxes, some mining districts charge the operations levies.

The tax rate that caters to small and informal businesses (referred to as the Income Tax Stamp[37]) cannot be used for this research because it is only applicable to informal service providers (Twum et al., 2020). The tax rate currently imposed on the Ghana minerals sector is 35%. Because of the ambiguity of the taxation of small-scale mines, the financial valuation in this report applies the 35% minerals sector tax rate.

[37] The rate of the Income Tax Stamp depends on the volume of produce, nature and size of the business

6.4 Financial valuation of a small-scale mining project

The purpose of financial valuation is to determine the future profitability of the project, and to indicate whether the project will be worth the investment. In this case, the discounted cashflow valuation method was used to evaluate the project presented in Case Study B. The discounted cashflow uses the principle of the time value of money to estimate the future value of an investment made in the present (Fernando, 2021; Wits University , 2015). It takes the future values of the cashflow and discounts them at a rate to values that are applicable to the present.

The discounted cashflow uses Net Present Value (NPV) and Internal Rate of Return (IRR) as metrics to evaluate potential projects. The NPV is the difference between the present value of cash inflows and outflows over a period of time. A negative NPV indicates that the project will make a loss, and it will not be worth the investment. The IRR gives an indication of how profitable a project will be. It estimates the discount rate at which the NPV will be zero. In simple terms, the higher the IRR, the more attractive the project. The challenge with the IRR is that at times, it can produce 'abnormal' results. This is because the IRR calculation requires the cash to flow in a certain way, i.e., from negative to positive, and in practice that is not always the case (Wits University , 2015).

A discounted cashflow was created for each scenario shown in Table 6.5. The following assumptions, conditions and parameters were applied to the cashflows:

a. A life of 10 years was forecasted for the project. The legal mine has proven that it has a life exceeding ten years (since it has been operating since 2009). The 2020 year was marked as the first year of production, and the year 2019 was marked as year zero (building up to production).

b. There was no interest charged to the capital invested. This is because normally the people who invest (sponsors) become partners, who deduct a percentage of the revenue rather than charging interest on the investment.
c. The cashflow contains the categories of machine buyers and machine renters. The former refers to a scenario where the project purchases the machinery used on the mine, and the latter refers to a scenario where the project rents the machinery.
d. The capital invested is paid off in production year 1. Because of the unpredictable nature of these operations, investors look for quick returns and recovery of investment.
e. To generate an IRR, the cashflow must indicate a loss in the first few years of the project. This resulted in the volume of material mined being decreased for the first few years of production. Reduced production at the start of a project is a reality because mines ramp up production in the initial years.
f. The gold price forecasting for the years 2021 to 2025 was made using data from the forecasting website knoema.com (2021). Realistic forecasts for 2026 to 2029 could not be found, this resulted in the research estimating the gold prices for these years.
g. A discount rate of 14% was applied to the cashflow. This is because the interest rate in Ghana at the time of this study was 13.5%. The rate was rounded off to 14%.

Four discounted cashflows were generated for the project. The cashflows for the scenarios are presented in Annexure 6 to Annexure 9. Each cashflow provides an IRR percentage and an NPV profile for the different production scenarios.

Following the analysis of the 10-year profile cashflows, the report also presents a brief analysis of the cashflows with a project life of 5 years (i.e., 2019 to 2025). This analysis is conducted because small-scale mining licences in Ghana are only valid for 5 years. The analysis helps to examine the practicality of the 5-year life of mine in comparison to a 10-year project life.

6.4.1 Analysis of the discounted cashflow results – 10-year profile

The results of the discounted cashflows for the four scenarios are summarised in Table 6.9, Figure 6.8 and Figure 6.9.

Table 6.9: Results of discounted cashflow: 10-year project life

Grade	0.21g/m^3	*0.5g/m^3*	1.05g/m^3	3.87g/m^3	6.69g/m^3
NPV - Machine Ownership (USD)	(415 018)	*23 097*	854 006	5 114 299	7 836 990
NPV - Machine Rental (USD)	(1 442 428)	*1 387*	225 687	4 485 980	7 342 648
IRR - Machine Ownership (%)	-27%	*1%*	30%	166%	166%
IRR - Machine Rental (%)	Numerical Error	*0.1%*	15%	344%	375%

The project returns a negative NPV and IRR with a recovery grade of 0.21g/m^3. This means that the project will make a loss at this recovery. The loss made will be four times bigger, if the project uses rented machinery. For this scenario, the IRR calculation returns a numerical error.

The project will begin to return a positive NPV at a recovery of 0.5g/m^3 for machine buyers[38]. At this recovery, it generates an NPV of USD23,097 and IRR of 1%. In the case of machine renters, the project will only begin to generate a positive NPV (USD1387) and IRR (0.10%) at a recovery of 0.9g/m^3.

[38] The column corresponding the value of 0.5g/m3 is highlighted yellow because it represents the point at which the NPV becomes positive. The same applies for table 6.10 at 1.09g/m^3.

The project will return a positive NPV if it mines at a recovery of 1.05g/m^3. With this scenario, the NPV is four times more (i.e., USD854,006) if the project buys machinery, and the IRR is double (30%) that of a project that will rent machinery.

At recoveries of 3.87g/m^3 and 6.69g/m^3, the project continues to generate positive returns. The gap between the NPV for bought and rented machinery decreases with higher recoveries, and the IRR of the machine renters begins to exceed that of machine buyers.

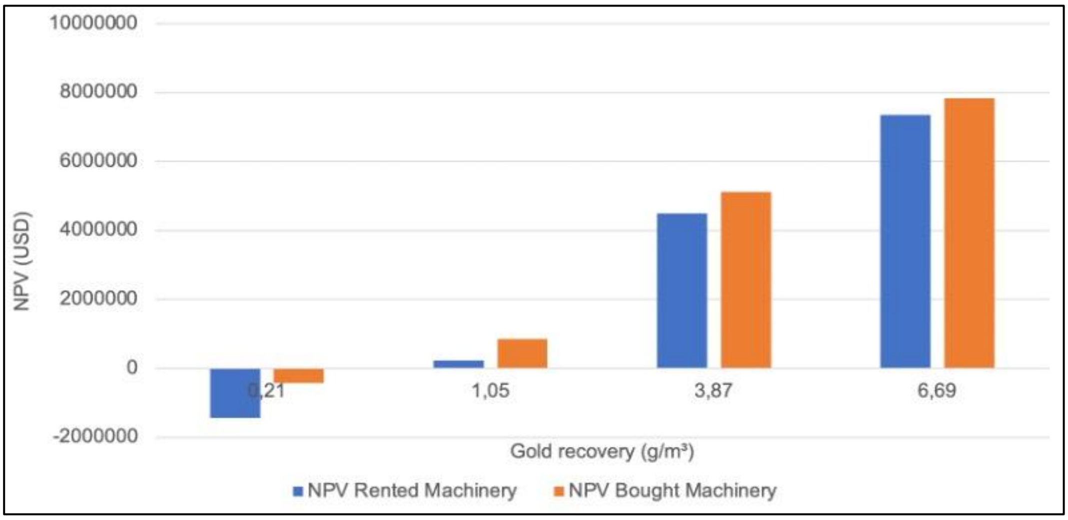

Figure 6.8: NPV of different scenarios as gold recovery increases

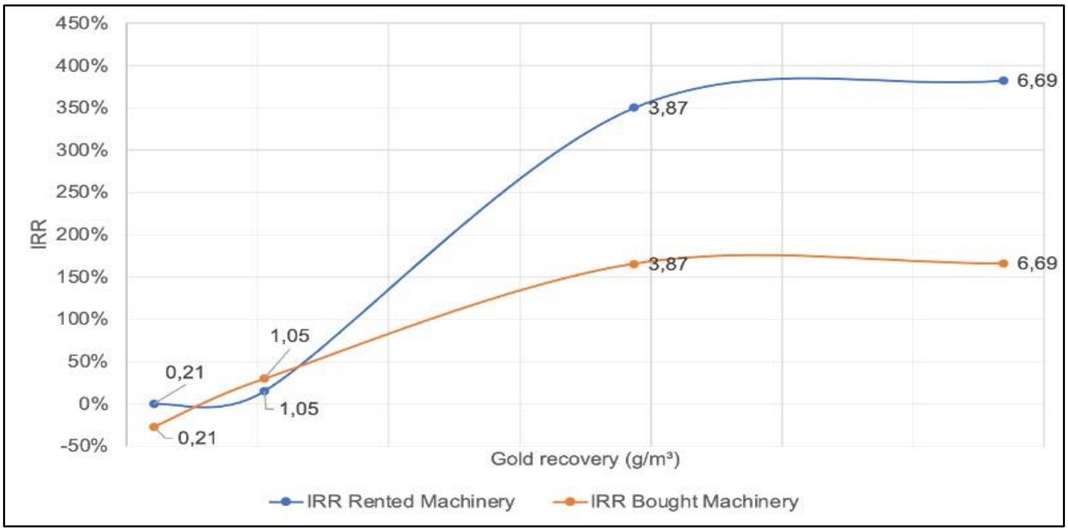

Figure 6.9: IRR as gold recovery increases: Bought vs rented machinery

Even though the gaps between the IRR for the machine renters and buyers reduces with an increase in gold recovery, the operating costs of the machine renters will always be significantly higher. However, the cashflow also shows that at higher gold recoveries, machine renters might be better off than machine buyers. This is shown in Figure 6.10. The high operating costs associated with renting machinery affect the profit margin of the project.

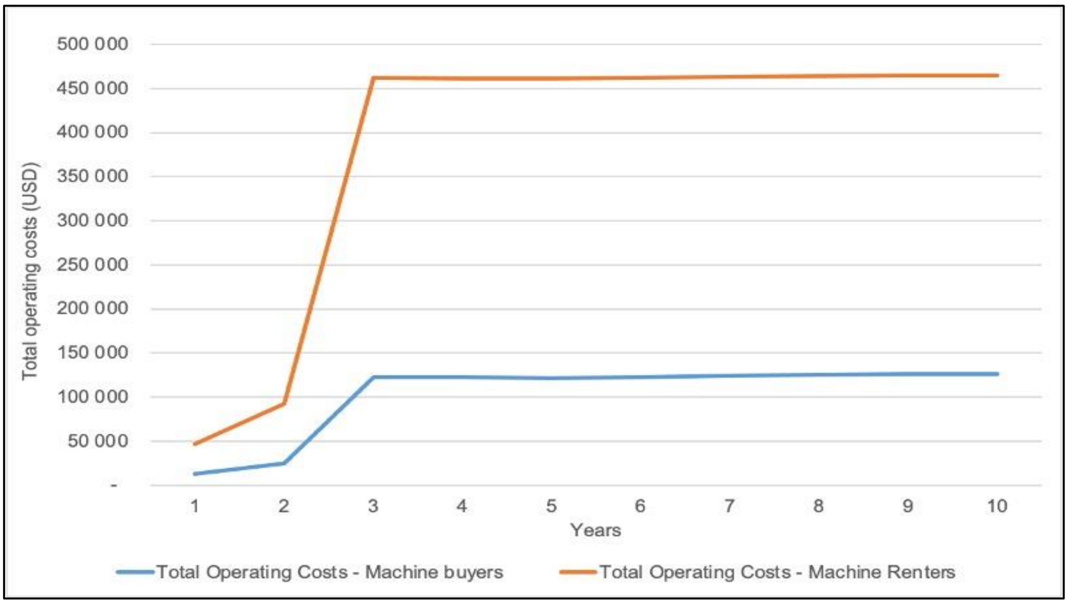

Figure 6.10: Operating costs of machine renters versus machine buyers.

6.4.2 Discounted cashflow analysis for small-scale mine: 5-year profile

Table 6.10: Results of discounted cashflow: 5-year project life

Grade		0.21g/m^3	1.05g/m^3	*1.09g/m^3*	3.87g/m^3	6.69g/m^3
NPV - Machine Ownership (USD)	USD	(458 006)	207 480	*239 170*	2 441 610	3 138 137
NPV - Machine Rental (USD)	USD	(901 251)	(25 281)	*6 409*	2 208 849	3 039 353
IRR - Machine Ownership (%)	%	-57%	15%	*17%*	162%	160%
IRR - Machine Rental (%)	%	Numerical Error	-4%	*1%*	349%	381%

The 5-year projection shows a decrease in the project NPV and IRR for all scenarios. A key observation here is that with machine renting, the project will only be feasible at gold recoveries higher than 1,09g/m^3. Similarly, to the 10 year cashflow, the gap of the NPV and IRR between the machine renters and buyers reduces with an increase in gold recovery.

6.5 Conclusion

Chapter 6 shows that it is possible to conduct financial valuation for a small-scale mining project, provided there is enough production and financial data. The chapter uses the production data provided by the legal miners to simulate the worst, most likely, and best-case scenarios for gold production and recovery. These scenarios are then used to create discounted cashflows for the project.

The discounted cashflows show that the project has the potential to generate a positive NPV. However, the NPV is affected by the decision to buy or rent mining machinery, especially when mining at low gold recoveries. Operating costs are four times higher when the machines are rented versus when they are bought. With low recoveries, it would be more feasible for this kind of project to buy mining machinery. With higher gold recoveries the gap of the NPV and IRR between machine buyers and renters reduces. In the case of the latter (i.e., high gold recoveries) machine renting might be a better option.

Chapter 6 also shows that the 5-year period that is currently allocated for small-scale mining licences in Ghana can count against the feasibility of a semi-mechanized project. This timeframe is not enough to generate positive returns on the cashflow, especially for projects that have low gold recoveries. Higher gold recoveries are required to mine profitably within the allocated 5-year licence period.

Chapter 7 is a continuation of the fieldwork exercise. The chapter documents the feedback from the engagements with different ASM stakeholders.

7 STAKEHOLDER ENGAGEMENTS

Chapter 7 documents the feedback from engagements with stakeholders that are involved in and affected by ASM. These engagements are important because they help the research to understand how the stakeholders perceive the ASM sector, and they help to gain insight on the way forward. The latter helps to bring a people-centred approach to solving the research problem.

Focus group discussions and individual interviews were used to engage with the stakeholders. Focus groups are an effective way to gather a large amount of data from selected groups in a limited amount of time (HERD, 2016). The method entails a group of peers discussing a topic under the facilitation of a moderator (the researcher)[39]. Individual interviews entail one-on-one discussions with individual people. The above discussions were conducted physically, and on virtual platforms such as Zoom and Microsoft Teams[40]. A summary of the feedback is provided in Annexure 10.

7.1 The planning process.

The planning of the stakeholder engagements consisted of the following:

1. Identifying the stakeholders;
2. Developing communication plans for the engagements;
3. Finalizing the selection of the stakeholders;
4. Conducting the discussions, and
5. Capturing and evaluating the feedback (in line with the wits code of ethics).

[39] Focus groups stimulate unrestricted, dynamic and open communication channels, which provide helpful insight for the research (HERD, 2016; Nyumba et al., 2018)

[40] The virtual meetings were conducted due to COVID 19 restrictions. COVID 19 safety measures were observed in all the physical meetings.

7.1.1 Selection of stakeholder groups.

Five stakeholder groups were initially identified for the interviews. However, two groups had to be adjusted during the execution stage due to risks and restrictions that were associated with the COVID 19 pandemic. These adjustments resulted in the university students' group being excluded, and the community group being replaced with community leaders (traditional authorities). At the end, four groups were interviewed. Table 7.1 provides a list of the stakeholders that were selected. It also shows the category they were placed under, and the communication method that was used to engage with them.

Table 7.1: Stakeholders and engagement methods

Stakeholder group	**Classification**	**Method of engagement**
Ghana Minerals Commission	Regulators	Individual interviews (Conducted in person)
The Ghana Chamber of Mines	Influencers	Individual interviews (Conducted virtually)
ASM owners and operators	Participators	Focus group discussion – In person (Conducted in person)
Traditional leaders/ Traditional authorities	Affected persons	Individual interviews (Conducted virtually)

7.1.2 Development of a communication plan

Eight themes were created to guide the stakeholder engagements, the themes are shown in Figure 7.1. The themes were designed in line with the research aim, objectives, and research question. Each question that was presented to the stakeholders fell under one of the 8 themes. It is important to note that the number and types of questions that were asked varied slightly between the groups. Seven of these themes are discussed in this chapter, and the feedback from the eighth theme is included in Chapter 8.

Figure 7.1: Eight themes used to guide the stakeholder engagements

7.2 Feedback from stakeholder engagements

7.2.1 The understanding of ASM

The stakeholders have a good understanding of ASM. Although their descriptions differed slightly, there was a common understanding that an operation falls into the category of ASM when it mines on a concession that does not exceed 25 acres. They indicated that in cases where the mining area is too big, the land can be divided into smaller portions (not exceeding 25 acres), and one can apply for an ASM mining licence for each portion of land.

The stakeholders voiced concerns about the current description of ASM in the legislation. One group felt that the description was outdated because small-scale mining has evolved and become more mechanized over the years. Half of the groups felt that the current legislation does not adequately describe, accommodate or recognize the more mechanized forms of small-scale mining. They gave a key example of the land allocation in ASM. They stated that the 25 acres maximum land size that is currently allocated for ASM has become too small for operations using heavy machinery. This land size might be more than enough for people using purely artisanal methods, but it is too small for semi-mechanized methods. Many of the stakeholders would like to see the legislation updated to accommodate the more mechanized small-scale operations.

7.2.2 The perception of ASM in Ghana

During the discussions, the groups constantly referred to ASM as Galamsey[41]. All the stakeholders shared the view that the perception of ASM in Ghana is negative. The sector is generally frowned upon because of its historical background. The view was that the sector has been severely mismanaged, with political influence being largely to blame for its chaotic state. In its current state, the sector is deemed to be dangerous, and very risky. It is regarded as one that brings more harm than good to the host communities and the country.

Despite this negative perception, all the stakeholders believe that ASM has significant potential, provided it is managed correctly. It is viewed as a lucrative business that has a future role, provided it is practised in an organised manner. One of the stakeholder groups drew attention to the evolution of ASM in Ghana over the years. They highlighted that in the past, it was only non-entities that were conducting ASM. However, the sector has grown to attract investment and

[41] A word commonly used by Ghanaians to describe the sector. According to Owusu-Nimo, et al (2018) Galamsey is a pidgin English word which originates from the phrase “gather them and sell”. The word is commonly associated with illegal artisanal and small-scale mining.

involvement from people of wealth and knowledge. Investors and sponsors are mostly wealthy people from large cities within the country such as Accra, Kumasi and Takoradi. One group ended by saying that the prospects of ASM are very good, production levels are high, and gold production from the sector is increasing.

7.2.3 Perceived ASM pull and push factors

The groups identified weak alternative livelihoods and the lack of economic opportunities as factors that push the locals to engage in ASM. They added that agriculture (i.e., palm tree plantation, cocoa farming, and other forms of farming) does not generate nearly as much income as small-scale mining. Some of the stakeholders spoke about a real-life scenario to give an example. They indicated that they could make a profit in excess of 10 000 to 20 000 Ghana Cedis in one month from ASM. However, on - 9ha cocoa farm, they only generate about 3 000 Ghana Cedis in profit in one financial year. This number is low considering that cocoa is one of the most profitable crops in Ghana. The stakeholders added that under the current circumstances, there is no way that farming can be considered as a better alternative livelihood to small-scale mining. They added that although ASM can be challenging, it pays well, generates quick returns and the income is consistent.

Other push factors that emerged during the discussions were the lack of job opportunities in large-scale mining, as well as ongoing retrenchments in the sector. One of the stakeholders indicated that he was formerly employed by a large-scale mining company. During the 2008 global recession, the company decommissioned a mining project and retrenched the employees. After the mine closure, the company gave the concessions back to the government which subsequently made the area available for small-scale mining. The former employee was able to obtain a mining concession on this land. He achieved this by collaborating with a group of local investors to apply and write a proposal to government (with assistance from the Small-scale Mining Association). This individual and his mining group have been successfully engaging in legal small-scale mining for more than 10 years.

Some of the push and pull factors identified by the stakeholders align with those that are discuss by the Extractives Hub in 2017. These push and pull factors are summarised in Table 7.2.

Table 7.2: ASM Push and pull factors identified by the Extractives Hub (2017)

Driving forces for ASM and SSM as indicated by the various countries	Push Factors for both ASM	Pull Factors for ASM
<u>ASM</u>: Economic conditions and economic hardship, commodity prices, desire for a subsistence livelihood, the lack of employment. Plunges in the agricultural sector **<u>Small-scale mining</u>** Financial interests, operational performance, commercial factors, and commercial desires	Desperation caused by unemployment or the need of income generation • A source of income to former mine employees or a transitional occupation for farmers, students on vacation etc. • An economic safety net in times of political and social unrest as well as economic and agricultural crises	Attractiveness due to low entry barriers such as: • The requirement of little to no skills • Low capital investment • An opportunity to "*get rich quick"* (Extractives Hub, 2017) a. Entrepreneurial opportunities in support services such as crushing, material handling, equipment sales, leasing, and maintenance b. The lack of regulation can cause criminals to see opportunities for illegal activities such as conflict funding, embezzlement of funds and other resources etc.

Source: Extractives Hub (2017)

7.2.4 Views on the ASM licensing process

In Ghana, small-scale mining applications are submitted to the Minerals Commission district offices. These applications are presented in hardcopy and in person. After receiving the application, the district office forwards them to the Accra Head Office for further processing. The applicants are not allowed to submit their applications directly to the Accra office. However, they are allowed to contact the Head Office to follow up on applications.

One of the stakeholder groups pointed out that obtaining a small-scale mining concession is an extremely difficult and daunting task. They say that it is costly, time consuming and the processing time is very long. There is a belief that the difficulty in obtaining a licence is one of the major factors that contribute to people mining illegally. They added that the licence application and processing time can take up to 1 year (if all goes well).

The stakeholders also spoke about the challenges created by the centralized processing of applications. Applicants frequently have to travel to Accra to follow up on and push their applications adding further to the costs and difficulties. The stakeholders also had a problem with the amount of paperwork involved. In the tedious application process, paperwork sometimes gets misplaced. In such cases, applicants have to travel to Accra to push the Minerals Commission to look for their documents, or alternatively find people within the commission to help them search for their files. The stakeholders believe that an electronic submission system can solve this problem. The Minerals Commission indicated that they are aware of the current challenges. They revealed that they had plans to take the application system online in the year 2021. They expected this to shorten the application process and make it easier to track submissions. The commission added that the district offices were going to be equipped for this transition.

The application timeline is also lengthened by the limited number of Minerals Commission district offices available. The stakeholders gave the example of the Dunkwa district office that was closed when the Akuffo-Addo regime came into power. The closure of the Dunkwa district office caused all regulatory activities to be channelled to the Obuasi office. This has put a very heavy workload on the

Obuasi office and has worsened the application backlog. This is seen as a big challenge because there is significant small-scale mining interest and activity in both Dunkwa and Obuasi. The Obuasi office services more than 200 small-scale mines from the two districts.

7.2.5 The challenges and factors limiting ASM

During these sessions, significant time was spent discussing the challenges facing the Ghanaian ASM sector. Many of the issues were brought up repetitively by the different groups. These challenges and limiting factors are captured in the order of the strongest to the weakest points that emerged.

a. Political Interference

The issue of political interference was brought up many times by all the stakeholders. There is a view that there is too much political interference in the sector. Most of the groups consider this to be the top factor that creates limitations in the sector. They believe that this puts the ASM sector in a perpetual state of turmoil and it prevents it from working towards any long-term goals. They added that political interference disturbs legislation and weakens the authority of the regulatory bodies. It also stops the relevant technical people from playing their roles. In the current climate when experts attempt to apply the book or their knowledge, they are counter acted by political interference. The groups added that politicians need to give the technical experts and regulators the space to guide the sector because they are specialists, and they are well equipped to do so. These parties are also inclined to being more impartial when it comes to advising the sector and applying the rules and regulations.

Another group added that politicians get involved in small-scale mining to get quick wins during their election terms. This disrupts the long-term goal of the sector because naturally, mining has a long gestation period that extends beyond election terms. Politicians usually try to shorten this natural gestation by cutting corners at the expense of legislation and the industry. This type of behaviour kills the long-term vision for the sector. One group gave a scenario where land was released by a large-scale mine for ASM. In this 9case, the politicians were accused of dividing the high-grade land amongst themselves and making the land with marginal and uneconomic deposits available to the public. This level of political interference was described as the looting of mineral resources (natural assets), and one of the highest degrees of theft.

All the groups believe that political interference in all forms of mining, especially small-scale, should be minimized. They articulated that politicians should focus on politics and leave the mining to the relevant regulatory bodies and technical experts to enable the industry to go a long way.

b. The lack of education and skills

All the stakeholders believe that mining is a highly specialized activity that needs technical skills to become profitable and sustainable. The lack of these requirements as well as education has become accepted and entrenched in the culture of ASM in Ghana. Some of the stakeholders believe that the only difference between large-scale mining and small-scale mining is the scale of mining. The stakeholders expressed that education and training in small-scale mining should be taken as seriously as in large-scale mining. They gave examples of the continuous training requirements in large-scale mining. These operations require educated professionals and other skilled labour to undergo training before commencing their duties[42]. In addition to this, some professionals go through years of competency training to specialize in their fields. This proves the high technical

[42] For example, detailed site training and induction when one starts working on site, followed by refreshers conducted at regular intervals.

and training requirements in mining. Some of the stakeholders believe that the mandate of adequate training and refreshers in ASM will displace the need to constantly remind people to observe safety and environmental regulations. The people will be more enlightened, and they will know what is expected from them, making them more inclined to comply. It was pointed out that there are some people working in the sector, who want to mine safely and efficiently without damaging the environment. However, most of them are not educated, they lack the technical knowledge and they do not have access to the relevant specialists.

c. Difficulties in accessing capital

This challenge was described as the difficulty in accessing capital to fund the small-scale mining projects. The miners experience this firstly because of the high investment risk associated with ASM, and secondly, because of the negative public perception of the sector. The stakeholders mentioned that banks are very reluctant to inject funding into ASM. This results in people seeking funds from other alternative sources. The reluctance from the banks is well understood because as mentioned in Chapter 4, feasibility studies are one of the weakest links in the ASM value chain.

In Ghana, many locals do not have access to the capital that is required to commission a small-scale mine. They mostly resort to assistance from sponsors. These are people, who provide financial support by lending the operation the required capital in return of a commission that is taken from the weekly profit. The fee paid to the sponsor can vary anywhere between 20% to 90% of the profit depending on the amount of capital invested and the terms and conditions of agreement.

d. Low recovery rates in ASM

Low recovery rates were also identified as a limiting factor in ASM. According to one of the groups, the recovery rates in ASM gold mining are in the region of 40% to 50%, while the average industry recovery rate of large-scale mines is about 80%. Recovery in ASM is low because the operations do not follow the full mining process, and they do not have the knowledge or ability to optimize their resources. They do not know how much they have and where it is located. The stakeholders added that mining is a process that is centred around the thorough knowledge of mineral deposits. If the full process is not followed and the nature of the mineral deposit is unknown, it will be impossible to develop the operation to its full potential.

e. A lack of designated areas for ASM

This was identified as a limitation by one stakeholder group. They indicated that there should be designated areas for ASM. They believe that without well-defined ASM areas, it will not be possible to solve some of the pressing problems in the sector. The Minerals Commission indicated that they are trying to partially address this challenge by liaising with large-scale mining companies to part with portions of concessions that are not being used, as well as those that are uneconomic to them. They believe that this will help to open up opportunities for legal small-scale mining. They also expect this to reduce illegal mining on the properties of large-scale mines.

7.2.6 ASM support from government

There was a consensus amongst all the groups that government currently only provides regulatory support to the ASM sector. However, the Minerals Commission indicated that this was not always the case. In the past, government used to offer financial support in the form of a revolving fund to the sector. This fund allowed miners to borrow a certain amount of money and pay it back through an arranged plan. The payback was required so that the fund could assist other applicants. However, many of the miners failed to honour the payment terms and conditions, and government struggled to identify the debtors and recover the debt. This resulted in the dissolution of the revolving fund.

The only other support offered by the Minerals Commission (in addition to regulation) is training. Two of the groups indicated that the district officers sometimes offer on the job training when they visit the mining sites. The miners also discussed some past initiatives, where they were taken for 5-day training courses. Although they understood the importance of the courses, they felt that they did not add much value because they were conducted inconsistently, they had a short duration, and they were impractical for their operations.

7.2.7 ASM success stories

The groups were able to identify some successes that operations and communities have achieved through properly engaging in the activity. The first story was that the sector has enabled some community members to develop businesses that support ASM such as trading, logistics, equipment assembly and supply (e.g., local assembly of the washing plants). The sector has also contributed to the creation of steady local employment. In addition to this, some of the registered small-scale mines run small Corporate Social Responsibility programs in the host communities.

The second success story was that of a very lucrative ASM project. Here a high-grade deposit was combined with good mining knowledge, the correct systems and technical skills. This resulted in the operation generating returns that were higher than expected. The success prolonged the life of the small-scale mine and expanded the size of the operation. It also enabled the concession owner to invest in other projects within and outside ASM.

The third success story focused on the involvement of community members in a mining project. In this case, the party that was interested in mining did not buy the land, but it entered a 50/50 partnership with the landowners. The mining group brought the capital and mining knowledge to the project, while the owner gave them access to the land and sourced labour from the host community. In this partnership, the landowners and miners divided the profit equally. The landowner was said to receive around 10 000 Cedis a month in profit. The landowner was not required to sell their land, and they were also involved in the mining activity. The community in this area was aware of the landowner's involvement in the mining project, and they held both the owner and the mining group accountable for any extended damage or inability to reclaim the surrounding land.

The last success story was about the establishment of small, informal ASM consulting services. The consultation services are commonly offered for sampling and surveying. They are provided by experienced miners, as well as people who used to work as samplers or survey assistants for large-scale mines.

7.2.8 Views of the recent ASM reforms

a. The 2016/2017 ban on small-scale mining

In 2016, the Akufo-Addo regime placed a temporary ban on all forms of small-scale mining. This was applied to both legal and illegal operations. According to the Minerals Commission, the ban was deemed necessary by government because the ASM sector was getting out of control. The government saw this as an opportunity to reform the sector and get it on the right track. Some of the end goals were to put ASM back into the hands of the indigenous people, and get people to do things the right way.

All the stakeholders understood the need and the importance of the temporary ban. One of the stakeholders stated that communities are desperate for solutions, so they will support any government initiative that has the potential to solve the problem. Even though the need of the ban was well understood, almost all of the stakeholders disagreed with the way in which it was executed. One group strongly believed that the ban was imposed solely for the benefit of politicians rather than the empowerment of the sector and its host communities. Other stakeholders expressed that although the ban was initiated with the correct intentions, the duration was too long, it was not well thought out, and it did more harm than good to the sector. This period also saw the infrastructure of small-scale mines being damaged and destroyed by army officials that were deployed by the government. This came at a great financial cost to the small-scale operations and to a certain extent, fractured the level of trust between the operators and the government. Some stakeholders were asking why mines should register or renew their licences if they are treated like illegal miners.

b. The Ghana Community Mining Scheme

After the lifting of the temporary ban, the government launched a flagship program called the Community Mining Scheme (CMS). This is currently the focus of the government. According to the Minerals Commission, the primary aim of the Community Mining Scheme is to provide opportunities to the indigenous people who live close to the mineral resources. The CMS is government's effort of modelling a community-based mining program. The Minerals Commission added that they would like to place a premium on host communities because small-scale mining should benefit them first. They also believe that the community members are more likely to engage in responsible mining because they rely on the land for their livelihoods.

In the CMS program, the communities are encouraged to arrange themselves into groups of cooperatives and apply for mining licences. This is based on the belief that mining cooperatives and mining groups are more inclined to benefit and succeed more than individuals. The Minerals Commission further stated that this system is no different from the previous one in terms of regulation because the current mining law already caters for small-scale mining cooperatives. The CMS has been launched on the highest level of government. It has drawn the involvement of officials such as the President, and the Ministry of Lands and Natural Resources.

The stakeholders that were interviewed support the idea of the Community Mining Scheme. They believe that if it is done well, it will benefit the sector and local communities. The Minerals Commission indicated that time needs to be given (for example, one year) before monitoring and evaluating the effectiveness of the CMS, and the program can be interrogated once its progress can be measured in numbers.

7.3 Conclusion

The stakeholder engagements in this chapter show that different groups share similar thoughts on ASM. There was an alignment of feedback across many of the themes that were discussed. The feedback shows that the current perception of the sector is largely negative because of the way it has been mismanaged. The feedback brings to light the licensing, political, socioeconomic, legislative, and technical issues that have contributed to the current state. The feedback reveals the modernisation of the ASM sector, and the need to have the legislation reflecting this modernisation. It also shows that at there is currently very little to no support for ASM operations, and the sector is largely self-reliant.

There are some successes that were identified in ASM. However, these are outweighed by the challenges in the sector. The most important finding in this chapter was that despite the numerous challenges, people still have a positive outlook and high hopes for the sector. The stakeholders agree that ASM will have a very bright future if things are done the right way.

The next chapter focuses on the development of a strategic framework to help Ghana in working towards developing a more sustainable and responsible artisanal and small-scale mining sector.

8 DEVELOPING A STRATEGIC FRAMEWORK FOR A SUSTAINABLE SMALL-SCALE MINING SUB-SECTOR IN GHANA.

Chapter 1 specified that the aim of this research is to develop a strategic framework that focuses on improving the way in which artisanal and small-scale mining is conducted and viewed in Ghana. This chapter (Chapter 8) focuses on the development of that framework. The strategic framework outlines a vision and a mission for the Ghanaian small-scale mining sector, it also identifies what needs to be done to work towards this vision. The strategic framework is also accompanied by a SWOT analysis, which is provided at the end of this chapter.

The strategic framework draws its structure and content from the leading practices, literature, and field observations that were documented throughout this research. It also incorporates the views of the small-scale mining stakeholders about the envisaged way forward. The framework can be used to guide the Ghanaian government in the development and amendment of legislation, regulations, and policies. It can also serve as a reference guide for the development of strategies. The document can also be used as an information guide for potential investors and entrepreneurs who are looking to engage in small-scale mining. It is important to note that this strategic framework is dynamic, which means that it can be improved or developed with more work and further research.

8.1 An overview of the strategic framework.

8.1.1 The rationale behind the strategic framework.

Valdes (2019) described a strategic framework as a visual outline or model of activities that offer guidance in working towards achieving a principal goal. He added that a strategic framework should be motivating, realistic, and it should set out a clear path (or an implementation plan) to achieving the desired end goal or vision. A strategic framework covers a broad spectrum of concepts and according to Garden (2017), it also shows a clear connection to the greater cause. This kind of framework is inclusive and flexible, and it can be modified to meet the evolving needs of the strategy, as well as changes in policies and legislation. A strategic framework should provide sufficient information without going into such detail that will constrain its executors to make good choices in a dynamic setting. Short-term milestones must also be developed to inform the larger long-term strategic framework.

8.1.2 The vision and the mission of the strategic framework

This research aims to improve the way in which artisanal and small-scale gold and diamond mining is conducted and viewed in Ghana. In addition to the research aim, the stakeholders expressed that they would like to see an improved small-scale mining sector that is managed well by government and operated well by the people of Ghana. These ideas resulted in the creation of the following long-term **vision** for the small-scale mining sector:

Building a sustainable small-scale mining sector that uplifts communities and creates diverse economic opportunities.

The **mission** statement that was developed for the framework is:

Empowering the small-scale mines in Ghana to operate in a professional, accountable, sustainable, and economic manner.

Figure 8.1: The vision and mission of the strategic framework

8.2 A visual identity for the strategic framework - The PASE Framework

The creation of a visual identity for this framework and research is important due to the following reasons:

- To make the framework and other information emanating from this research stand out and be identifiable;
- To give the framework and other research outcomes a consistent image, making it recognizable online and on the bookshelves; and
- To increase the likelihood of stakeholders engaging with the framework and research (Step4youth, 2015).

This strategic framework will therefore be referred to as the **PASE** framework (pronounced as "pace"). The **PASE** framework and other outcomes of this research will fall under a bigger umbrella, which will be called the **PASE** Initiative. **PASE** is an acronym that is derived from the key words that describe the mission statement shown in Figure 8.1. All the outcomes of this research will be disseminated under the brand of the **PASE** Initiative. Future project partners and material identifiable with this research will be required to align with this visual identity.

8.3 The structure of the PASE framework

The preceding chapters have highlighted a number of critical issues that need to be addressed to move the Ghanaian small-scale mining sector forward. These issues can be grouped under one or more of 6 main headings which are:

i. The definition and the structure of the small-scale mining sector;
ii. Licensing;
iii. Training and education;
iv. Technical function;
v. The mining life cycle and value chain; and
vi. Business function and image.

These 6 focal points were used to derive the 6 pillars of the **PASE** framework (as shown in Figure 8.2. The 6 pillars represent the set of interventions that need to be advanced to enable Ghana to achieve the vision of the **PASE** framework. Each pillar contains sub-themes that are discussed in detail.

Figure 8.2: The six pillars of the **PASE** framework and initiative

8.3.1 Pillar 1: Redefining and restructuring the small-scale mining sector

Chapters 2 and 3 showed that the Ghanaian small-scale mining legislation is lagging behind its international peers in terms of the definition of the sector. Chapter 7 showed that the legislation does not accommodate the more mechanized forms of small-scale mining. To address the identified gaps, the **PASE** framework recommends for Ghana to follow Ethiopia's lead (see 48 of Chapter 2) in the re-definition and re-arrangement of the sector. The proposed restructuring is shown in Figure 8.3.

In the new structure, the broader mining sector would be divided into the sub-sectors of large-scale mining and small-scale mining. The small-scale mining sub-sector would contain the categories of artisanal mining, and semi-mechanized or junior mining.

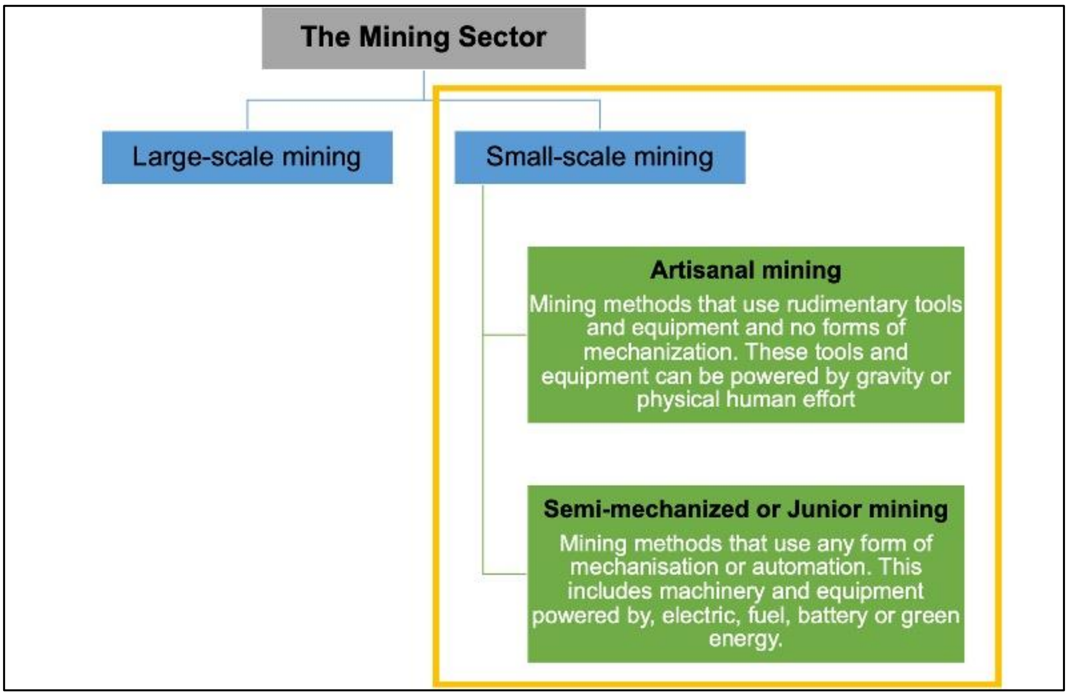

Figure 8.3: Proposed restructuring of the small-scale mining sector

Artisanal mining would refer to any mining activity that uses tools or equipment powered by gravity or human effort (e.g., manual panning, sluice boxes, manual digging using shovels, axes, pics etc.). Artisanal mining would exclude any equipment powered by fuel, solar, electric, hydro, or wind battery energy. Artisanal miners would be considered as people, who mine for subsistence reasons. This means mining to produce enough just to stay alive or to maintain and support oneself at the most minimum level (Cambridge Dictionary, 2020). Artisanal mining would largely be informal, and it would be practised by individuals, families, and cooperatives that do not need to register companies.

Semi-mechanized small-scale mining (or junior mining) would refer to mining activity that involves the use of any machines or equipment that need to be powered by an engine, electricity, battery, or any green energy. This includes mines that use mechanized water pumps and other dredging equipment as well as earth breaking and moving equipment such as rock drills and excavators. Junior miners would be classified as people who mine for commercial production or larger economic gain. These mines would be operated by registered companies. They would be more formal, and market driven (Lexico, 2020; Business Dictionary, 2020). This category of miners would be comparable to Ethiopia's category of special small-scale miners.

8.3.2 Pillar 2: Introducing licensing reforms

The second pillar of the **PASE** framework requires the review and restructuring of the small-scale mining licence system and process. The research shows that Ghana has a centralized and manual licensing system. The **PASE** framework suggests the modernization and decentralization of this licensing system.

a. Modernizing the licensing system

The phasing out of manual applications is long overdue. Chapter 3 showed that Ghana launched an online mining repository in 2016, however, the repository was still not in full effect at the time the chapter was written. The country needs to focus on bringing this electronic system into full functionality to modernize the licensing process. The current manual system is time consuming, it lacks transparency, and it is also difficult to track. It is one of the major causes of backlog in the licence application and issuing process.

An electronic or computerized system that is well thought-out and fully commissioned will have many advantages. It can be set up to receive first time applications, allow application renewals, and receive electronic payments. The system can also be designed to act as a ‘one-stop-shop’ that provides information for applicants and other parties.

b. Decentralizing the licensing process

Even with the proposed modernization, there will still be a need to decentralize the small-scale licensing process. Learnings from Brazil in Chapter 3 show that a country can still face application backlog with a modernized system if the process is centralized and digitalized. The current centralized licensing system in Ghana places a heavy burden on the Minerals Commission Head Office. The licensing process should be reformed in a way that allows the Minerals Commission district offices to facilitate and process applications from beginning to end, and issue out the small-scale licences. Decentralisation will enable the Minerals Commission to distribute the burden of decision making, thereby allowing head office to put more focus on the overall development, planning and steering of the small-scale mining sector.

c. Different licences for artisanal miners and junior miners

The **PASE** framework recommends two different licensing systems for artisanal mining and semi-mechanized small-scale mining. This proposal takes account of education levels, the unique life cycles of both mining streams, and value chain issues. The licence for artisanal mining would be simpler, it would involve less paperwork, and it would require lower barriers to entry. The applicants eligible for this licence would be members of the mining host communities (i.e., the indigenes). Community leaders and traditional authorities can be trained to facilitate the application process of these licences. These individuals can also be trained to monitor compliance and enforce legislation on the artisanal mines. The Minerals Commission district offices can process the applications and guide the community monitoring.

The semi-mechanized or junior miners would have to follow a more formal and stringent licensing process. The licence applicable to this category would be referred to as a Junior Mining Licence. This licence would be eligible for all Ghanaians that have registered companies. The application for the Junior Mining Licence would be facilitated by the Minerals Commission district offices. In the zoning of the small-scale mining areas, the country can allocate the higher-grade areas for junior mining and the lower grade areas for artisanal mining.

d. Revising the licence duration time for junior miners

According to the Ghana mining legislation, small-scale mining operations are allocated licences for a maximum of 5 years. However, the research shows that the 5-year duration is not practical for semi-mechanized operations that mine low grade gold placer deposits. The production scenarios in Chapter 6 (also summarized in Table 8.1) show that a semi-mechanized small-scale operation will only make a profit within this period if it mines a gold placer deposits with grades exceeding 0.8g/m^3. In this case, a marginal NPV of USD 9419 would be made within 5 years if the project uses bought machinery. However, a project that rents machinery would have to mine grades that exceed 1.09g/m^3 to generate a positive NPV (USD 6409) within the allocated 5 years.

Table 8.1: NPV of junior miners within 5 versus 10-year life of mine.

		Machine buying operations	**Machine renting operations**
5 years	Min grade required for profit	0,8g/m^3	1.09g/m^3
	NPV	$ 9 419	$ 6 409
10 years	Min grade required for profit	0.5g/m^3	0.9g/m^3
	NPV	$ 23 097	$ 1 378

Table 8.1 shows that extending the duration of licences from 5 years to 10 years, would count in favour of semi-mechanized operations that mine low grades. If the life of mine is extended to 10 years, the machine buyers and renters can mine grades as low as 0.5g/m^3 and 0.9g/m^3 respectively. Based on this information, the **PASE** framework proposes a minimum licence duration period of 10 years for semi-mechanized small-scale mining operations.

e. Revising the land allocation size for artisanal miners and semi-mechanized small-scale miners.

During the stakeholder engagements, some groups expressed that the 25-acre land size (10,2 hectares) allocated for small-scale mining is too small for mines that use machinery. The research used the production data provided by the case study to determine whether 25 acres is a suitable land size for the semi-mechanized operations.

The legal small-scale miners indicated that they mine an area of 2500 ft^2 (i.e., 232,3 m^2) on an average week. This adds up to approximately 60 398 m^2 (15 acres) over 5 years. This calculation shows that the current 25-acre land allocation is sufficient for 5 years. However, if the 10-year recommendation provided in Table 8.1 is taken into consideration, the land allocation for junior miners or semi-mechanized small-scale miners would have to be increased from 15 acres to 30 acres as shown in Table 8.2.

Table 8.2: Projected area to be mined over 5 years vs 10 years

Duration	**Area mined (m^2)**
Per week	232.3
Per year (52 weeks)	12 079.6
Over 5 years	60 398 (15 acres)
Over 10 years	120 796 (30 acres)

Table 8.2. shows that the semi-mechanized mine can mine 15 acres (6ha) within 5 years. Since mining with machinery is faster than mining using artisanal methods, one can draw the conclusion that 15 acres of land will be more than sufficient for a purely artisanal mine that has a 5-year licence. It is because of this observation that the **PASE** framework recommends the land size for artisanal mining to be reduced from 25 acres to 15 acres.

From the perspective of government, dormancy or inactivity on the land is a risk that comes with issuing a bigger land size for a longer duration for junior miners. If the permit holder does not mine, there will be no benefits for the economy and the mining area. To mitigate this risk the government can introduce a “use it or lose it” clause that states that if development or production does not occur within the first 2.5 years[43] (from the date the licence is issued), the licence holder will be stripped of their semi-mechanized small-scale mining permit, and the land will be made available for new applications.

Figure 8.4 provides a summary of the proposed licensing structure with the recommended land size allocations and licence durations for the two small-scale mining licences.

[43] The research shows that it takes less than one year to bring a semi mechanized small-scale mine into full production. The 2.5-year period is a fair amount of time.

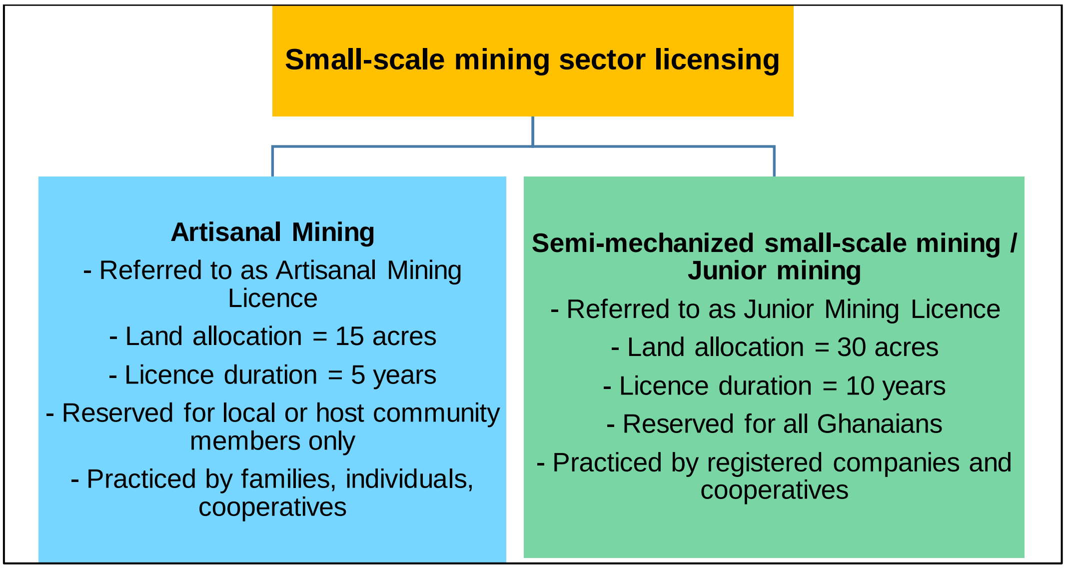

Figure 8.4: Restructuring of small-scale mining licences

f. The inclusion of community consultations in the licence application process.

Mining communities experience the first-hand impact of small-scale mining. Because of this, community consultations should be a prerequisite in the application of small-scale mining licences, especially for semi-mechanized mines. During the stakeholder engagements, the traditional rulers stated that the entire licence application process bypasses them and their communities. In many instances, the people who are granted licences come to the local palace to inform the traditional authorities without consent from or consultation with the communities. The leaders added that if a project will bring more harm than good to their communities, they should have the authority to stop people from encroaching on their land.

The **PASE** framework therefore proposes the meaningful consultation and participation of the indigenous people in the licence application process. In these consultations, the licence applicant should provide the community with information on how the mining activity will benefit the host community. They should also explain the safety and environmental hazards and risks that are involved, and how they plan on mitigating these risks. They should inform the community about the life of mine, and indicate how they plan on rehabilitating the land after mining. This process will increase accountability on the part of the miner, the landowner, and the concessions owner.

8.3.3 Pillar 3: Improving training and education

The third pillar of the **PASE** framework requires for small-scale mining training and education to be strengthened. The research shows that the small-scale miners receive very little to no training support from government or other institutions. In Chapter 6, the stakeholders expressed that mining education (particularly basic training) is essential to both the small-scale miners as well as the host communities.

a. Community-based and community driven small-scale mining educational programs

There is a need for regional and community based small-scale mining training programs. These training programs should also be community-driven. They can be facilitated by trained members of the communities and managed by the Minerals Commission district offices. These programs will help to achieve the following:

- They will make training more accessible to the artisanal and junior miners;
- They will make the communities more knowledgeable about small-scale mining;
- They will help to entrench the culture of small-scale mining education in the communities;
- They will raise more awareness about the impacts of small-scale mining; and;

- They will empower the community members to play an integral part in the monitoring of legal small-scale mining and the prevention of illegal mining.

b. Small-scale mining training as a prerequisite to obtaining mining licences.

Small-scale mining training should be a prerequisite to the issuing of artisanal and junior mining licences. The requirements should be as follows: basic training for the artisanal miners, and more advanced training for the junior miners. To propel the advance training requirement for semi-mechanized small-scale miners, the **PASE** framework proposes the introduction of a certificate of competency. This would be more applicable for the people who are involved in the daily management of these operations. A Certificate of Competency verifies that an individual is skilled and qualified to carry out a particular task safely. Certificates of Competency do not require an academic qualification. They only require a good understanding of the technical and safety aspects of a task, as well as the ability to read and write. Including these training and competency requirements in the legislation will help to entrench the culture of education into the small-scale mining sector. This will create opportunities for the development of individuals and the sector.

Inclusion of small-scale mining in the National Service Scheme

In Ghana, it is compulsory for all the graduates to join the National Service Scheme after the completion of their first degree. Some of the purposes of this program are to help graduates to develop their technical skills, and to involve them in projects that assist to combat poverty, illiteracy, and unemployment (National Service Scheme , 2021). The graduates receive a stipend from government during their duration of the National Service.

According to the feedback from the stakeholders, there are not enough National Service opportunities for mining graduates on large-scale mines or other mining related companies. As a result, some mining graduates are placed in other economic sectors that are not relevant to their field of study. To address this challenge, the **PASE** framework suggests for small-scale mining to be included in the National Service program. The government can set up a program that grooms graduates to serve their communities, while specializing in small-scale mining-related fields. This will help them to develop into mining entrepreneurs, and prepare them to enter the expert database of small-scale mining (which is explained in section 8.2.4).

The stakeholders also would like to see graduates and young professionals being encouraged to apply for small-scale mining licences. They believe that these groups are more enlightened, and they are more inclined to adhere to rules, regulations and follow the law. According to one group, the few graduates that practise small-scale mining do so very well. They would like to see attention being drawn to the immense opportunities that are available to the youth in the sub-sector. The stakeholders stated that people need to be aware that with the correct tools and knowledge, they have the potential to create and grow successful companies within small-scale mining.

8.3.4 Pillar 4: Strengthening the technical function of small-scale mining

In Chapters 4, 5 and 6, the research showed that despite its informality, small-scale mining is a technical field that applies the methods, principles, and designs of mining engineering. However, these applications may be based on first principles or occur on a small scale. It is therefore important to put emphasis on, and strengthen the technical and engineering components of small-scale mining.

a. Assisting the sector to access the required technical skills.

The technical function of small-scale mining is weak not only because of poor education and training, but also because small-scale mining operations do not have access to the required technical skills. These operations cannot afford to hire people with specialized mining skills because of the high professional and consultation costs. In addition to this, some specialized skills are required on an intermittent basis. To strengthen the technical ability, the sector should have access to people with specialized skills. To achieve this, Ghana can create a national pool of local consultants and experts that offer services to small-scale miners. This pool can be tailored to suit the technical needs and affordability of the sub-sector. The small-scale miners can adopt a consultation system similar to that used in large-scale mining, which entails outsourcing consultants when they need specific work done. Ghana can follow the lead of Brazil by creating a consultant database and making it available on its mining repository. Mining graduates and other young professionals can also be encouraged to join this pool after completing the small-scale mining National Service program.

b. Investing in small-scale mining research and development.

Research and development is important because it creates new knowledge and builds on existing knowledge. There is a need to develop more mining methods and technology suitable for small-scale mining. There is also a need to document, learn from, and improve the existing small-scale mining methods, and discover new methods. In addition to the above, research and development can lead to increases in production efficiency, the improvement of systems and processes, and the reduction of costs in small-scale mining.

The government should develop strategies that will enable Ghana to invest in small-scale mining research and development. The function of R&D should be carried out by the Minerals Commission or the Department of Lands and Mineral Resources. The investment should match the magnitude of small-scale mining activity. Ghana should aim to become one of the world leaders in small-scale mining research, knowledge, solutions, and technology.

8.3.5 Pillar 5: Strengthening the small-scale mining life cycle and value chain

a. Exploration

In Chapters 2 and 3, the research showed that exploration and establishing feasibility are the weakest components of the Ghanaian small-scale mining value chain. Exploration methods such as diamond drilling and circular drilling are not practical because they are expensive and require specialized skills. Even though there are simpler and cheaper exploration methods (as shown in Chapter 2), small-scale miners tend to bypass the exploration step.

The **PASE** framework proposes strengthening the exploration link of the value chain by creating a National Exploration Program (NEP) in Ghana. This exploration program can occur on a large scale. It can include diamond and circular drilling, as well as the simple exploration methods that do not require drilling. This proposed National Exploration Program can help to determine the quantity and quality of gold and diamond resources in Ghana. With this information, the country can delineate zones for small-scale mining. This program should be initiated and run by government, as a collaborative effort between the Minerals Commission and the Ghana Geological Survey Authority (GGSA). The role of the latter (GGSA) would be to ascertain the values, while the role of the Minerals Commission would be to demarcate and gazette the mineralized areas. Because of the high intensity of small-scale mining, sampling data from existing operations can be used to populate the NEP database. Graduates in the National Service Program can be incorporated into the National Exploration Program as field workers and data capturers.

b. Feasibility studies

The research also shows that feasibility studies are not conducted in small-scale mining. This is because of the lack of exploration information, knowledge, and skills. Moreover, the sector does not understand or realize the importance of feasibility studies. Feasibility studies have not been tailored for small-scale mining. Before this research, there has been no attempt to simplify feasibility studies for small-scale mining operations.

Chapter 6 showed that it is possible to adapt feasibility studies for small-scale mining operations. This can be done if information such as operation costs (which can be sourced from similar projects), and representative grades (sourced from active mining or sampling) are available. With the correct skills and knowledge, this information can be used to conduct a simple financial valuation to help ascertain the likelihood of the project becoming successful. The financial valuation in Chapter 6 showed that small-scale mines have the potential to generate high income. However, it is important to give the sector access to the technical skills that can assist them to optimize their mining methods (e.g., showing them the benefits of buying equipment over renting).

8.3.6 Pillar 6: Improving the business function and image of small-scale mining

a. Empowering small-scale mines to operate as micro, small and medium-sized enterprises

Small and Medium-sized Enterprises (SMEs) are described as privately owned businesses that function with few employees and generate revenue or a volume of sales below a certain threshold. Ayandibu and Houghton (2017) described SMEs as engines of growth, drivers of efficient and competitive markets, and crucial role players in inequlity and poverty reduction. SMEs are also viewed as business opportunities that nurture local entrepreneurship. The World Bank (2021) highlighted the important contribution of SMEs to the economic growth and development of countries around the world, more especially in developing countries. These enterprises make up around 90% of the global businesses, and more than half of the global employment. In emerging markets, 7 out of 10 jobs are created by formal SMEs, and up to 40% of the GDP comes from SMEs (The World Bank, 2021).

Similar to the definition of small-scale mining, there is no widely accepted legal definition for SMEs. Various countries define them according to different parameters (Liberto, 2020; Nkuah, Tanyeh & Gaeten, 2013). In Ghana, this category of businesses is referred to as Micro, Small and Medium Enterprises (Ministry of Trade and Industy, 2019). According to the National Micro Small and Medium Enterprises (MSME) Policy, there is no standard definition for the MSMEs in Ghana. The policy identifies this as a constraint to the development of these enterprises. Because of the lack of a standard definition, different institutions in Ghana define the sector in different ways. According to Nkuah, Tanyeh, & Gaeten, (2013), the definitions used by the different institutions do not give a good description of MSMEs in Ghana.

Because of the lack of a standard definition, researchers normally use the definition provided by Osei et al (1993). According to Nkuah, Tanyeh & Gaeten (2013), this definition provides a better reflection of the employment conditions in Ghana, and it allows a wider inclusion of enterprises. Table 8.3 shows the different categories of MSMEs according to Osei et al (2013).

Table 8.3: MSME categories

Category	Number of employees
Micro enterprises	< 6 employees
Very small enterprises	6 – 9 employees
Small enterprises	10 – 29 employees
Medium enterprises	29 – 50 employees

Source: Osei et al (2013)

Table 8.3 shows that the legal small-scale mine used for the research case study falls into the category of a small enterprise because it had a total of 16 employees.

Sustainability is important for MSMEs because of their economic significance. However, sustainability principles are not embedded in these enterprises due to the following reasons:

- The lack of awareness, technical knowledge and skills amongst MSME owners and employees;
- The lack of access to finance;
- The lack of knowledge and information about sustainability; and
- Sustainability initiatives being interrupted by other business and political initiatives (Sustainable Knowledge Group, 2019).

The points listed above are similar to what is experienced in the Ghanaian small-scale mining sector. In enabling small-scale mines to function as MSMEs, it is also important to embed the principles of sustainability into the business culture. Working towards sustainability requires the small-scale miners to have access to resources such as education, finance, and support from government. There also needs to be access to skills that can assist the miners to set up their businesses and produce documents such as business plans, operation plans and forecasted cashflows. This will assist the miners to demonstrate financial viability, enabling them to access finance. Moreover, there should be an introduction of tax incentives that favour the emergence, growth, and sustainability of small-scale mines (Ayandibu & Houghton, 2017).

b. Access to finance and credit

The research shows that semi-mechanized open-pit small-scale mines require an initial investment of around USD 400 000 if the operation will be buying mining equipment and machinery, and about USD 150 000 if the operation will be renting machinery and equipment. The miners often struggle to access the required finance because of the following reasons:

- The negative image and high investment risk associated with small-scale mining and;
- Demanding and burecratic financial lending requirements that are not well understood by the small-scale miners.

This results in the miners seeking finance from sponsors, informal institutions, savings, traditional lenders, families and friends. There is currently no program (from government or the private sector) to assist or guide small-scale miners to obtain access to finance in Ghana. According to Nkuah, Tanyeh & Gaeten (2013), the difficulty of accessing finance is not unique to small-scale mining, but it is common to all MSMEs in Ghana. The lack of access to finance is one of the main factors suppressing the growth of MSMEs in the country.

c. Improving the public perception of small-scale mining

The current perception of small-scale mining in Ghana is negative. Public perception is important because it plays a role in the growth and survival of businesses. Public opinion influences democratic systems because government tends to adopt the viewpoint of the majority (Read, 1996). It is important to work on changing the public perception of small-scale mining. Correcting or improving the image does not mean understating the challenges that are facing the sector, but it means drawing attention to the positive attributes of small-scale mining.

8.4 A SWOT analysis of the PASE framework

Table 8.4 identifies the strengths, weaknesses, opportunities and treats of the PASE framework plan. This SWOT analysis is conducted to identify the factors that that can work in favour of or against the PASE framework.

Table 8.4: SWOT Analysis of the PASE framework

Strengths	Weaknesses
• The PASE framework was developed using a bottom-up approach, which makes it practical. • The framework is designed to blend into and capitalise on existing systems. • The framework is simple, easy to understand and follow. • The framework is dynamic, which means it can be improved by further input and research. • The framework incorporates the input of stakeholders, which gives it a people-based approach. • The PASE framework is accompanied by an implementation plan. The PASE framework can be applied to all the commodities within the sector, as well as different countries (with slight modifications).	• Many of the policy objectives and intentions that align to the PASE framework have not been implemented. • The PASE framework will require policy and legislation to be amended. This will have a long lead time. • The PASE framework plan may be viewed as broad and extensive. • The PASE framework requires a large commitment of financial and human resources.
Opportunities	**Threats**
• Introduction of a QA/QC system in the Minerals Commission. • Making the Minerals Commission systems more transparent. • Increasing the functionality of the Minerals Commission. • Re-energising of Minerals and Mining Policy and the Minerals Act. • Rebranding or repackaging of small-scale mining sector. • Modernisation of the small-scale mining sector. • Bringing the small-scale mining legislation up to date. • Current political party or opposition adopting this plan into their strategy. • The creation of a long-term vision for the sector. • The recently developed Ghana Community Mining Scheme can be used as a vehicle to drive this implementation plan.	• The current lawlessness within the small-scale mining sector culture. • The requirement of amendments to policy and legislation within and outside the mining sector. • Political interference and corruption. • Lack of political will, differences in political opinions may make it difficult for institutions to work together. • Using the PASE framework for short-term political gains. • The resistance created by the previous small-scale mining ban. might make people reluctant to buy into the framework.

8.5 Conclusion

Chapter 8 uses the information from Chapters 1 to 7 to develop the **PASE** Framework for the Ghanaian small-scale mining sector. This framework falls under the umbrella of the **PASE** Initiative. The **PASE** framework is structured on 6 pillars which form the focal points or main areas of improvement. It is important to note that although gold and diamond operations were used as case studies, this framework is applicable to all commodities that are mined on a small-scale. With slight modifications, the **PASE** framework can also be used by other countries facing small-scale mining challenges that are similar to Ghana.

The next chapter provides an implementation plan for the **PASE** framework, as well as a dissemination plan the **PASE** Initiative.

9 AN IMPLEMENTATION PLAN FOR THE PASE STRATEGIC FRAMEWORK

In Chapter 8, the research develops the **PASE** framework, which is supported by 6 pillars (shown in Figure 9.1). The **PASE** framework conceptualizes the envisioned small-scale mining sector. This chapter (Chapter 9) develops an implementation plan to bring the **PASE** framework into action.

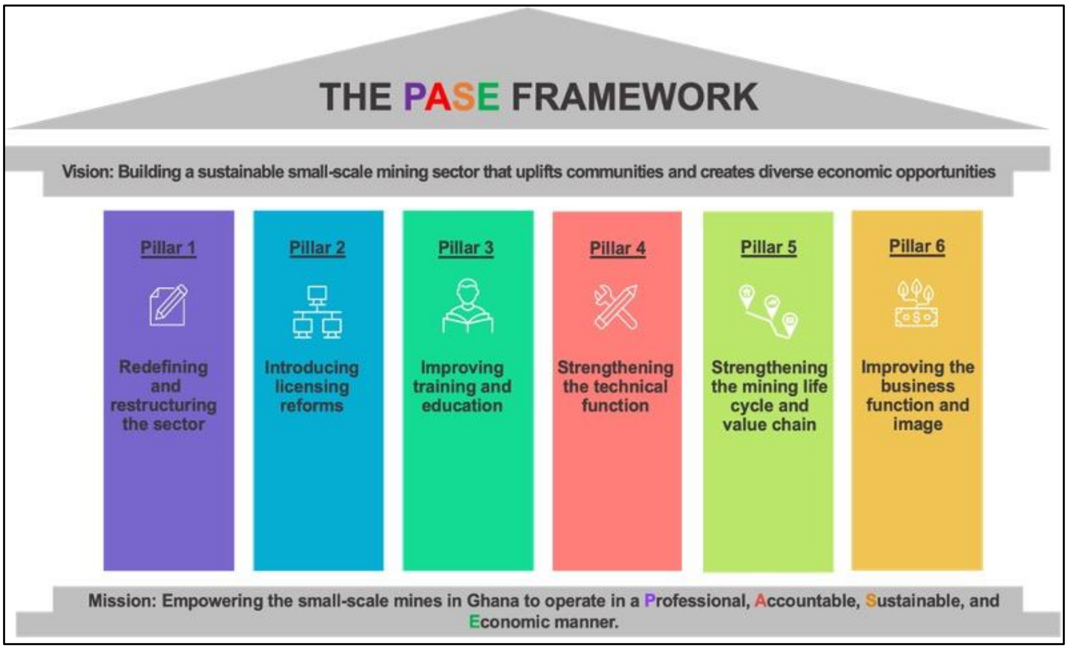

Figure 9.1: The 6 pillars of the **PASE** framework.

The implementation plan is important because it outlines the changes that need to occur to work towards the vision of the **PASE** framework. The plan identifies the leadership, technical, and behavioural changes (i.e., soft, and hard changes) that need to occur to ensure the successful implementation of the **PASE** framework.

The implementation plan is designed to support existing legislation, policies, structures, and systems. It is also designed to avoid the duplication of initiatives, and to ensure that implementation is possible and practical. In areas where similarities exist between the **PASE** framework and the existing legislation and policies, the plan references the correlation and continues to provide steps for implementation.

The developed implementation plan is guided by the fundamental principles of change management. After examining the various change management theories, Lewin's 3 stage change model was selected as the best fit for this implementation plan. Lewin's model appeared to be more adaptable, and easier to implement for change in the small-scale mining sector. This model focuses on demonstrating the need for change (unfreezing), moving to the desired state (change), and then solidifying the new normal (refreezing). Figure 9.2 shows the structure of Lewin's model.

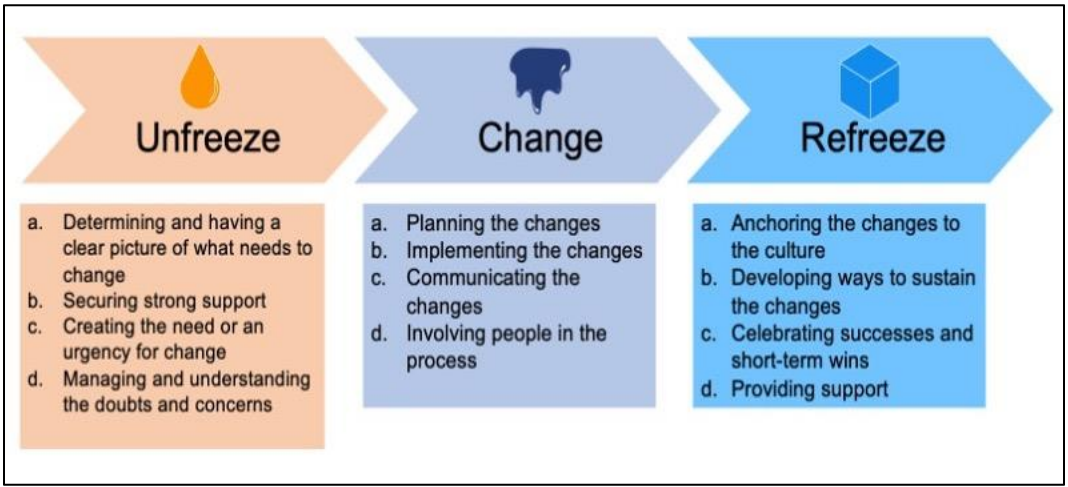

Figure 9.2: Lewin's 3 stage model for change. Source: Culture University (2018).

It is important to note that the different steps in each phase can occur simultaneously or in a slightly different order. Figure 9.3 shows how Lewin's change model was applied to the implementation plan of the **PASE** framework.

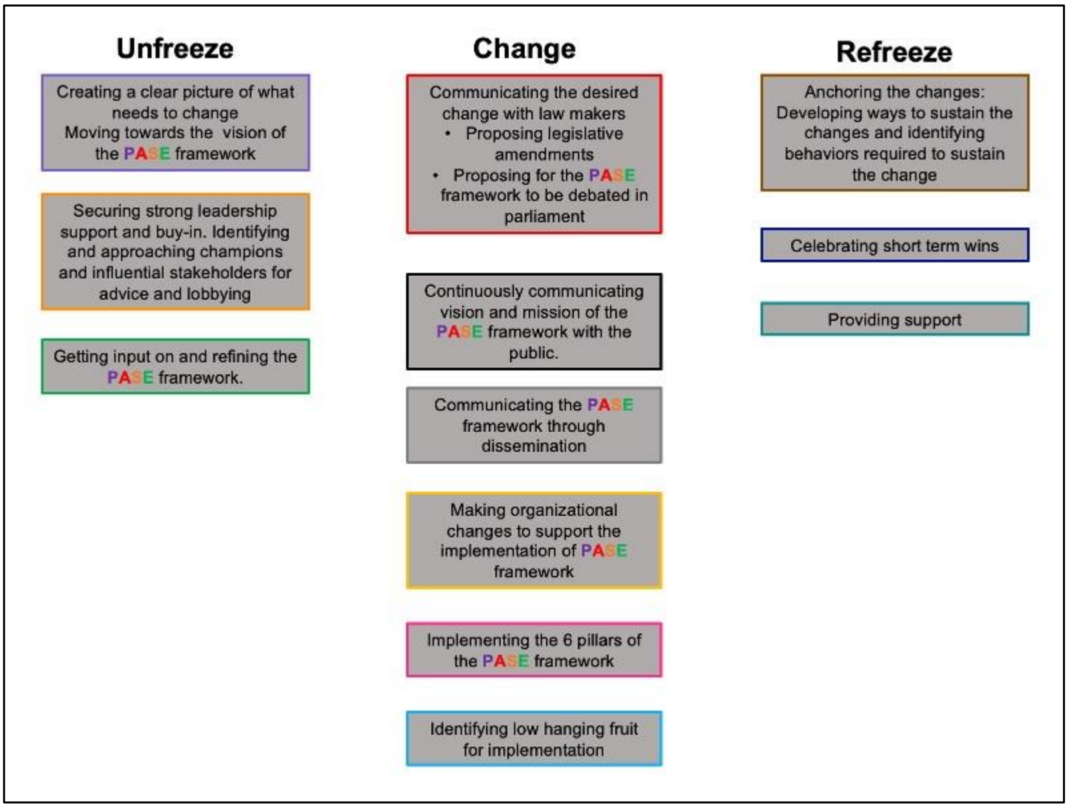

Figure 9.3: The application of Lewin's change model to the **PASE** framework implementation plan

9.1 Creating a clear picture of what needs to change: The envisioned small-scale mining sector

The first step of implementing this roadmap to change is to make people understand the desired outcome (i.e., the envisioned destination). The vision of the **PASE** framework is to build a sustainable small-scale mining sector that benefits the Ghanaian economy and communities through empowering professional, accountable, sustainable, and economical small-scale mining. The aim is to move the sector from the current state, where most of the small-scale mines are illegal, unorganized, and non-compliant, to the desired state that is shown in Figure 9.4.

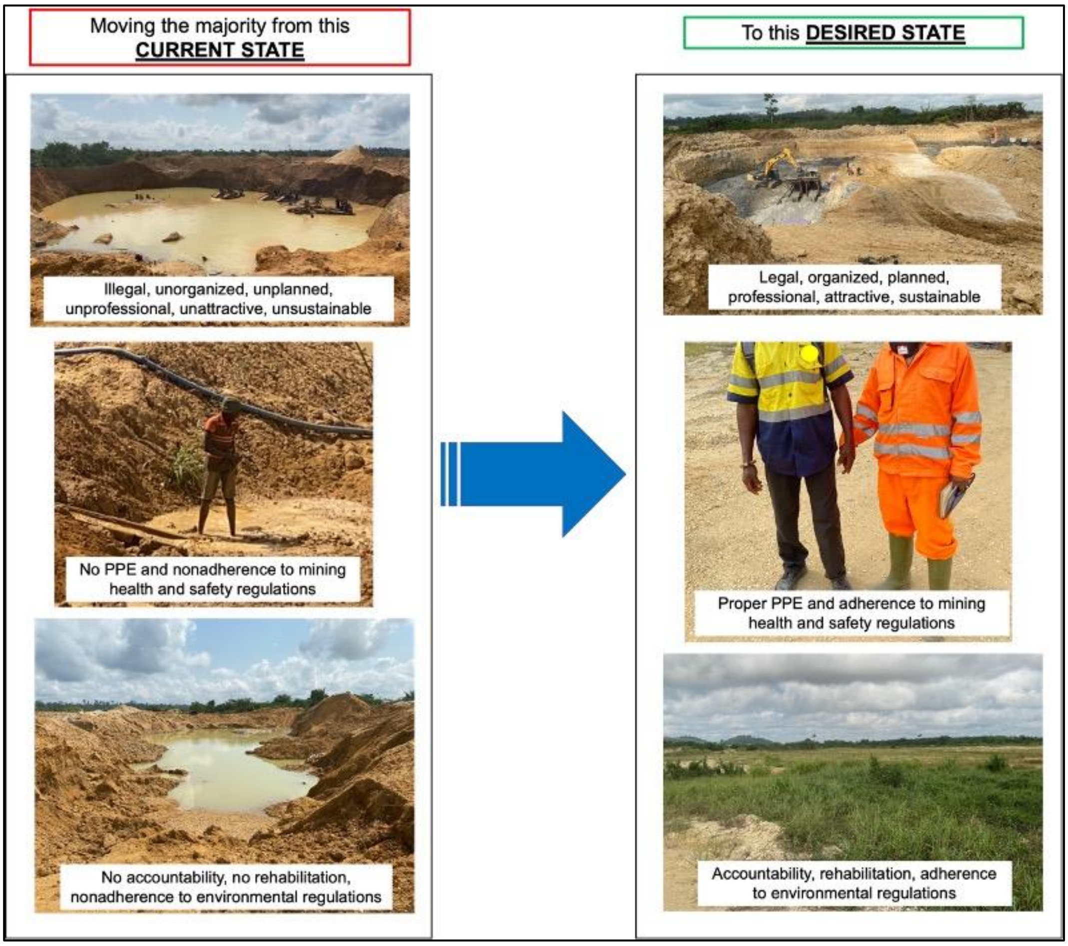

Figure 9.4: Moving the small-scale mining sector from the current state to the desired state

The desired state is one where most small-scale mines do the following:

- Operate legally within the boundaries of the mining legislation and applicable regulations;
- Demonstrate competency and reflect the required technical skills and engineering principles;
- Operate as legitimate businesses that create solid entrepreneurship opportunities for the youth and attract legitimate funding.

9.2 Securing strong leadership support

The implementation plan requires the leaders and decision makers in the Ghanaian small-scale mining sector to buy into the **PASE** framework. It will require the people at the top to act as change champions and leaders in driving implementation. It will also require other influential stakeholders to lobby for the envisioned change. Support will be sought from the following structures:

- The Minerals Commission (to act as a champion for change);
- The Ghana Chamber of Mines (to lobby for change);
- Professional associations such as the Accra Mining Network (to lobby for change); and
- The Association of Small-scale miners (to advocate for change on the ground).

The **PASE** framework and the implementation plan will be sent and presented to the Minerals Commission. A recommendation will be made for the Minerals Commission to adopt the **PASE** framework and refine it to make it more implementable. In this process, the Minerals Commission will be requested to recommend for the framework to be presented before parliament for debating and further input.

The **PASE** framework will also be presented to the Ghana Chamber of Mines, Accra Mining network, and Association of Small-scale Miners. This will occur in the form of one-on-one presentations, workshops, and days of learning. These stakeholders will be invited to give input on the **PASE** framework. They will also be requested to advocate for the adoption of the **PASE** framework, and lobby for the required change.

9.3 Communicating the PASE framework and the desired change

It will be essential for the change champions to communicate the framework to parliament and to the public. The communication to the former will focus more on the proposal of legislative recommendations, and the communication to the latter will focus on spreading the mission and vision of the PASE framework in the public.

9.3.1 Communicating the recommended amendments to legislation

If the PASE framework is adopted by the Minerals Commission, one of the first steps should be to communicate the recommended legislative changes to the law makers. It is recommended for this to occur in the early stages of adoption. This will assist the champions to gain support from the parliamentarians and to remove legal obstacles that may hinder the implementation of the PASE framework.

To meet the requirements of this step, the Minerals Commission, in conjunction with the Ministry of Lands and Natural Resources (and private or non-governmental advocacy groups), would be required to make suggestions to the Law Reform Commission on how the law must change. The Law Reform Commission would in turn make an assessment and if accepted, a bill would be drafted to amend the law. This bill would then have to be debated and approved by parliament, and finally assented to by the president (Baddoo, 2021). Table 9.1 provides the list of amendments that are recommended for the Mining legislation to enable the implementation of the PASE framework. The institutions that have been identified to carry out these actions are the Minerals Commission, Ministry of Lands and Natural Resources, and the Law Reform Commission.

Table 9.1: Recommendations for amendments to the Minerals and Mining Act (2006)

Pillar	Recommended amendments
Pillar 1 component Redefining and re-organizing small-scale mining	• Amendment to Sections 82(1)(2) – Changing the wording to reflect the more modernized mining methods, including the terms "artisanal" mining and "semi-mechanized (junior) mining". • Amendment to Section 111(1)[44] – Changing the definition of small-scale mining and including the definition of artisanal mining as per the **PASE** framework.
Pillar 2 component Separating the licences for artisanal mining and semi-mechanized mining	• Amendments to Section 82 – Clearly indicating the differences between a semi-mechanized small-scale mining licence, and an artisanal mining licence as recommended in the **PASE** framework. • Amendments to Section 85(a) – Recommendations for a 5-year duration for the artisanal mining licence, and a 10-year duration for a semi-mechanized (junior) mining licence. Also, the inclusion of a clause stating that semi-mechanized mining licences will be stripped if there is no mining activity on the land within 2.5 years from the date the licence is issued. • Amendments to Section 86[45]– Clearly indicating the sizes of the land areas prescribed for small-scale mining instead of referring to a "prescribed number of blocks". ○ Recommendation for the land size allocated to semi-mechanized small-scale operations to be increased to 30 acres (12ha), and for artisanal mining, it should be reduced to 15 acres (6ha). • Amendment of Section 83 (1)(a) to reflect the following for artisanal mining: "A citizen of Ghana and an indigene of the local community". • Addition of a new subsection (2) to be named Section 83 (e) indicating the following: "should be a company registered under the Ghana Companies Act, 2019 (Act 992)".
Pillar 3 component Training as a prerequisite to obtaining small-scale mining licences	• Amending Section 83 to make the current licence application criteria suitable for artisanal mining, introducing an additional requirement for artisanal miners to complete community-based training. This criterion can be and referred to as subsection (1). • The addition of a new subsection (2) in Section 83 to include the licence application requirements for semi-mechanized small-scale mining. This subsection should stipulate the following: (d) "should be in possession of the small-scale mining certificate of competency issued by the Minerals commission".

[44] Current definition in the Act: "*small scale mining operation" means mining operation over an area of land in accordance with the number of blocks prescribed"*

[45] *"The size of the area in respect of which a licence may be granted for small-scale mining shall be in accordance with the member of blocks prescribed"*

9.3.2 Communicating the vision and mission of the PASE framework to the public stakeholders

This communication should be aimed at the public, as well as the stakeholders who are involved in and affected by small-scale mining. The communication should serve three purposes: firstly, to create a sense of urgency for change, secondly, to communicate the desired end vision, and thirdly, to induce a paradigm shift (i.e., to change the public's perception and thinking of the small-scale mining sector).

The need to change the small-scale mining sector already exists in Ghana. This urgency is demonstrated by government's recent efforts to curb illegal mining and redirect the sector (e.g., the temporary ban and the Community Mining Scheme). The shortfall that was identified is that the end vision and the plans on how to bring about change are not well communicated with the public. In addition to this, the current communication methods do not induce behavioural change. Table 9.2 makes suggestions on how communication can be improved to trigger changes in human behaviour and encourage the public to align to the desired end vision.

Table 9.2: Recommendations for communicating the desired vision to the public

Method	Recommended steps to be followed
Launching a nation-wide small-scale mining awareness and transformation campaign	This campaign should emphasise the urgency for change by focusing on the following: • Highlighting the disadvantages of and losses caused by the current state and culture of small-scale mining. • Showing the envisioned or desired state versus the current state by highlighting the advantages of the desired state. • Drawing attention to the positive attributes of proper professionalism, attractiveness to investors, increase in economic opportunities, efficient and more profitable mining • Publicly recognition and reward system for legal and compliant small-scale mining operations.
Communicating the awareness and transformation campaign via various platforms	• Through print and publication media (newspapers, magazines etc;), broadcast media (radio and television), social media, broadcast texts, the internet, etc • Community engagement sessions that serve the dual purpose of informing the mining communities about the new plans, understanding, and addressing concerns and doubts, and dispelling rumours.

9.3.3 Communication through research dissemination

The researcher will also contribute to the communication of the desired vision and change by disseminating the **PASE** framework as well as other important outcomes of this research. The dissemination will serve the following purposes:

i. To create awareness and increase understanding of the research topic and the **PASE** framework;

ii. To make the research stand out, be impactful, and sustainable; and

iii. To encourage the adoption of the **PASE** framework.

Table 9.3 shows the dissemination plan for the **PASE** initiative and framework.

Table 9.3: A dissemination plan for the research outcomes

Task and purpose	Implementation
1. Creating a PASE Initiative website and social media accounts • To increase the footprint, and accessibility. • To monitor and measure online dissemination. • To communicate new developments of the research.	• Creating website and dedicated social media accounts. The content will be constantly updated according to the needs of the **PASE** Initiative and framework. • The website will be user-friendly, accessible, and well-designed. • Website traffic analysis tools will be used to measure and understand the website audience. • Social media accounts will be regularly updated to share interesting information related to the research. • Information videos will be created and to be shared online (e.g., **PASE** framework YouTube channel). • Project partners will be encouraged to mention or tag the initiative on their accounts and webpages.
3. Academic publications and formal presentations • To communicate the research findings. • To contribute to new knowledge.	• Scientific papers will be written from the research outcomes and the **PASE** framework. The papers will be published in peer-reviewed academic journals, and digital knowledge platforms such as ResearchGate, ScienceDirect and Academia.edu. • The research will be presented at meetings, conferences, days of learning, lectures, and workshops.
4. Print and promotional materials • To share the outcomes. • To create guiding and educational materials.	• The creation of promotional content, which will include printed and digital material such as infographics, information cards, pamphlets, and posters. • Digital material to be shared via email, on electronic publications, blogs, newsletters, and other online media. • The creation of other material such guiding ("how to") booklets, information, and training booklets.

Source: Step4youth (2015)

9.4 Planning and implementing the required changes

9.4.1 Implementing Pillar 1: Redefining and reorganising small-scale mining

To implement Pillar 1, the Minerals Commission should recommend for the Ghanaian small-scale mining sector to be redefined and reorganized as shown in the strategic framework. This recommendation should begin with the revision of the Minerals and Mining Policy to reflect the definitions and structure proposed by the **PASE** framework. Following this, the Minerals Commission would propose amendments to the Minerals and Mining Act (2006) as shown in Table 9.1.

9.4.2 Implementing Pillar 2: Licensing reforms:

a. Modernising the licensing system by improving the Mining Cadastre Administration System (MCAS)

The Ghana online mining repository has been further developed since the time of the literature review in 2020. The updated interface shows a more user-friendly and modern system. Another improvement that was observed was the inclusion of a list of mining support services on the Minerals Commission website

To test the updated online system, the researcher attempted to register as a user once again. However, the system malfunction that was encountered in the literature review chapter (Chapter 3) was experienced. Confirmation of registration was received; however, the user was unable to log on. This made it difficult to identify other improvements that could have possibly been made to the system.

Although there have been efforts to modernize the cadastre, there is still a need for further development. It is recommended for the Minerals Commission to increase the functionality and effectiveness of the system by doing the following:

i. Providing a link to the Mining Repository on the Minerals commission's web page to increase accessibility;

ii. Solving the system malfunctions and testing the system to ensure that the registration link works effectively. Applicants should be able to register and complete applications with minimum glitches;
iii. Creating a video guide on how to use the portal and providing this guide on the portal;
iv. Including spatial information showing maps and plans of designated small-scale mining zones, indicating zones with active mining and those that are free for application, as well as exploration information.
v. Displaying the application costs, and enabling online payments;
vi. Providing links to small-scale training and development material, policies, regulation, and legislation; and
vii. Bringing the system up to date by transferring all existing paper applications and licences to the system within a specific timeline.

The implementation plan proposes for the Minerals Commission to create a task force that will work on the continuous improvement and updating of the MCAS. This task force can capitalise on existing resources and comprise of internal employees, vacation work students, graduates involved in national service, and other experts in the field of GIS. Section 5 of the Minerals and Mining Policy should also be updated to reflect the commissioning of the online Mining Cadastre Administration System. The mining cadastre of Brazil can also be used as a reference in the development of the MCAS.

b. Decentralising the licence application system

The small-scale mining licensing system in Ghana is already partially decentralised. However, it needs to be further decentralised to reduce the current backlog and slow turnaround times. The district offices should be empowered to process applications from start to finish, and issue small-scale mining licences.

This action will not require any amendments to the law as it is currently supported by the Minerals and Mining Act's Sections 82(1) and 91(1) [46]. It would only require the Minerals Commission to advise the Minister and make the necessary changes.

This decentralisation will require the district offices to be enabled and equipped to carry out the new functions. To achieve this, the agency would have to ensure that the correct systems and procedures are set up and put in place. They would also have to train the relevant personnel and put measures in place to streamline the applications that reach the Minister. The Minerals Commission will also have to set up quality assurance and quality control (QA and QC) systems to ensure that the district offices follow the correct processes and maintain the required standard.

c. Separating the licences for artisanal mining and semi-mechanized small-scale mining

The implementation plan also proposes the separation of artisanal mining licences from semi-mechanized mining licences. It is recommended for the Minerals and Mining policy to be revised to reflect this recommendation. The Minerals Commission should also make a proposal for the mining legislation to be amended to align with the revised policy. Table 9.1 shows the amendments that have been recommended for the Minerals and Mining Act regarding this component of Pillar 2.

d. Improving the requirements for community consultations and making consultations compulsory for licence applicants

Sections 5 (d) and 6 of the Minerals and Mining Policy state that upon receiving applications, the Minerals Commission is obliged maintain an active liaison between mining companies and the local communities. The policy also states that effective community consultation is an important part of the mineral licensing

[46] *"a person engaged in or wishing to undertake a type of small-scale mining operation shall register with the District Office of the designated area where the person operates or intends to operate"*

process. Although this is written, the research shows that it is not implemented. The only system that is implemented is the 21 days stakeholders that are given to query a licence application after it has been gazetted. The implementation plan recommends for the Minerals Commission to request the following from licence applicants as proof of effective consultation with community members:

- The applicants should attach a copy of the meeting agenda of the consultation process, a signed attendance register, as well as the points raised, and input given by the community. The points captured should be verified with a signature by a member of the community leadership, who was present during the consultation process. The applicants should also provide a plan showing how their company plans on mitigating concerns raised by the community members.
- The Minerals Commission should encourage district offices to diligently exercise the liaison roles that are specified in the Minerals and Mining Policy Section 5(6). The district offices can achieve this by making traditional authorities aware of the notifications gazetted for their communities, to enable them to notify community members.

9.4.3 Implementing Pillar 3: Training and Education

a. Community based and community driven small-scale mining education and training programs

The strategic framework proposes the creation of community-based and community driven small-scale mining training and education programs. The mining legislation and policy are in line with this recommendation; however, the requirements are not implemented. Section 90(30(a) of the Minerals and Mining Act states that the government (through the Minerals Commission) will *"advise and provide training facilities and assistance necessary for effective and efficient small* *scale mining operations".* In Section 2.1 (viii), the Minerals and Mining Policy states the following government intention: *"Assist in the development of skilled human resource and develop local industrial capacity for the mineral industry*". Section 9(d) of the Minerals and Mining Policy states that the government has implemented training and educational programs for small-scale miners. However, these systems and institutions were not observed during this research. The research shows that there are currently no systems in place for small-scale mining training and education in the local communities.

The implementation plan recommends for government to invest in the creation of small-scale mining training institutions. These training programs should be community-driven, they should be facilitated by trained members of the communities and managed by the Minerals Commission district offices. Some of the youth in these communities can be selected and upskilled to offer the training programs. Traditional authorities and community leaders should also be involved in the community-driven training initiative. It is recommended for the Minerals Commission to consider adopting the process shown in Figure 9.5 when setting up the community-based training initiative. This initiative can also be incorporated into the recently developed Ghana Community Mining Scheme.

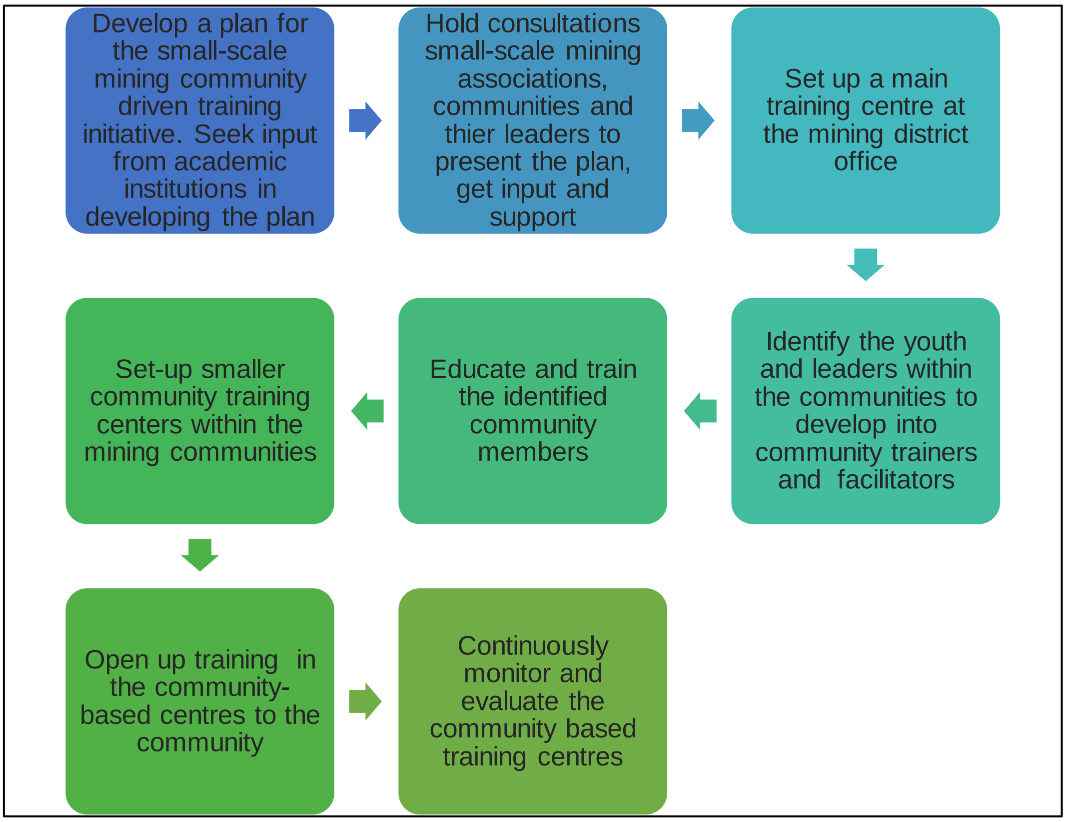

Figure 9.5:Guiding steps for setting up the community driven training program

In this program, the community centres can offer basic training for community members, who would like to increase their understanding of small-scale mining. This should include people who want to apply for artisanal mining licences, and all small-scale mining workers who want to expand their knowledge. More advanced training[47] would be required for semi-mechanized small-scale miners, therefore, their training should be offered by the main centre, which would be located at the district office.

The community training initiative will require the commitment of resources. To meet some of the financial requirements, the training programs can be subsidised by government, and sponsored by large-scale mining companies or other private

[47] Training and refresher courses for the trainers and facilitators, as well as for people looking to obtain certificates of competency.

institutions as part of Corporate Social Responsibility. To address the requirement of human resources, the Minerals Commission can absorb some of the National Service graduates into the district offices and involve them in this initiative.

b. Training as a prerequisite to obtaining small-scale mining licences.

The implementation plan recommends for training to be made a legal requirement in small-scale mining. This can be achieved by making the legislative amendments (related to Pillar 3) that are shown in Table 9.1. Basic training should be mandatory for artisanal miners, and advanced training (accompanied by a Certificate of Competency) should be a requirement for junior miners.

c. The introduction of a small-scale mining Certificate of Competency.

The Minerals Commission currently has a competency examination system for the large-scale mining companies as well as their support services. According to the Minerals Commission website, the people looking to apply for these exams are required to register through their employer and then send their CV and a written application to the inspectorate (Minerals Commission Ghana, 2021b). The implementation plan recommends for the proposed small-scale mining Certificate of Competency to be incorporated into the existing system of statutory examinations. However, there should be the option of registering through the district offices since some of the candidates may not have formal employers. The research recommends for the implementation of the small-scale mining Certificate of Competency to follow the process shown in Figure 9.6

Figure 9.6: Suggested implementation of small-scale mining certificate of competency.

The research recommends for the legal small-scale miners to be given a grace period of 5 years to obtain this certificate. The certificate can also be made mandatory upon the renewal of small-scale mining licences (depending on which comes first).

d. The inclusion of small-scale mining in the National Service Scheme.

The strategic framework recommends for small-scale mining to be included in the deployment list of the National Scheme. Section 3(1)(g) of the National Service Scheme Act, 1980 lists rural development (which includes surveying, planning, civil, engineering, and rural industries) on the deployment list. Small-scale mining can be accommodated into the category of rural industries[48]. If small-scale mining is not seen as a good fit for this category, then this research recommends for the Board of the scheme to apply Section 3(1)(i) of the Act and prescribe small-scale mining as an additional field to the deployment list. After including small-scale mining in the deployment list, the Scheme should collaborate with the Minerals Commission, the Ghana Geological Survey Association, and other relevant government agencies to develop a deployment program for the graduates in the category. Figure 9.7 can be used to guide the development of this program.

[48] It is important to note that the National Micro, Small and Medium Enterprises Policy views mining as a rural enterprise.

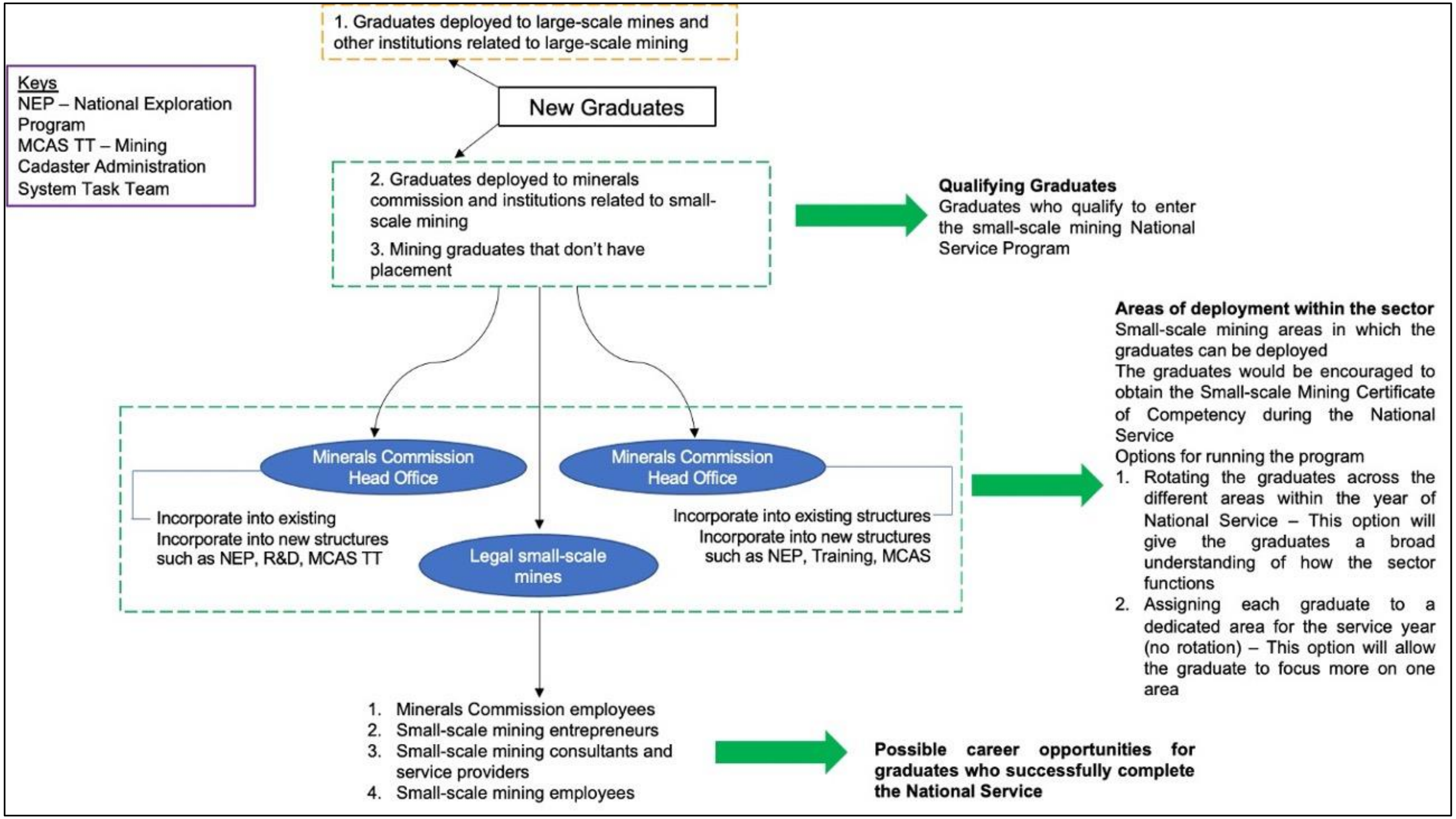

Figure 9.7: Structure of the proposed Small-scale Mining National Service Program

The program can absorb new graduates in fields related to mining, mineral resources, earth sciences and engineering. The program should also be open to absorbing graduates from other fields, who cannot find placement. The graduates can be deployed at the Minerals Commission head office, district offices or legal small-scale mining operations. The graduates at the Minerals Commission would be involved in the regular tasks of the commission, as well as the interventions that have been proposed by the **PASE** framework (i.e., the NEP, MCAS Task Team, R&D, and community training initiatives). The graduates from other fields can be assigned to perform less technical tasks or they can be trained to perform more advanced tasks. During the duration of service, the graduates should be encouraged to work towards obtaining the proposed small-scale mining Certificate of Competency.

Figure 9.7 shows that the Minerals Commission can choose to rotate the graduates between the different work areas to give them a wholistic understanding of the small-scale mining sector. They could alternatively allow the graduates to serve in one field to allow them to specialize. In the future, this program can go as far as involving the Precious Minerals Mining Company to give the graduates exposure to the full mining value chain.

Involving National Service graduates in small-scale mining will enable the young professionals to realize the numerous opportunities available in the sector. They will understand how the sector functions and they will be more encouraged to partake as potential entrepreneurs, service providers, researchers, and employees.

9.4.4 Implementing Pillar 4: Strengthening the technical function of small-scale mines.

a. Assisting the sector to access the required technical skills.

Section 93[49] of the Minerals and Mining Act calls for effective, efficient, and good mining practices in the small-scale mining sector. This can only be achieved if the sector has a firm technical footing. Section 9(a) of the Minerals and Mining Policy states that the Minerals Commission district offices were established to provide technical assistance to the sector. However, the research shows that the district offices are unable to carry out the technical and training duties because of the lack of adequate human resources. The research therefore proposes for the steps shown in Table 9.4 to be followed to enable the strengthening of the sector's technical function.

Table 9.4: Suggestions on increasing the technical functionality of the small-scale mining sector

Recommended actions	Description
Investing in human resources and financial resources at the Minerals Commission.	The Minerals Commission needs to be equipped with sufficient human and financial resources to carry out the required technical duties. The organogram provided in Figure 9.10 can be used to guide the investment in skills.
Reopening district offices in high density areas.	The government should consider reopening the district offices that have been closed in the areas that have a high density of small-scale mining (e.g., in Dunkwa) to help increase the functional capacity of the Minerals Commission.
Building a database of small-scale mining consultants and technical experts.	The Minerals Commission should not only rely on internal skills, but it should also look for technical skills externally. The commission can design criteria for the consultants and issue public communication or call for qualified small-scale mining experts to join the database or pool of technical consultants.

[49] *"A person licenced under section 82 may win, mine and produce minerals by an effective and efficient method and shall observe good mining practices".*

Recommended actions	Description
Applying legal appointments to high-risk areas	The Minerals Commission can apply legal appointments to high-risk areas of the mining operations. This will help to strengthen the importance of the technical pool and encourage the operations to buy into the idea of working with technical consultants. The mines should be able to demonstrate that they regularly consult with the relevant experts to avert the health, safety, financial and other operational risks.

As discussed earlier, the Minerals Commission's website contains a database of mining service providers. The research recommends for the Minerals Commission to develop this database further in the following way to ensure that it adequately caters for small-scale mining:

a. Expanding the database to include small-scale mining consultants. Ensuring that the consultants are competent and verified;
b. Clearly indicating the service providers for large-scale mining, small-scale mining, and both; and
c. Including the contact information of the service providers, or a link to their company information (e.g., company web page or linked in profile) on the website.

b. Investing in small-scale mining research and development.

Section 9(5) of the Minerals and Mining Policy states that government intends to enhance the development of the small-scale mining sector by encouraging *"the use of appropriate, affordable, and safe technology*", and it will *"support the collation and dissemination of information on appropriate technologies, the provision of extension services and demonstration of improved technologies"*. The intentions stated in the Minerals and Mining Policy align with Pillar 4 of the strategic framework. However, they have not been implemented by government.

The research recommends for Government to set up a small-scale mining research and development program to work towards the intentions written in the policy. This program should focus on the creation of a R&D team within the small-scale mining directorship of the Minerals Commission. This team should focus on activities such as:

- Promoting and advocating for small-scale mining research in Ghana.
- Looking at ways that strengthen, customise, and optimise the value chain for small-scale mining; and
- Developing technology that promotes environmentally-friendly, efficient small-scale mining and mineral processing.

An identified quick-win research project is the small-scale demo mine planned by the University of Mines and Technology in Tarkwa. The government should allocate funds towards this project and consider fast tracking it.

9.4.5 Implementing Pillar 5: Strengthening the small-scale mining life cycle and value chain.

a. The creation of the National Exploration Program

The need for exploration information reflects in the mining policy and legislation which state the following:

- The Minerals and Mining Policy
    - Section 2.1 - (i) "*Generate adequate geo-scientific data to promote investment"; (iii) "Generate detailed geological information in designated areas for demarcation to artisanal and small-scale miners".*
    - Section 9(b) – "*geological investigation and demarcation of areas suitable for small-scale mining".*

- Section 9(3a) – "*The Minister exercises his authority, in consultation with the Minerals Commission, to continuously designate areas to be reserved for small-scale mining activity based on technical and financial viability of the areas*"[50].

- The Minerals and Mining Act, 2006: Section 89: "*the Minister may by notice in the Gazette, designate that area for small scale mining operations and specify the mineral to be mined*".

Exploration information is needed to carry out the objectives written in the policy and the actions stated in the legislation. The creation of the National Exploration Program should therefore be high on the list of national priorities for the Government of Ghana. The diagram shown in Figure 9.8 can be used to guide the development of the proposed National Exploration Program.

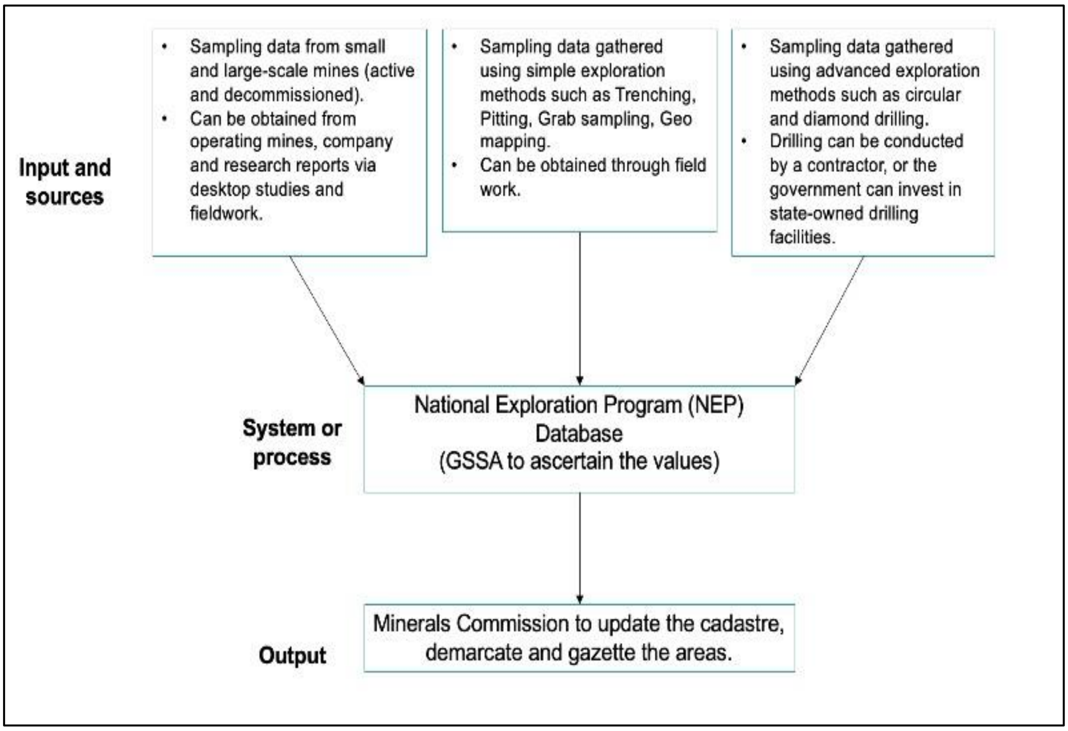

Figure 9.8: Envisaged schematic of the National Exploration Program

[50] It is important to that note exploration information is needed to determine financial viability.

In Chapter 4, the research explains that small-scale mining can be seen as a form of prospecting. Ghana can use information from the activity to populate the NEP database and national mineral resource maps. This will help Ghana as well as other countries that cannot afford large-scale or national prospecting programmes. The input required for the NEP database can be sourced using exploration methods, desktop studies, and consultations with both large and small-scale mines. The research recommends for simple and complex exploration methods to be used to gather the input data. The implementation plan proposes for the government to invest in state-owned drilling equipment because of the anticipated extensiveness and long duration of the drilling program. The research also recommends for government to invest in laboratories, skills, and software that will assist with the analysis and interpretation of the exploration data.

As indicated in Chapter 8, the research recommends for the National Exploration Program to be a collaborative effort between the Minerals Commission and the Ghana Geological Survey Authority. The GGSA would lead the program with support from the Minerals Commission. Table 9.5 shows the responsibilities of the two government agencies in this program.

Table 9.5: Recommended roles and responsibilities in the NEP collaboration

Recommended roles for the GGSA	**Recommended roles for the Minerals Commission**
• Managing and planning the exploration program. • Identifying areas where exploration will be conducted. • Managing the exploration drilling teams and other teams that gather and analyse data. • Gathering the exploration data in the field (including core analysis). • Management of the facilities that analyse the results (e.g., laboratories) • Ascertaining the values obtained during exploration. • Analysis of exploration data.	• Input into the planning of the NEP. • Assisting the GGSA to identify exploration areas. • Assisting the GGSA to gather data in the field (gathering existing data from sources, assisting with the simple sampling methods). • Submitting the gathered data to the GGSA for input into the database. • Using the information generated by the database to update the mining cadastre, demarcate, and gazette areas for small-scale mining.

The function of the GGSA would be similar to that of the Ethiopian Geological Survey (see page 49 of the thesis).

b. Adapting and encouraging feasibility studies for small-scale mining

The implementation plan recommends for the Minerals Commission to build on the work done in this research by developing feasibility studies that are suitable for small-scale mining. Although Chapter 5 does not conduct a full feasibility study, it shows that it is possible to produce a discounted cashflow for a small-scale mining project. This can be achieved if the required input parameters (shown in Table 9.6) are obtained. The input parameters can be sourced from various sources such as sampling, existing production information, legislation, and similar projects. The parameters provided in Table 9.6 are applicable to semi-mechanized small-scale mining operations; however, the table can be simplified for artisanal mining. With the correct technical skills, the information shown in Table 9.6 can be used to indicate the future profitability of the project.

Table 9.6: Input parameters for basic small-scale mining financial model

Required input parameters	Source of data or information
Type and cost of capital required	• Estimates by project planners • Similar projects • Supplier websites and other internet sources
Expected mining surface area, gravel and overburden depth	• Exploration data • Similar projects
Expected mineral recovery	• Exploration data • Similar projects
Commodity price	• Commodity trading and information websites
Exchange rate	• Financial information websites
Buyer price (in the case of gold)	• Potential buyers
Indirect costs such as labour costs, operating costs etc.	• Estimates by project planners • Similar projects
Royalties	• Mining legislation
Tax rate	• Revenue authority website • Economic websites
Interest rate	• Economic websites

9.4.6 Implementing Pillar 6: Improving the business function and image of small-scale mining

a. Empowering small-scale mines to operate as Micro Small Medium sized Enterprises.

Section 2.1 (paragraph 5) of the Ghana MSME Policy lists mining as one of the major activities in rural enterprises. In addition to this, the case study used for this research shows that a typical small-scale mine aligns to both the World Bank and Osei's description of MSMEs. Small-scale mines in Ghana should therefore be officially placed under the category of MSMEs. They should also be encouraged to operate as such. This will help to strengthen the business functionality and the entreprenureship capability of the sector. MSME policies, legislation, best practices, and tax regulations should also be applicable to small-scale mining, and they should be developed with the sector in mind.

The Ghana MSME policy shows that there is still a lot of work that needs to be done to enable the legal and regulatory frameworks to favor the development of MSMEs. The implementation plan recommends for the following to be considered when developing the required laws and regulations:

i. The development of a standard definition for MSMEs. This definition should reflect the current employment conditions in Ghana, and it should allow a wider inclusion of enterprises, including small-scale mining;
ii. Introducing tax incentives that favour the growth and development of small-scale mines and other MSMEs; and
iii. Creating channels or opportunities that can help MSMEs gain access to finance.

The implementation plan recommends for the Minerals Commission to take a lead and create business development programs for small-scale mines. The initiative should focus on offering small-scale miners the following:

- Training and education about business, entrepreneur and sustainability;
- Business support to the youth and women;
- Technical support;
- Information about access to the market and fair market value; and
- Identification of financing and financial products through existing legitimate financial institutions. This should include grant financing through government and parterships with the large-scale mines (legal small-scale mines can be sponsored by large-scale mines as part of the corporate social responsibility).

The proposed business training can be included in the curriculum of the community-driven training initiative, as well as the certificate of competency. It is also important include the leaders of the small-scale mining communities (specifically the traditional authorities) in educational programs. This will enable them to realize the importance of the long-term economic contribution of the sector, over short-term economic gains for an individual.

b. Aiding to small-scale mines to access finance

Ghana is currently in the pipeline of establishing The Development Bank Ghana. The project was approved and funded by the World Bank and the African Development Bank in 2020 and 2021 respectively[51] (World Bank, 2020; African Development Bank, 2021). According to these institutions, the bank will be designed specifically to provide long-term finance to MSMEs and small companies. The project is also envisioned to help financially constrained viable MSMEs to attract funding opportunities from the private sector (World Bank, 2020). It is important for Ghana to accelerate the development of this bank and include small-scale mining as one of the sectors that will be eligible for finance[52]. If small-scale mines are given access to this finance, mineral rights can be used as equilaterals (because the development bank would be state-owned), with payment of the loan occurring over the longer life of the licence.

The stakeholders interviewed in Chapter 7 also raised other options on how finance opportunities can be created for the sector. These suggestions are shown in Table 9.7.

[51] The project was granted USD 250 million from The World Bank and USD 40 million from the African Development bank (World Bank, 2020; African Development Bank, 2021).
[52] It is important to note that development banks are state-owned. Giving the small-scale miners access to this finance, will allow government to support the sub-sector.

Table 9.7: Small-scale mining finance options proposed by stakeholders

Options	Description
Option A	• Creating a local pool of investors for legal small-scale mining projects. The potential investors will be required to complete a registration of interest. Their information would be captured on a database kept by the Minerals Commission, and they would be matched to suitable projects. • Small-scale miners would be required to submit a good business proposal to be considered for this program
Option B	• Allowing foreign investment for semi-mechanized small-scale mining or junior miners.
Option C	• Allowing legal small-scale mining projects in Ghana to enter the local Stock Exchange. This would present an opportunity to create an entire subsidiary around raising capital for local small-scale miners. Moreover, listing small-scale mines on a reputable stock exchange will drive them to stop operating under the radar. It will push them into disclosure in all elements of the operations including finance, health, and safety.

c. Improving the public perception of small-scale mining

The Ghanaian government should work on drawing attention to the positive attributes of small-scale mining. These attributes can be highlighted through awareness campaigns, infographics, adverts, and community engagement sessions as discussed in Table 9.2.

Official recognition will also assist to improve the public image of the sector. Many of the stakeholders would like to see the sector holding recognition that is like that of large-scale mining. The legal definition of official recognition, according to the Law Insider (2021), is as follows: "*the procedure by which the Government agency having jurisdiction formally recognizes the competence of a body*". This definition includes the word 'competence'. This suggests that for something to be officially recognized, it should demonstrate a certain level of competence. Competence requires work to be done skilfully and according to health, safety, and environmental regulations. Increasing competency in the sector can be achieved by implementing pillars 3 and 4 of the **PASE** framework.

9.5 Quick wins identified in the implementation plan

One of the important requirements for change management is the identification of quick wins or low-hanging fruit. It is important to identify what can be done immediately to demonstrate the benefits of the **PASE** framework early on. Demonstrating the quick wins and early befits will enable the initiative to win people over and gain increasing support. Table 9.8 shows the quick wins that have been identified, and it also estimates a time frame for implementation.

Table 9.8: Quick wins identified in the implementation plan

Identified quick wins		Estimated timeline for implementation
Pillar 2	• Creating a task force to work on the continuous improvement and updating of the Mining Cadastre Administration System.	2 months
	• Increasing the functionality effectiveness of the Mining Cadastre Administration System.	1 year
	• Improving the requirements for community consultations and making consultations compulsory for the licence applicants.	Immediate (less than 1 month)
Pillar 3	• Developing the community-based and community-driven small-scale mining training and education program. Incorporating this initiative into the Community Mining Scheme.	1 year
	• The inclusion of small-scale mining in the National Service Scheme.	2 years
Pillar 4	• Setting up database of small-scale mining consultants; Improving the database of service providers on the Minerals Commission website to accommodate the small-scale mining consultant pool.	1 year
	• Creating a small-scale mining research and development team within the Minerals Commission.	Immediate (less than 1 month)
	• Funding R&D initiatives at the Tarkwa University of Mines and Technology (UMaT) and fast-tracking the small-scale demo mine project at UMaT.	1 year
Pillar 5	• Adapting feasibility studies for small-scale mining through research • Requesting for small-scale licence applicants to submit a discounted cashflow (and other proof of feasibility) with their applications.	1 year

Identified quick wins		Estimated timeline for implementation
Pillar 6	Improving the image of small-scale mining Developing campaigns to communicate the desired vision for the sector and the positive attributes of small-scale mining.	1 year

9.6 Actions required to anchor and sustain the change

9.6.1 Increasing organizational support for the sector

One of the strengths of Ghana is that the country has the Minerals Commission, a government agency which contains a directorate that is dedicated to small-scale mining. The Minerals Commission's small-scale mining department needs to be equipped with sufficient skills, and human resources to be able to carry out the requirements of the **PASE** framework (as the identified champions of change).

The current organisational structure of the Minerals Commission below the level of the Deputy CEOs is unclear. There is information about the different management roles on the agency's website, however, there is no information to show how the roles are connected. The Minerals Commission's annual reports show a breakdown of the staff composition, however, they do not provide an organogram. The organogram of the district offices is also unclear. The Minerals Commission indicated that the organogram was still work-in-progress due to the extensive restructuring that has been taking place since the 2017 government elections. In the absence of an official organogram, the research has created an interpretation that is shown in Figure 9.9. The organogram was interpreted using information on the Minerals Commission's website, and feedback from stakeholders. It is important to note that this is not the official organogram of the Minerals Commission, it is only an interpretation developed to guide the implementation plan.

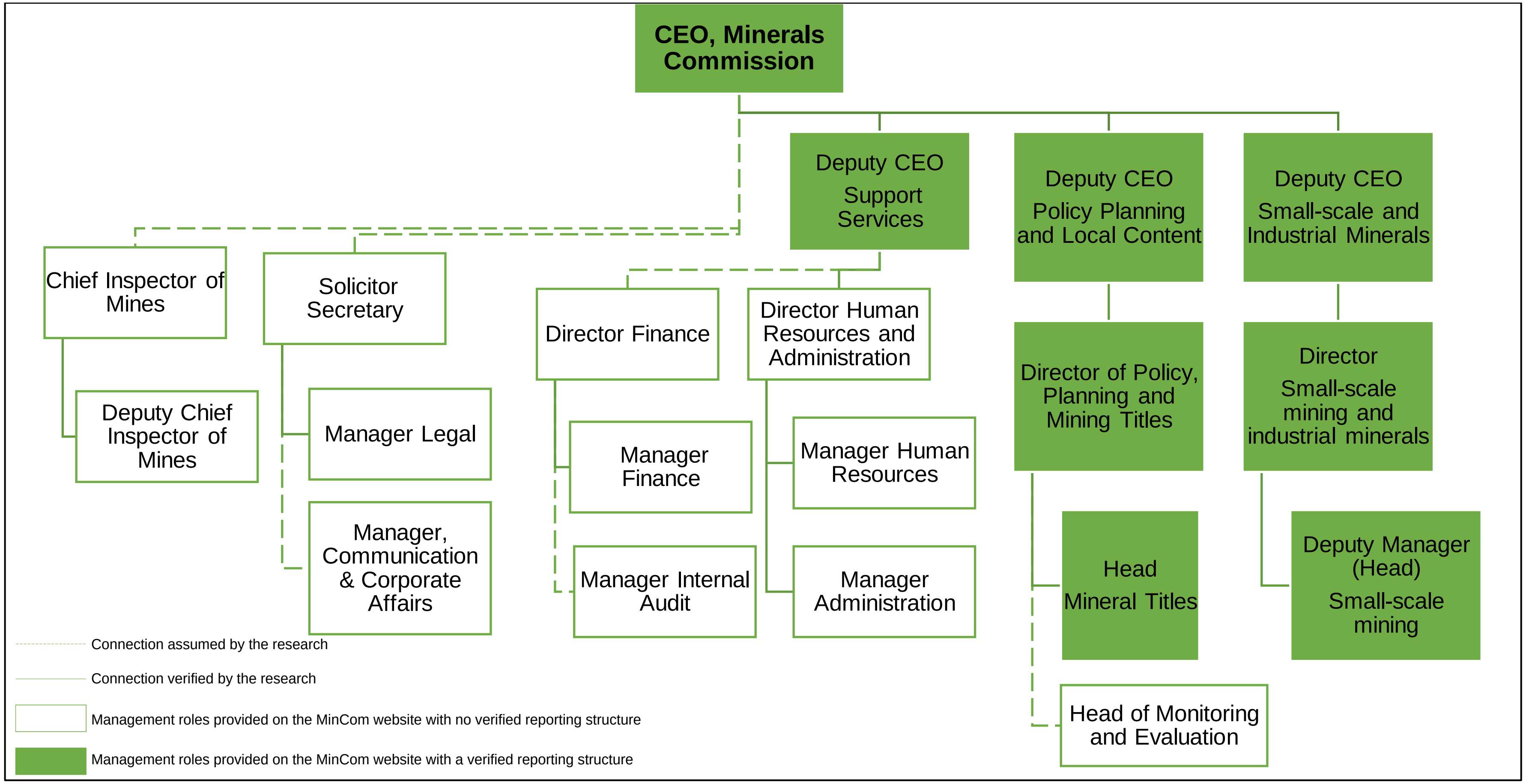

Figure 9.9: The research’s interpretation of the organisational structure of the Minerals Commission Head Office

Source: Minerals Commission Website (2021).

Figure 9.9 shows that the Directorate of Small-scale Mining and Industries reports to a Deputy CEO. According to the stakeholder feedback, the Director is assisted by the Head of Small-scale Mining, whose responsibility is to oversee and manage the district offices in Ghana. Each district is run by a district officer, who is supported by District Administrators. This organogram as well as the information gathered by this research shows that the structure of the small-scale mining directorate is lean. According to a paper written by the former CEO of the Minerals Commission, Dr. Toni Aubynn (2017), the lack of adequate staff in the district offices is seen as one of the factors that contribute to the increase of illegal mining in Ghana.

The analysis of Ethiopia and Brazil in Chapter 2 showed that even with the best systems and initiatives, implementation can be poor if human resources are insufficient. This is one of the reasons why the research highly recommends the expansion and strengthening of the Minerals Commission’s small-scale mining directorate. This expansion can be achieved by capitalising on existing positions and creating new roles as shown in Table 9.9.

Table 9.9: Roles that are recommended for the implementation of the PASE framework

Recommended roles for Head Office	Creation of new role or capitalising on existing roles
Head of Small-scale Mining	**Capitalising on existing roles:** This role currently exists. However, it is recommended that the responsibilities be revised to align with Figure 9.10.
Head of Systems Research and Development.	**Creation of a new role:** This role currently does not exist. It is recommended for this role to be created.
Research, Monitoring and Evaluation officers.	**Capitalising on existing roles:** This role currently exists in the Minerals Commission. However, the reporting structure is not clear. It is recommended that the Minerals Commission capitalises on this role by expanding its scope to include monitoring and evaluation, and research and development of small-scale mining to assist the Head of Systems, Research and Development.
Licensing and regulation District Officer. **Licensing and regulation assistant.**	**Capitalising on existing roles:** These roles currently exist on district level. However, it is recommended for the roles and responsibilities to be adjusted as indicated by the **PASE** framework and Figure 9.10.
Training and technical services District Officer. **Training and technical assistant**	**Creation of new roles:** These roles currently do not exist in the Minerals Commission. It is recommended for these roles to be created as suggested by the **PASE** framework and Figure 9.10.

Figure 9.10 shows the organogram that the implementation plan proposes. It also identifies the relevant roles and responsibilities. This organogram is recommended for head office to district level.

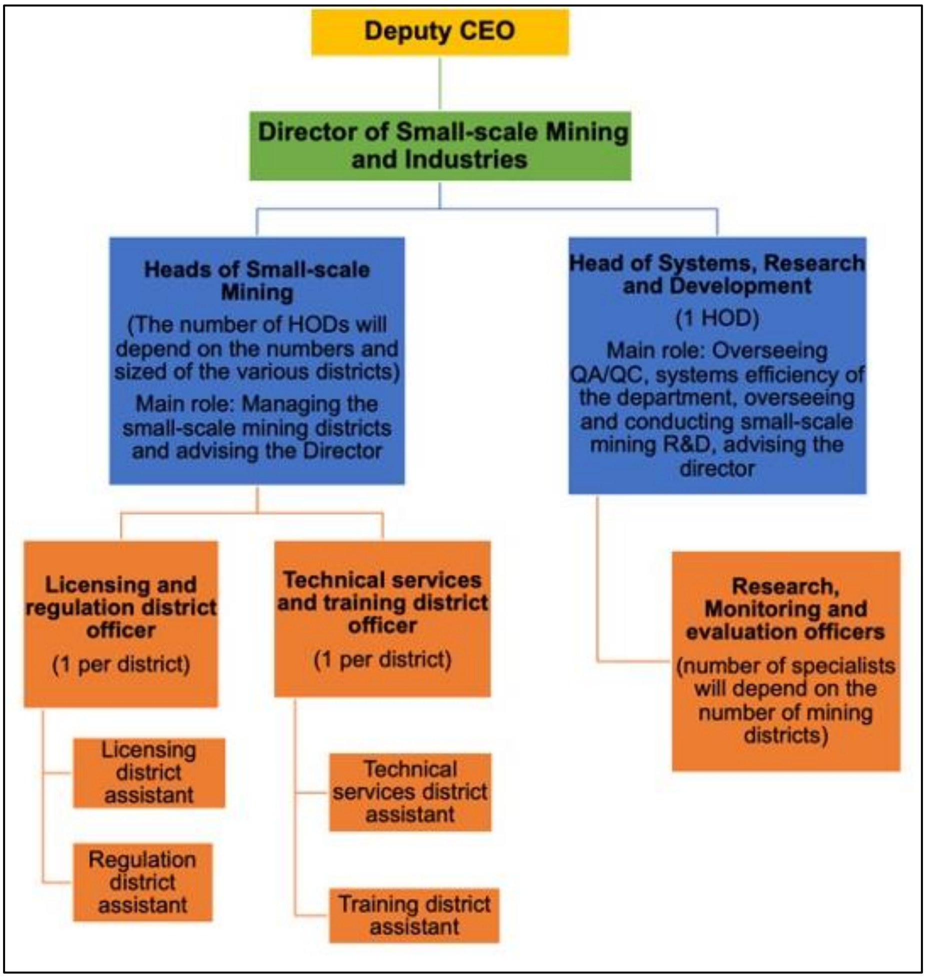

Figure 9.10: The recommended organogram for the small-scale mining directorship.

9.6.2 Behaviours that are required to support and sustain the implementation of the PASE framework

Human behaviour is important to the successful implementation of change management. It is important to change behaviour (moving from the current behaviour to the desired behaviour), and to sustain the change in behaviour. Anchoring the **PASE** framework will require significant behavioural changes from the top to the bottom structures of the small-scale mining sector. Table 9.10 identifies some of the desired behaviours that will be required from the stakeholders to enable the successful implementation of the **PASE** framework.

Table 9.10: Identified desired behaviours required from stakeholders

Stakeholder group	Desired behaviours
Government and government agencies	• Minimizing political interference in the sector. • Giving technical and regulatory bodies the latitude to operate. • Working towards a long-term vision and goals versus short-term political gains. Enabling the small-scale mining sector to survive political administrations.
Small-scale mining communities and miners	• Being well organized and cooperative or organizations. • Following legal requirements, complying with the terms and conditions of establishing a small-scale mine. • Honouring and respecting terms and conditions of collaborative efforts with LSM. • Willingness to educate and be educated. • Calling out illegal mining activity in communities. • Abiding by mining ethics and principles.
Traditional and community leaders	• Understanding their power to help regulate and streamline small-scale mining. • Orientating themselves well with their land and communities. Knowing the parameters and features of their land and the protected areas. • Educating themselves about small-scale mining. Developing a good understanding of the business. • Not pressuring small-scale mines for quick money and encouraging them to grow into sustainable businesses with long term value and community upliftment. • Encouraging mines to operate within the boundaries and terms and conditions of permits and agreements. • Co-regulating on a local level to help enforce regulations. Showing an interest in mining regulations. • Holding community members and small-scale mining operations accountable for their mining practices and impact on the communities and the environment. • Blocking illegal miners from encroaching on land.
Chamber of Mines and large-scale mining companies	• Stopping the condemnation of small-scale mining. Recognizing the sector as a legitimate contributor to mineral production. • Opening membership of the Chamber of Mines to the legal small-scale mines that meet the requirements of the membership compact. • Increasing collaborations with the small-scale mining sub-sector. • Large-scale mines releasing some of their unused or unoccupied concessions for small-scale mining. • Large-scale mines should allow small-scale miners to mine on a portion of their concessions for a period, under mutually agreed terms and conditions.
Academic and training institutions	• Investing in and assisting with small-scale mining research and development. • Adapting curriculums at universities to small-scale mining (i.e., business principles, technical and legislative requirements etc.) • Making students aware of opportunities available in small-scale mining and encouraging them to explore the opportunities.

9.7 Conclusion

The implementation plan developed in this chapter should be viewed as a roadmap to change, which is guided by Lewin's 3 stage model of change. It is designed to facilitate change in leadership, technical, and behaviour areas. It is also designed to be practical and sustainable. The plan is dynamic, which means it can be refined by valid input and further research. The implementation plan is also cyclic (like most change management plans and models). The repetition is important because it helps to embed the normal into the subconscious of the people involved in the change process, thus making it more sustainable. Because the change required is significant, the research recommends for the Minerals Commission to hire a change management specialist or expert (on a consultancy basis) to help with planning for and working towards the envisioned change.

The next chapter draws conclusions for the research. It makes general recommendations on the improvement of small-scale mining in Ghana, and provides recommendations for further research.

10 CONCLUSION AND RECOMMENDATIONS

10.1 Introduction

The purpose of Chapter 10 is to summarize and reflect on the thesis. This chapter sums up the main findings of the research, it provides general recommendations for the identified problem, and makes suggestions for future research.

This research topic was selected to help Ghana work towards converting its mineral wealth into lucrative and sustainable income-earning opportunities. It investigates achieving this through maximising the proficiency of the country's small-scale mining sector. The research takes a technical, and people-centred approach to solving the identified problem. Figure 10.1 provides a summary of the areas that were addressed in this thesis in developing a solution for the research problem.

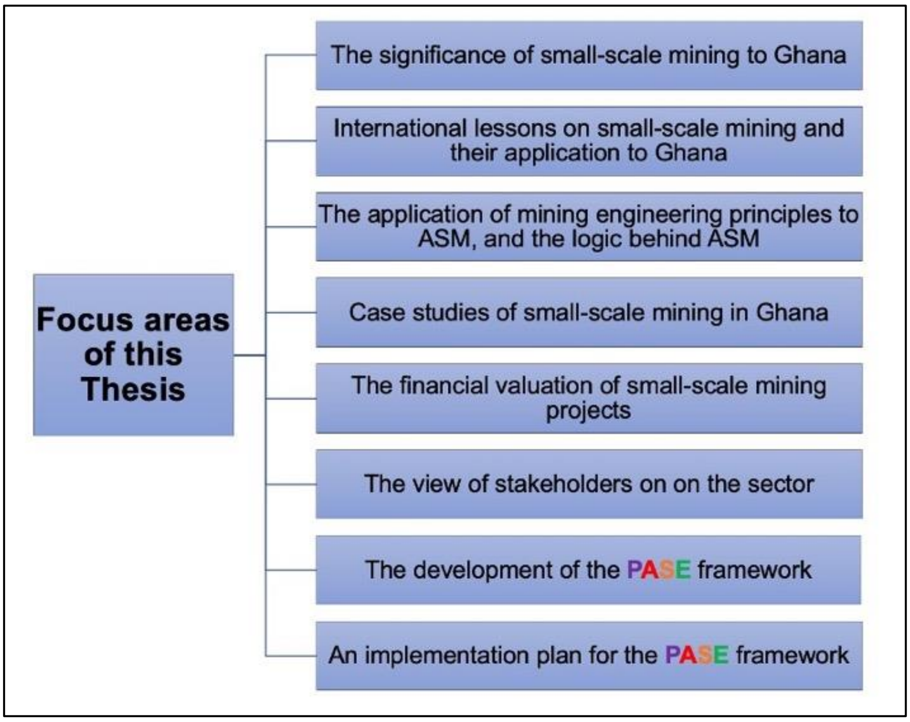

Figure 10.1: The focus areas of the thesis

The thesis develops a vision and a strategic framework for the Ghanaian small-scale mining sector. It also develops an implementation plan (a roadmap to change) to guide the country to work towards the vision. The proposed solution, which is called the **PASE** framework, is formulated using a bottom-up approach, while the implementation plan takes on a top-down approach.

10.2 A summary of the research findings

10.2.1 The significance of small-scale mining to Ghana

Chapter 1 discusses the research problem and purpose. It puts the study into context by highlighting the significance of small-scale mining to the Ghanaian economy and people. The chapter shows that small-scale mining is a larger employer than large-scale mining. It also shows that production of gold dominates the sector, and small-scale mines in Ghana collectively generate more revenue than any single large-scale gold mining company. The chapter shows the importance of small-scale mines to diamond production as diamonds are sourced solely from these mines.

Chapter 1 shows that the projected global demand of gold and diamonds is high. It also shows that the global market will struggle to meet this future demand. It concludes that Ghana needs to work on improving the small-scale mining sector to enable it to take advantage of the projected high demand.

10.2.2 Identifying international lessons on small-scale mining and applying them to Ghana.

Chapter 2 focuses on identifying international lessons that can be used to guide Ghana, while Chapter 3 applies these international lessons to Ghana. These chapters examine the small-scale mining definitions, legislation, and mining cadastre of 5 different countries that have significant small-scale mining activity.

The analysis shows that 3 out of the 5 countries regard artisanal mining and small-scale mining as different entities and they define them separately. Some countries have even gone as far as developing different licensing requirements and procedures for artisanal miners. This analysis also shows the importance of a modernized mining cadastre to the transparency and efficiency of mineral rights applications.

Chapter 2 shows that the mining chain is applicable to the small-scale sector. However, the value chain is weak because small-scale miners bypass many critical steps of the value chain (such as exploration and feasibility), and they trade minerals anywhere throughout the value chain.

Chapter 3 finds that the observations made in Chapter 2 apply to Ghana. It shows that even though Ghana has made effort to develop the small-scale mining sector, it is still lagging behind its peers in legislation and support for the sector. It finds that Ghana needs to make more effort to improve these areas to support the development of small-scale mining.

10.2.3 The application of mining engineering principles to ASM.

Chapter 4 examines the application of mining engineering techniques and theory to ASM. To structure the chapter and give a wholistic view, it conducts this analysis according to the order of activities in the mine value chain.

Chapter 4 finds that there are blurred lines between prospecting and small-scale mining, and it shows why ASM can be regarded as a form of prospecting. The chapter then shows that there are simplified components of the value chain that are (or can be) adopted by small-scale mines, these lie in exploration, sampling, mine development, and production. However, there are some activities in the value chain that are too complex for the sector (such as resource modelling and feasibility studies) and are hence, not frequently applied. Chapter 4 finds that there is rationale behind ASM, and the sector applies mining engineering, but in first principles.

10.2.4 Case studies of Ghanaian small-scale mines

Chapter 5 investigates the real-life activity of small-scale mining operations in Ghana. During this stage, the research experienced the difficulty of identifying a small-scale diamond mine that was willing to participate in the study. As a result, the research resorted to removing the diamond mining case-study, and replacing it with two gold mines.

Chapter 5 therefore documented the activities of the following four gold mining operations: two illegal mines (collectively referred to as Case Study A) and two legal mines (referred to as Case Study B). The main findings in this chapter were as follows: The mines that operate legally looked better, they were better equipped, better structured, and they appear to function significantly better than the illegal mines. The people working on the legal mine (Case Study B) had good technical knowledge. They applied mining engineering principles, and they adhered to environmental regulations. Their site also looked better and safer than that of the illegal miners. With the illegal mining case study, observations and interactions with workers were limited due to safety. However, the photos that were taken showed that they are the complete opposite of the legal mining operations. I

10.2.5 The financial viability of small-scale mines.

Chapter 6 serves two purposes, firstly to determine if financial valuation can be applied to small-scale mining, and secondly, to give an idea of the financial viability of small-scale gold mining projects. Chapter 6 shows that with enough production data and financial information, it is possible to conduct financial valuation for small-scale mining. A person with enough technical skills, and a good understanding of the process can generate a discounted cashflow for the project.

The chapter finds that the legal small-scale mining project presented in Case Study B has the potential to generate a very high NPV and IRR. However, this profitability will be affected by the projects' decision to buy or rent equipment and machinery. The discounted cashflows show that in a situation where gold recovery is low, it would be more profitable for the project to buy machinery. However, if gold recovery is high, the project is less likely to be affected by the decision to buy or rent.

Chapter 6 also finds that the current 5-year licence allocation period does not favour semi-mechanized projects that mine low gold recoveries. Such projects would need to recover at least 1.09g/m^3 of gold to generate a positive NPV within 5 years. Any recovery lower than this will generate a negative NPV within this period.

10.2.6 The view of stakeholders on the small-scale mining sector

Chapter 7 provides feedback from interviews with stakeholders that are involved in and affected by small-scale mining. The chapter aims to investigate how the different stakeholders view the sector.

Chapter 7 finds that the stakeholders share very similar thoughts on the small-scale mining sector. They view it as one that is doing more harm than good because of the way it is currently managed. However, all the stakeholders have hope for the sector. They believe that it has high potential, and it can make an even bigger economic contribution if it is managed correctly. The stakeholders also believe that the youth stand to benefit significantly from proper small-scale mining.

The stakeholder feedback brings to light the pull and push factors that are causing people to engage in ASM. It also reveals some of the biggest challenges facing the sector (i.e., legislation, licensing, politics, education, training, and technical issues).

The chapter also finds that the sector is largely self-reliant. There is no support (aside from regulation) that the government offers to small-scale mining.

Despite the many challenges in the sector, the stakeholders were still able to share success stories. They gave examples of economic linkages, employment, and community development opportunities that emerged from small-scale mining in various communities.

10.2.7 The development of the PASE framework

Chapter 8 uses the information gathered in the preceding chapters to develop the **PASE** strategic framework. This framework focuses on helping Ghana to work towards the improvement of the small-scale mining sector. From Chapter 8 onwards, the research stops using the phrase "artisanal and small-scale mining" and refers to the sector as "small-scale mining" to align to the **PASE** framework, and the proposed way forward.

In this chapter, the **PASE** framework creates the following long-term vision for the Ghanaian small-scale mining sector: *Building a sustainable small-scale mining sector that uplifts communities and creates diverse economic opportunities*. It intends on achieving this vision by empowering the small-scale mines in Ghana to operate in a professional, accountable, sustainable, and economic way. The **PASE** framework draws its content from the work done in the research, and it is founded on the 6 pillars that are shown in Figure 10.2. The 6 pillars of the **PASE** framework describe the areas that Ghana needs to focus on to work towards the desired vision.

The end of Chapter 8 provides a SWOT analysis on the **PASE** framework and finds that the identified strengths and opportunities of this framework outweigh the weaknesses and threats. The chapter also finds that the **PASE** framework can be applied to all forms of small-scale mining, as well as other countries that face similar challenges to Ghana.

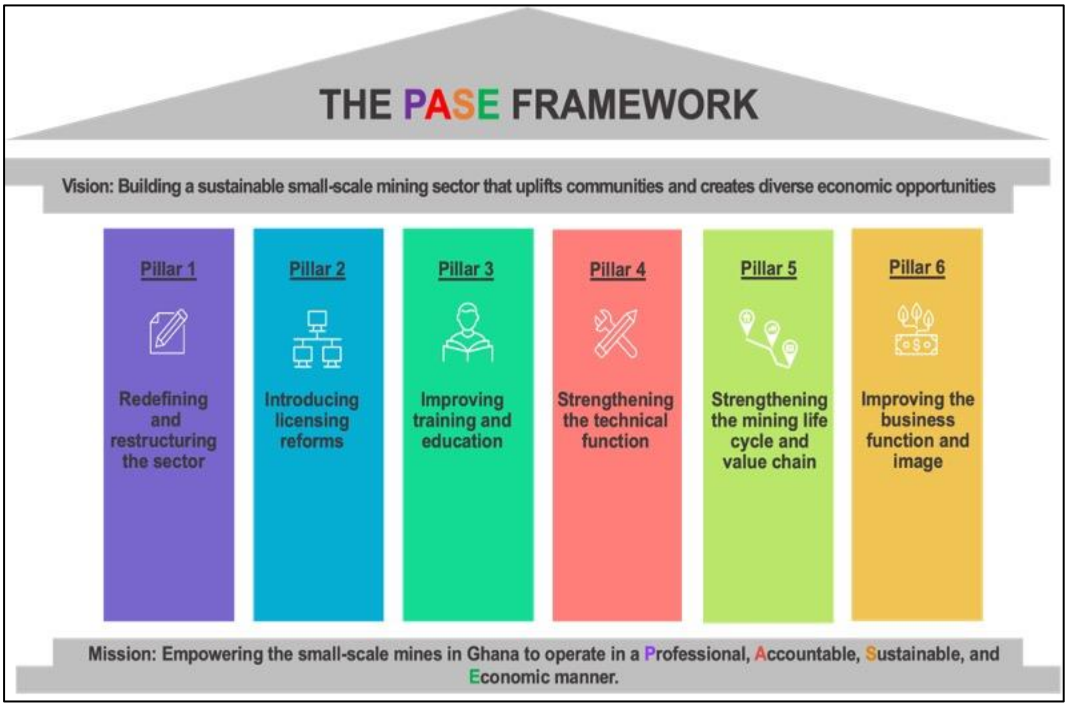

Figure 10.2: The PASE framework

10.2.8 An implementation plan for the PASE framework

Chapter 9 develops a plan to guide the implementation of the PASE framework. Here the research finds that the implementation will require a change management approach because the PASE framework proposes significant changes. The chapter refers to this implementation plan as a roadmap to change, it then structures it according to the key principles of change management. The research uses Lewin’s change model of unfreezing, changing, and refreezing to guide the implementation plan as shown in Figure 10.3.

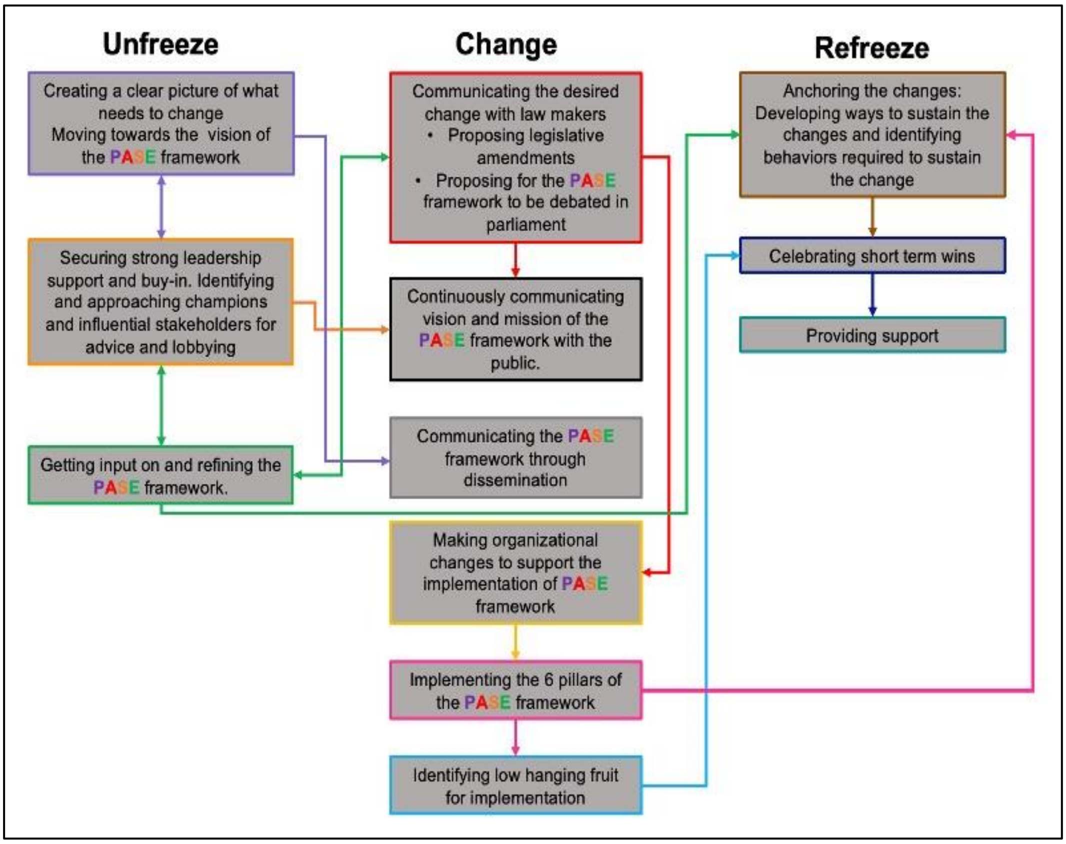

Figure 10.3: A summary of the PASE framework implementation plan

The implementation plan is designed to fit into and capitalise on existing systems and structures. It recommends for adoption by the Minerals Commission, and support by influential leadership structures in mining.

Chapter 9 finds that some of the initiatives proposed by the PASE framework already exist in the current mining policy and legislation. However, they are either poorly implemented, or not implemented at all. The plan provided by this thesis bridges this gap by making recommendations on how these initiatives can be implemented.

Towards the end of Chapter 9 the implementation plan identifies the quick wins of the PASE framework. It also shows the support structures and behaviours that are needed to ensure the sustainability of the PASE framework.

10.3 Research Limitations

The following limitations were identified in this research

- The inability to interact with a wider audience in the small-scale mining communities due to the COVID 19 pandemic;
- The exclusion of small-scale diamond mining in the case studies due to the difficulty of identifying a mine that was willing to participate in the research;
- The use of only 4 gold mines in the case study. With more time and resources, the research could have expanded the case studies to cover more operations;
- The inability to obtain production data from the illegal mine; and
- The inability to get accurate financial data for the legal mine. This resulted in the estimation of the project finances.

Although the limitations did not significantly affect the quality of the thesis, they could have added more valuable information. These limitations will be addressed in future research projects, which will focus on building on this thesis, and refining the **PASE** framework further.

10.4 General recommendations of this research

This section makes recommendations for Ghana to work towards an improved small-scale mining sector. The recommendations here are more general, and they also include summaries of the key recommendations of the research.

10.4.1 Recommendation 1: Positioning the small-scale mining sector as a cornerstone for economic growth and development.

The research recommends for Ghana to strategically position the small-scale mining sector to become a catalyst for economic growth and development. The strategy of using mineral wealth to develop economies has been applied elsewhere on the African Continent and it has been successful. In a report titled *"Towards Sustainable Economic Development in the Gold Mining Areas of Ghana and South Africa",* Boaduo (2017) discussed how South Africa used the gold mining industry as a cornerstone for economic development. The country developed this strategy in the mid-1900s, and it ensured that the strategy was supported by the law and linked to the policies and legislation of the larger economy.

The main recommendation in this research is for Ghana to follow a similar route to South Africa. This will require political parties to agree on and follow one long term economic plan and vision. It will also require them to put aside their differences in working towards the plan. This initiative should surpass the motives of individual political parties, and it should also survive political administrations. If possible, the commitment to this strategy should be included in the Constitution, or alternatively, political parties can sign a compact agreeing to work together towards the vision.

Adopting this strategy will mean ensuring that policies, legislation, and regulations encourage the creation and strengthening of economic linkages between small-scale mining and other sectors of the economy. In doing this, the government should also focus on developing strategies to decouple the economy from small-scale mining in the long term. This will help the government to maintain the value of the extracted mineral resources.

10.4.2 Recommendation 2: Adopting the PASE framework and implementation plan

The research recommends for the **PASE** framework and implementation plan to be adopted by the Ghanaian government. The government institutions can refine the **PASE** framework with further research and discussions, and it can be used to guide the strategy that is proposed in recommendation 1.

10.4.3 Recommendation 3: Improving value addition in small-scale mining

In Chapters 2 to 5, the research shows that value addition is generally poor in small-scale mining. Minerals are traded prematurely, and at any time throughout the value-chain. The thesis recommends for Ghana to encourage enhanced value addition in small-scale gold mining by doing the following:

- Hosting workshops and days of learning in communities to educate small-scale miners and traders about the benefits and importance of value addition;
- Accelerating the construction of the state-owned gold refinery. In 2019, the government committed to building a state-owned gold refinery (through the PMMC), which was to be commissioned in November 2021. However, the project was only 85-90% complete towards the end of 2021 (African Mining Market, 2021). It is important for Ghana to accelerate this project and bring the gold refinery into commission as soon as possible; and
- Increasing the red tape on (or entirely banning) the export of unrefined ore, metallic concentrates, and unpolished diamonds.

10.4.4 Recommendation 4: Including small-scale mining in the mainstream educational programs of higher learning institutions.

Recommendation 4 goes beyond the training that is discussed in Chapters 8 and 9. It proposes for small-scale mining courses to become part of the mainstream syllabus of universities from first year to final year. The current mining engineering educational programs focus on preparing students to work in large-scale mining. This research shows that the large-scale mines in Ghana are too few to absorb the number of mining graduates. The magnitude of small-scale mining in Ghana should cause the subject to form part of the core courses for undergraduate students. Ghana (and the rest of the African continent) needs to destigmatize the career path of small-scale mining amongst young professionals. The continent should promote this as a legitimate career path that has the potential to offer lucrative opportunities in entrepreneurship. It should also encourage specialisation for postgraduate students. Small-scale mining research topics and academic projects should be encouraged and subsidised by government. These research topics and projects can feed into the research and development initiative that is proposed by the **PASE** framework and implementation plan. The research also recommends for African universities that offer mining engineering qualifications to include courses on topics such as the African Mining Vision, African mineral wealth, and the development of small-scale mining in Africa.

10.4.5 Recommendation 5: Reviving small-scale diamond mining in Ghana.

Chapter 1 shows the decline of diamond production in Ghana. A few reasons behind this decline are: the stronghold of gold in Ghana, the perceived difficulty of prospecting for and trading diamonds, and insufficient diamond exploration. The last point means that there is no discovery of new orebodies to replace the depleted deposits.

Mineral exploration is needed to increase the knowledge and understanding of the diamond resources in Ghana. Government can achieve this by commissioning the National Exploration Program that is recommended by the **PASE** framework. The technical and training support that is recommended by the **PASE** framework should also cater for diamond mining.

The research also recommends for Ghana to launch a campaign to revive diamond mining. The campaign should include the creation of a diamond mining indaba or conference, as well as an association for young diamond miners. These initiatives should aim to boost diamond exploration, mining, processing, and manufacturing. The campaign should also aim to encourage local investment into diamond mining projects. This will not only help to increase diamond production, but it will encourage product diversification in small-scale mining.

10.4.6 Recommendation 6: Strengthening alternative livelihoods

In Chapter 7, the stakeholder feedback reveals that small-scale mining is popular because alternative livelihoods are not lucrative. The research recommends for the Ghanaian government to strengthen other economic activities in the mining communities, more especially farming, to help relieve the economic pressure on mining. Ghana can focus on commercializing the agricultural sector to strengthen it as an alternative to mining. There is a significant amount of subsistence farming in Ghana, however there is very little commercial farming. Some of Ghana's biggest food imports are rice, wheat, and poultry, all of which can be sourced locally (Ghanatrade, 2021). But the subsistence farmers cannot meet this demand or match the prices of global competitors created by the economies of scale.

Ghana can draw learnings from South Africa on commercialized farming. In the early 1900s, South Africa improved the agricultural sector by importing commercial farming skills and transferring them to the locals. The country provided the farmers with capital, access to the local and international markets, and formulated laws and policies to encourage local production and consumption of local products (Boaduo, 2017).

10.5 Recommendations for further research

There is a need to build on the research conducted in this thesis. To enable this, the following areas are recommended for future research:

- The small-scale mining value chain: Investigating ways of strengthening the value chain for small-scale mining;
- Developing simple, cost-effective exploration methods for developing countries or countries that cannot afford expensive exploration. Looking into the use of small-scale mining trails and production data to inform prospecting and exploration respectively;
- Documenting and improving assaying methods used by small-scale mines;
- Small-scale mining resource modelling and feasibility studies: Investigating simplified ways of conducting feasibility studies for small-scale mining; Building on the financial valuation that has been conducted in this thesis;
- Developing a mineral reporting code for small-scale mining projects;
- Documenting the small-scale mining methods, to understand and improve how the operations mine, and identify possible new mining methods; and
- Conducting this type of research for other commodities in small-scale mining, and other countries.

10.6 Conclusion

The researcher strongly believes that Ghana has the potential to turn the small-scale mining sector around. The sector has proven that it has the potential to follow legislation and regulations and do things the right way. There are legal miners who mine according to the law, and advocate for proper small-scale mining. However, these miners are part of the minority. The focus for Ghana should be to convert this minority into a majority. Even though the legal miners realize the benefits of doing things the correct way, they face the hurdles of bureaucracy, the lack of transparency and very little support from government. It is the responsibility of the Ghanaian government to reduce these hurdles and empower these miners.

Ghana needs to develop innovative local ways of solving its small-scale mining problems[53]. In 1992, Ghanaian Economist George Ayittey coined the phrase "*African Solutions to African Problems*" (Ayittey, 1992). This phrase is one of the driving factors behind this thesis. Ghana needs to invest in problem solving, and creating knowledge linkages for small-scale mining. The research conducted in this thesis proves that solutions to the small-scale mining problems can be found internally (i.e., in Ghana and on the African continent). However, there must be initiative to search for, document, and implement these solutions. There should also be unity amongst the relevant political and leadership structures to work towards a common long term economic vision.

[53] The small-scale miners have their own local methods of conducting mining which have been passed down from one generation to another. These methods were more environmentally friendly. However they have largely been replaced by modern methods because they were not as efficient as the new methods. The local methods were not adequately documented, developed or modernized because of a lack of research, and investment into knowledge linkages.

11 BIBLIOGRAPHY

Abbot & Rinehart Jewelers. 2017. *How to calculate pure gold content and percentage .* 21 November . https://www.arjl.com/blog/2017/11/21/how-to-calculate-pure-gold-content-percentage11.

Abor, Joshua, and Peter Quartey. 2010. “Issues in SME Development in Ghana and South Africa.” *International Research Journal of Finance and Economics* (39): 218-227.

Adjaye, KE, and K Ampofo . 2017. *The employment, income and foreign exchange effects of small-scale mining ("Galamsey").* Accra: Ghana Growth and Development Platform.

African Development Bank . 2021. *Ghana: African Development Fund extends $40 million grant to establish The Development Bank Ghana.* 13 November . https://www.afdb.org/en/news-and-events/press-releases/ghana-african-development-fund-extends-40-million-grant-establish-development-bank-ghana-46817.

African Mining Legislation Atlas. 2019. *Summary: Siera Leone .* 12 May. https://www.a-mla.org/countries/43?name=Sierra+Leone.

African Mining Market. 2021. *Ghana's new gold refinery to be ready by Novemeber 2021.* 28 September . https://africanminingmarket.com/ghana-new-gold-refinery-ready-by-november-2021/11490/.

African Mining Vision. 2011. *African Mining Vision ISG Bulletins.* Accessed June 15, 2018. www.africaminingvision.org/amv_resources/ISGbulletin4.pdf.

Agência Nacional de Mineração -a. 2020. *Permissão de Lavra Garimpeira.* Accessed March 2020. http://outorga.dnpm.gov.br/SitePages/Regimes%20PLG.aspx?

Agência Nacional de Mineração -b. 2020. *To the Miner.* http://www.anm.gov.br/assuntos/ao-minerador.

Ajediam. 2018. *Historical diamond prices.* Accessed September 12, 2018. https://www.ajediam.com/historical_diamond_prices.html.

Akafia, M. 2019. *Mining- Ghana .* July. https://gettingthedealthrough.com/area/22/jurisdiction/134/mining-ghana/.

ALS Chemex. 2012. *Small Scale Mining Info.* Accessed April 2020. http://mine-engineer.com/mining/SmallMining/small_mining1.htm.

Amadeo, Kimberly. 2018. *Gold and the Economy.* Accessed July 26, 2018. https://www.thebalance.com/gold-and-the-economy-3305655.

Amankwah, R.K, and C Anim-Sackey. 2004. *Strategies for sustainable development of the small-scale gold and diamond mining industry of Ghana.* Ontario: Science Direct.

AMETrade. 2019. *A Snapshot of Ethiopia's Mineral Resources Immense Potential & Untapped Resources.* 25-26 November. Accessed 2020 January. https://ametrade.org/miningethiopia/ethiopias-mineral-wealth/.

Amoako-Tuffour, Joe, Tony Aubynn, and Alhassan Atta-Quayson. 2015. *Local Content and Value Addition in Ghana's Mineral, Oil and Gas Sectors: Is Ghana Getting it Right?* Accra : African Centre for Economic Transformation .

Ashraf, H. 2017. *Mineral Development for Growth: Developing a Mineral Policy Framework and Mining Cadastre System for Pakistan .* Johannesburg : University of the Witwatersrand.

AU. 2009. *African Mining Vision.* Addiss Ababa: African Union.

Augustyn, Adam, Patricia Bauer, Brian Duignan, Alison Eldridge, Erik Gregersen, Amy McKenna, Melissa Petruzzello, et al. 2019. *Assaying Chemical Process.* 9 May. Accessed April 2020. https://www.britannica.com/science/assaying.

Austrailian Government . 2016. *Leading Practice Sustainable Development Program for the Mining Industry.* Canberra: Commonwealth of Austrailia .

Ayandibu, Ayansola Olatunji, and Jennifer Houghton. 2017. "The role of Small and Medium Scale Enterprise in local economic development (LED)." *Journal of Business and Retail Management Research (JBRMR)* (Journal of Business and Retail Management Research) 11 (2): 133-139.

Ayittey, George B. N. 1992. *Africa Betrayed.* New York : New York : St. Martin's Press,. https://issafrica.org/iss-today/african-solutions-to-african-problems.

Ayree, BNA, BK Nitbery, and E Atokui. 2002. "Trends in the small-scale mining of precious minerals in Ghana: A perspective on its environmental impact ." *Journal of Cleaner Production* 11: 131-140.

Baah-Ennumh, Theresa Y., and Gifty Adom-Asamoah. 2019. "Land Use Challenges in Mining Communities – The Case of Tarkwa-Nsuaem Municipality." *Environment and Ecology Research* 139-152.

Baartjes, Neale. 2015. *From Deposit to mine from mine to mining value chains - Diversifying a mineral based economy .* Eco Partners .

Baddoo, Samual, interview by Adwoa Issaka. 2021. *Lawyer* (12 December).

Balasubramanian, A. 2017. "Basics of Mineral Processing (Ore Dressing Opperations)." *Slide Share.* 29 July. https://www.slideshare.net/bala1957/basics-of-mineral-processing.

Bermúdez-Lugo, Omayra. 2016. “The Mineral Insutry of Ghana .” *United States Geological Society 2013 Minerals Year Book.*

Beyene, T. 2014. *ASM Sector and Sustainable Developmemt in Ethiopia .* Addis Ababa: Ministry of Mines of Ethiopia .

Bitarafan, M.R., and M. Ataei. 2004. “Mining method selection by multiple criteria decision making tools.” *The Journal of The South African Institute of Mining and Metallurgy* 493-498.

Boaduo, Adwoa. 2017. *Masters Research Report: Toward Sustainable Economic Development in the Gold Mining Areas of South Africa and Ghana.* Johannesburg: University of the Witwatersrand.

Bolormaa, P. 2019. “Envrionmental Rehabilitation in Artisanal and Small-scale Mines (ASM): Case of Mongolian Artisanal Miners.” *Academia.* 10 November. Accessed May 2020. https://www.academia.edu/40893889/ASM_environmental_rehabilitation_pptx.

Botchwey, G, and G Crawford. 2019. *Lifting the lid on Ghana’s illegal small-scale mining problem.* Accra: The Conversation.

Brimhall, George H, John H Dilles, and John M Proffett. 2005. “The Role of Geologic Mapping in Mineral Exploration .” In *Wealth Creation in the Minerals Industry: Integrating Science, Business, and Education*, by Society of Economic Geologists, 221-241. Society of Economic Geologists.

Business Dictionary. 2020. *Subsistance Economy.* May. Accessed May 2020. http://www.businessdictionary.com/definition/subsistence-economy.html.

Caley, E. 1949. *Validity of the Specific Gravity Method for the Determination of the Fineness of Gold Objects.* 1 March .

https://www.semanticscholar.org/paper/Validity-of-the-Specific-Gravity-Method-for-the-of-Caley/2ea3e56ae4bf2746c40c5ff185012c09d971bc06.

Cambridge Dictionary. 2020. *Meaning of subsistence in English.* Accessed May 2020. https://dictionary.cambridge.org/dictionary/english/subsistence.

Carlson, D. 2013. *2008 Financial Crisis Set Stage for Gold Rally.* Kitco News. Accessed August 18, 2018. http://www.kitco.com/news/2014-10-13/2008-Financial-Crisis-Set-Stage-For-Gold-Rally.html.

Chirico, Peter, Katherine Malpeli, Solomon Anum, and Emily Phillips. 2010. *Alluvial Diamond Resource Potential and Production Capacity Assessment of Ghana.* Virginia: United States Geological Survey.

CIEC Data. 2018. *Ghana Gold Production.* Accessed August 18, 2018. https://www.ceicdata.com/en/indicator/ghana/gold-production.

CISL. 2015. *Graduate study - 'Value Chain' Definitions and Characteristics.* Accessed June 16, 2018. https://www.cisl.cam.ac.uk/graduate-study/pgcerts/pdfs/Value%20Chain%20Definitions%20Rev%201%20-Updated%20links.pdf.

Clacherty, Alistair, and Peter Moodie. 2004. *Environmentally Responsible Mining - Water management guidelines for small-scale mining.* Pretoria : Water Research Commission - South Africa.

Creamer, M. 2017. *Remove exploration red tape or mining will die, geologist warns.* 19 October . https://www.polity.org.za/article/remove-exploration-red-tape-or-mining-will-die-geologist-warns-2017-10-19.

Cremers, L, J Kolen, and M de Theije. 2013. *Small-Scale Gold Mining in the Amazon The Cases of Bolivia, Brazil, Colombia, Peru and Suriname.* Amsterdam: Cuadernos del CEDLA.

Department of Minerals and Energy. 1998. *A Minerals and Mining Policy for South Africa.* Pretoria: Department of Minerals and Energy.

Department of Water Affairs and Forestry. 2006. *Best Practice Guideline A1: Small-Scale Mining.* Johannesburg: Department of Water Affairs and Forestry.

Diamondrocks. 2018. *Why are diamonds so valuable?* Accessed August 26, 2018. https://www.diamondrocks.co.uk/Diamond-Information-Centre/buying-guides/general-diamond-information/why-are-diamonds-so-valuable/.

DiamondSpot - a. 2002. *Industrial Diamonds on the Diamond Market.* Accessed October 1, 2018. https://www.diamondspot.com/?p=464&lang=en.

Diamondspot -b. 2002. *Industrial Diamonds on the Diamond Market.* Accessed September 24, 2018. https://www.diamondspot.com/?p=464&lang=en.

DiSanno, J. 2007. *Indicators of Sustainable Development: Guidelines and Methodologies.* United Nations Division for Sustainable Development.

Dorner , Ulrike , Gudrun Franken , Maren Liedtke, and Henrike Sievers. 2012. *Artisanal and Small-scale Mining.* Dundee : University of Dundee.

Economic Commision for Africa. 2009. *Compendium on Best Practices in Small-scale Mining in Africa .* Addis Ababa: African Union.

EEITI. 2016. *Artisanal Mining Operation and Its Economic Values, Ethiopia.* Addis Ababa: Ethiopian Extractive Industrues Transparency Initiative.

Environmental Protection Agency Ghana . 2021. “Regulations .” *epa.gov.za .* http://www.epa.gov.gh/epa/regulations.

Eshun, P, and E Okyere. 2017. "Assessment of the Challenges in Policy Implementation in the Small Scale Gold Mining Sector in Ghana – A Case Study*." *Ghana Mining Journal* 17 (1): 54 - 63.

Extractives Hub. 2017. *Artisanal and Small-scale Mining.* Extractives Hub.

FAO. 2010. *Ethiopia Mining Operations Proclamation No. 678/2010.* 4 August . http://www.fao.org/faolex/results/details/en/c/LEX-FAOC183181/.

Fernando, Jason. 2021. *Discounted Cashflow .* 2021 March . https://www.investopedia.com/terms/d/dcf.asp.

FoN. 2014. *Baseline Information for the National Action Plan on Artisanal and Small - Scale Gold Mining: Ghana.* Friends of the Nation.

Frost, Jim. 2021. *Normal Distribution in Statistics.* Accessed 2021. https://statisticsbyjim.com/basics/normal-distribution/.

Gem diamonds. 2018. *Strategic Focus.* Accessed October 1, 2018. http://www.gemdiamonds.com/investors-strategic-focus.php.

Gemological Institute of America. 2018. *The 4 Cs.* Accessed September 12, 2018. https://4cs.gia.edu/en-us/.

Geology Hub. 2017. *What is pitting and trenching?* 15 July. Accessed April 2020. What is PITTING AND TRENCHING ?

Geospatial Media . 2016. *Mining Cadastre Administration System launches in Ghana.* 29 August. https://www.geospatialworld.net/news/mining-cadastre-administration-system-launches-ghana/.

Ghana Chamber of Mines. 2016. *Performance of the Mining Industry in 2016.* Accra: The Ghana Chamber of Mines.

Ghana Chronicle. 2018. *Diamond Scarcity Hits Ghana … As Production Drops From 2 Million Carats To 800,000.* Accra: Modern Ghana.

Ghana News Agency. 2020. *Water pollution should be criminalised – Prof Owusu-Sekyere.* https://ghanasummary.com/citinewsroom/117602/water-pollution-should-be-criminalised-prof-owusu-sekyere.

Ghana Statistical Service (a). 2015. *Ghana Statistical Service Poverty Mapping Report.* Accra: Ghana Statistical Service.

Ghana Statistical Service (b). 2014. *Population and Housing Census District Analytical Report.* Accra: Ghana Statistical Service.

Ghanatrade. 2021. *Top 3 Agricultural Imports to Ghana.* http://ghanatrade.org/agricultural-import-ghana/.

Goldberg, Gary, and Laurie Brals. 2014. "Goldman Sachs Global Metals & Mining Conference Newmont Presentation." Newmong Mining Coorporation.

Golden Star Resources Ltd. 2016. *Golden Star Receives Mining Lease for High Grade Mampon Deposit.* 27 October . https://www.prnewswire.com/news-releases/golden-star-receives-mining-lease-for-high-grade-mampon-deposit-598840081.html.

Goldprice.org. 2020. *Gold Price on 24 February 2020.* 24 February. https://goldprice.org/gold-price-today/2020-02-24.

Golow , A A, and E A Adzei. 2002. "Mercury in surface soil and casava crop near an alluvial goldming at Dunkwa-on-Offin, Ghana ." *Ghana Bulletin of Environmental Contamination and Toxicology*, 228-235.

Gutu, Angeline . 2017. *Artisanal and Small-scale Mining in Zimbabwe – Curse or Blessing?* Harare : Parliment of Zimbabwe .

Hammel, A, C White, S Pfeiffer, and D Miller. 2000. “Pre-colonial mining in southern Africa.” *South African Institute of Mining and Metallurgy* 49-56.

Harraz, H Z. 2016. *Mining Methods: Part I-Surface mining.* Tanta: Tanta University.

Hentschel, T, F Hruschka, and M Hruschka. 2003. *Artisanal and Small-Scale Mining .* London : International Intstitute for Environment and Development .

Hentschel, T, F Hruschka, and M Priester. 2003. *Artisanal and Small-Scale Mining.* London: International Intstitute for Environment and Development.

HERD. 2016. *Focus Group Discussion .* March . https://www.herd.org.np/uploads/frontend/Publications/PublicationsAttachments1/1485497050-Focus%20Group%20Discussion_0.pdf.

Hilson, G. 2001. *A Contexual Review of the Ghanaian Small-scale Mining Industry.* London: Internatonal Institute for Environment and Develooment .

Hilson, Gavin (a). 2003. *GOLD MINING AS SUBSISTENCE: GHANA'S SMALL-SCALE MINERS LEFT BEHIND.* Accessed May 28, 2018. https://www.culturalsurvival.org/publications/cultural-survival-quarterly/gold-mining-subsistence-ghanas-small-scale-miners-left.

Hilson, Gavin (b). 2002. “Promoting sustainable development in Ghanaian small-scale gold mining operations.” *Environmentalist* Volume 22 (Issue 1): 51–57.

Hindeya, Tilahun Weldie. 2012. “An Overview of the Legal Regime Governing Minerals in Ethiopia.” *Bahir Dar University Journal of Law* 3 (1): 25-66.

Hruschka, Felix. 2015. *Comparative analysis of ASM strategies in four countries of Africa, Asia and Latin America.* Pact, Estelle Levin Ltd et IPIS.

Husseini, T. 2018. *History of mining: five of the oldest mines still in operation.* 20 September. Accessed January 2020. https://www.mining-technology.com/features/history-of-mining-oldest-mines/.

Hustrulid, William Andrew. 2020. *Prospecting.* 21 July. Accessed March 2020. https://www.britannica.com/technology/prospecting-mining.

ICLG -a. 2019. *Ethiopia: Mining Law 2019.* 5 September. https://iclg.com/practice-areas/mining-laws-and-regulations/ethiopia.

ICLG -b. 2019. *Brazil: Mining 2020.* 2 October. Accessed February 1, 2020. https://iclg.com/practice-areas/mining-laws-and-regulations/brazil.

ICLG -c. 2019. *Ghana: Mining 2020.* 2 October. Accessed January 23, 2020. https://iclg.com/practice-areas/mining-laws-and-regulations/ghana.

ICLG. 2019. *Ethiopia: Mining Law 2019.* 5 September . https://iclg.com/practice-areas/mining-laws-and-regulations/ethiopia.

Idris, Ahmed. 2019. *Sierra Leone diamond mine: Legal action over land grab.* 5 Novemeber. Accessed April 2020. https://www.aljazeera.com/news/2019/11/sierra-leone-diamond-mine-legal-action-land-grab-191105103133141.html.

IGF . 2017. *Global Trends in Artisanal and Small-Scale Mining (ASM): A review of key numbers and issues.* Canada: International Institute for Sustainable Development.

IIED. 2002. “Chapter 13: Artisanal and small-scale mining.” In *Mining, Minerals, and Sustainable Development - Breaking New Ground*, 314 to 315. London: International Institute for Environment and Development.

Indevelopment. 2006. *Industrialisatio & Related Policies.* Indevelopment.

InvestorWords. 2016. *Online Gorssary.* Accessed August 4, 2016. http://www.investorwords.com/1604/dutch_disease.html.

Jobs and skills. 2022. *Mining Engineer Excluding Petroleum.* Accessed January 2022. https://www.jobsandskills.wa.gov.au/jobs-and-careers/occupations/mining-engineer-excluding-petroleum.

JORCA. 2009. "African Mining Legislation Atlas Summary: Central African Republic." *African Mining Legislation Atlas.* June . https://www.a-mla.org/countries/9?name=Central+African+Republic.

Kambani, Stephens M. 2009. *The illegal trading of high unit value minerals in developing countries.* Natural Resources Forum.

Kimberly Process. 2020. *What is the Kimberly Process.* Accessed May 2020. https://www.kimberleyprocess.com/en/what-kp.

Kubach, Charles. 2012. *Mecury Amalgamation.* Accessed May 2020. http://mine-engineer.com/mining/minproc/MercAmal.htm.

Ledwaba, P, and N Mutemeri. 2017. *Preliminary study on artisanal and small-scale mining in South Africa.* Cape Town : Open Society Foundation for South Africa.

Levin Sources. 2020. *Swiss development and cooperation: low cost ('frugal') methods for asm environmental rehabilitation study.* Accessed May 2020. https://www.levinsources.com/what-we-do/case-studies/low-cost-frugal-methods-for-asm-environmental-rehabilitation-study.

Lexico. 2020. *The definition of subsitance in english.* Accessed May 2020. https://www.lexico.com/en/definition/subsistence.

Liberto, Daniel. 2020. 14 November . https://www.investopedia.com/terms/s/smallandmidsizeenterprises.asp.

Mabuwa, Chiratidzo Iris. 2014. “Value Addition in Raw Material and Agricultural Exports from Zimbabwe.” Deputy Minister of Industry and Commerce .

Maluka, A. 2017. “Pakistan.” In *The Mining Law Review Sizth Edition*, 158 - 166. London: Gideon Roberton.

Marufu, Livingstone. 2018. *Govt shelves mining fees for small scale miners.* 6 June. Accessed 2020. https://www.zimbabwesituation.com/news/govt-shelves-mining-fees-for-small-scale-miners/.

Mathis, A. 2012. *Artisanal and small-scale gold mining in the North of Brazil.* Cape Town : World Wide Fund for Nature.

McQuilken, J, and G Hilson. 2016. *Artisanal and small-scale gold mining in Ghana: Evidence to inform an 'action dialouge'.* London: International Institute for Environment and Development.

Mero, J, and G Clark. 2017. 25 April. Accessed 2020 March. https://www.britannica.com/technology/mining.

Michaud, David -b. 2017. *Gold Prospecting Methods.* 11 January. https://www.911metallurgist.com/gold-prospecting-methods/.

Michaud, David. -d. 2016. *Mining Geology Sampling Methods: Channel, Chips, Core.* 3 November. https://www.911metallurgist.com/blog/mining-geology-sampling-methods-channel-chip-core#nugget_effect_sampling.

mindat.org. 1985. *Dunkwa State Gold mine (Dunkwa Operation).* https://www.mindat.org/loc-10830.html.

Minerals and Mining Policy of Ghana . 2014. *Minerals and Mining Policy of Ghana .* Accra: Ghana Minerals Commision.

Minerals Commision Ghana. 2019. *Acquiring a Mining Licence.* Accessed April 2020. http://www.mincom.gov.gh/acquiring-mining-licence#.

Minerals Commission Ghana -b. 2021. *Minerals Commission Ghana.* December. https://www.mincom.gov.gh/organisation-profile/.

Minerals Council South Africa and Coaltech . 2007. *Guidelines for the rehabilitation of mined land .* Johannesburg : Minerals Council South Africa .

Mines and Minerals Act. 2010. "The Mines and Minerals Act, 2009." *Sierra Leone Gazette Vol. CXLI, No. 3* (Re).

Mining Global. 2015. *10 minerals that make modern life work.* Accessed July 26, 2015. https://www.miningglobal.com/machinery/photos-10-minerals-make-modern-life-work.

Ministry of Mines and Energy-a. 2009. *National Reporting on Mining.* Addis Ababa: Ministry of Mines and Energy.

Ministry of Mines and Energy-b. 2009. *A Proclamation to Promote and Regulate Transactions of Precious Minerals.* Addis Ababa: Ministry of Mines and Energy of Ethiopia.

Ministry of Mines and Energy. 2010. *Ethiopia Mining Operations Proclamation No. 678/2010.* Addis Ababa: Ministry of Mines of Ethiopia. Accessed February 2020. http://www.fao.org/faolex/results/details/en/c/LEX-FAOC183181/.

Ministry of Mines and Mineral Resources. 2018. *Artisanal Mining Policy for Sierra Leone .* Freetown: Ministry of Mines and Mineral Resources.

Ministry of Mines and Mining Development - a. 2016. *Mining Promotion and Development - Procedures And Criteria Of Obtaining Mining Claims.* Accessed January 2020. http://www.mines.gov.zw/?q=mpd/60.

Ministry of Mines and Mining Development - b. 2016. *Downloads.* Accessed 2020 January. http://www.mines.gov.zw/?q=downloads&tid=21.

Ministry of Petroleum and Natural Resources. 2013. *National mineral Policy - 2013.* Islamabad,: Government of Pakistan .

Ministry of Trade and Industy. 2019. *National Micro, Small and Medium Enterprises (MSME) Policy.* Accra: Ministry of Trade and Industy.

Ministry of Water Resources, Works and Housing . 2013. *Riparian Buffer Zone Policy for Managing Freshwater Bodies in Ghana .* Accra : Government of Ghana .

Ministry of Water Resources, Works and Housing. 2013. *Reparian Bufferzone Policy for Managing Freshwater Bodies in Ghana.* Accra : Government of Ghana .

Mischaud, David. 2016. *Mining Geology Sampling Methods: Channel, Chips, Core.* 3 November. https://www.911metallurgist.com/blog/mining-geology-sampling-methods-channel-chip-core.

MMSD. 2002. *Artisanal and Small-Scale Mining.* Research Gate .

Myjoyonline. 2015. *Ghana losing ₵500m to small scale miners annually.* Accessed May 26, 2018. https://www.myjoyonline.com/business/2015/April-2nd/ghana-losing-500m-to-small-scale-miners-annually.php.

National Service Scheme . 2021. *Our Rules and Regulations .* 19 November . https://nss.gov.gh/rules-and-regulations/.

New Pacific Metals. 2018. *Types of Mineral Exploration.* 12 March. Accessed April 2020. https://newpacificmetals.com/mining-101/types-of-mineral-exploration.

Nkuah, Joseph Kofi, John Paul Tanyeh, and Kala Gaeten. 2013. "Financing Small and Medium Enterprises (SMEs) in Ghana: Challenges and determinants in accessing bank credit." *International Journal of Research In Social Sciences* 2 (3): 12-25.

Nyabor, Jonas. 2018. *Ghana discovers new mineral, lithium in commercial quantities.* Accessed January 17, 2018. https://citifmonline.com/2018/01/17/ghana-discovers-new-mineral-lithium-in-commercial-quantities/.

Nyaungwa, Mathew. 2006. "Ghanaian firm seeks to resuscitate Akwatia diamond mine." 2016 April . Accessed September 24, 2018. https://www.rough-polished.com/en/exclusive/101955.html.

Nyumba, Tobias, Kerrie Wilson, Christina Derrick, and Nibedita Mukherjee. 2018. *The use of focus group discussion methodology: Insights from two decades of application in conservation.* 11 January . https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210X.12860.

Okubo, S, and J Yamatomi . 2009. *Underground Mining Methods and Equipment.* Japan : University of Tokyo.

Olivera, F. 2014. "Brazilian Mining Code – Licence Procedures." *Workshop on best practices on mining policies and technologies.* Brussels: Ministry of Mines and Energy.

Olson, D. 2003. *Diamond, Industrial .* United States Geological Society.

Owusu, Matida Kokui, Daniel Obeng Donkor, and Samed Abdul Muntaka. 2016. “mproving Local Linkages in the Supply Chain of Ghana’s Mining Industry: A Case of Newmont Ghana Gold Limited.” *Journal of Logistics Management* (Journal of Logistics Management) 5 (1): 32-38.

Pact . 2017. *Training Handbook for Artisanal and Small-Scale Miners in Zimbabwe.* Washington, D.C: Pact .

PAKP . 2017. “The Khyber Pakhtunkhwa Minerals Sector Governance Act, 2017 .” *Provincial Assembly of Khyber Pakhtunkhwa.* http://www.pakp.gov.pk/2013/acts/the-khyber-pakhtunkhwa-minerals-sector-governance-act-2017/.

Petra Diamonds. 2018. *About Diamonds: Why are diamonds so special?* Accessed August 26, 2018. https://www.petradiamonds.com/our-industry/about-diamonds/why-are-diamonds-so-special/.

PMMC. 2018. *About us Our History.* Accessed May 25, 2018. https://www.pmmc.gov.gh/pmmc/about/history.

Pramoda, Raj. 2017. “Sampling techniques for mineral deposit.” *Linked In.* 11 September. Accessed April 2020. https://www.slideshare.net/pramodgpramod/sampling-techniques-for-mineral-deposit.

Pulles Howard & de Lange Inc. 2006. *Smalll-Scale Mining (Standard Format) Best Practice Guidelines for Water Resource Protection in the South African Mining Industry .* Pretoria : Department of Water Affairs and Forestry South Africa .

Punjab Government . 2002. *Procedure For Grant Of The Mining Concessions Of Small- Scale Mining Under Punjab Mining Concession Rules 2002.* Lahore: Punjab Government .

Rajagopalan, Ganesh. 2015. *Industry Value Chain: Understand its Importance and Application to the Mining Industry.* Accessed June 16, 2018. http://flevy.com/blog/industry-value-chain-understand-its-importance-and-application-to-the-mining-industry/.

Ralph, Chris. 2005. *Understanding Sampling Techniques .* April . https://www.icmj.com/magazine/print-article/understanding-sampling-techniques-660/.

Rare Gold Nuggets. 2015. *Gold Mining and Prospecting in Pakistan.* 6 October. Accessed January 2020. http://raregoldnuggets.com/?p=1783.

Read, J. 1996. "Importance of public perception ." In *Radiation Society: Comprehending Radiation Risk* , by International Atopmi Energy Agency, 217 - 220. Vienna : International Atopmi Energy Agency.

Rodríguez-Pose, A, and S Tijmstra. 2009. *The Emergence and Significanc of Local Economic Development Strategies.* CAF.

SADPMR. 2013. *Overview of the SADPMR.* Accessed January 2020. http://www.sadpmr.co.za.

SAMREC. 2009. *The South African Code for the Reporting of Exploration Results and Mineral Resources and Mineral Reserves (The SAMREC Code).* Johanessburg : The South African Mineral Resources Committee (SAMREC) Working Group .

ScotiaMocatta. 2017. *Precious Metals 2017 Forecast Gold .* Scotibank.

Shah, S. 2018. *Stratergy for Mineral Sector Development in Pakistan .* Ministry of Planning, Development & Reform Government of Pakistan.

Sibanda, Nonjabulo. 2017. *Getting a mine in Zimbabwe: How to get started.* 25 September . Accessed January 2020. https://njabulosibanda.wordpress.com/2017/09/25/getting-a-mine-in-zimbabwe-how-to/.

Small-scale Gold Mining Law. 1989. *Small-scale Gold Mining Act, 1989 (P.N.C.D.I. 218).* Accra: Government of Ghana.

Sousa, R, M Veiga, D Van Zyl, K Telmer, S Spiegel, and J Selder. 2011. “Policies and regulations for Brazil’s artisanal gold mining sector: analysis and recommendations.” *Science Direct* 742 - 750.

South African Government . 1996. *No. 102 of 1996: National Small Buisness Act, 1996.* Pretoria : President's office .

Statista -a. 2018. *Diamond prices per carat from 1960 to 2016 (in U.S. dollars).* Accessed October 1, 2018. https://www.statista.com/statistics/279053/worldwide-sales-of-polished-diamonds/.

Statista -b. 2017. *Diamond prices per carat from 1960 to 2016 (in U.S. dollars).* Accessed September 24, 2018. https://www.statista.com/statistics/279053/worldwide-sales-of-polished-diamonds/.

Step4youth. 2015. “D7.7: 2nd Dissemination Plan.” *Step4youth.* June . http://step4youth.eu/wp-content/uploads/2015/09/D7.7-2nd-Dissemination-Plan.pdf.

Stevens, Robert, Andrew Duthie, and Bernardo Ranieri. 2017. *Environmental Assessment and Management for Artisanal and Small-scale Mining.* Vancouver: Canadian International Resources and Development Institute .

Sustainable Knowledge Group. 2019. *The importance of SMEs role in achieving sustainable development.* 1 March. https://sustainabilityknowledgegroup.com/the-importance-of-smes-role-in-sustainability/.

Szirmai, A. 2009. *Is Manufacturing Still the Main Engine of Growth in Developing Countries?* Accessed May 16, 2016. https://www.wider.unu.edu/publication/manufacturing-still-main-engine-growth-developing-countries.

The Asia Foundaiton. 2016. *Frugal Rehabilitation Methodology Field Hanbdbook .* Ulaanbaatar: Mineral Resource Authority of Mongolia.

The World Bank . 2002. "A Source Book for Poverty Reduction Stratergies - Chapter 25 Mining." *Macroeconomic and Sectoral Approaches* 2: 439 - 486.

The World Bank . 2021. *Small and Medium Enterprises (SMEs) Finance: Improving SMEs' access to finance and finding innovative solutions to unlock sources of capital.* https://www.worldbank.org/en/topic/smefinance.

Tichauer, Ricardo M, Tatiane Marin, Martins C Antônio , Giorgio de Tomi, and Vagner R Elis. 2014. *Application of Geophysics for Mineral Exploration in Small-scale Mining.* Sao Paolo: University of Sao Paolo.

Treadgold, Tim. 2013. *Diamonds as investment, investing in diaomonds part 3.* Accessed September 12, 2018. https://www.ajediam.com/investing_diamonds_investment_part3.html.

Twum, Kojo Kakra., Martin Kwadwo Amaniampong, Ebenezer Nyarko Assabil, Martin Ameabuno Adombire, Daniel Edisi, and Dr. Charlse Akuetteh. 2020. "Tax knowledge and tax comliance of small and medium enterprises in Ghana." *South East Asia Journal of Contemporary Business, Economics and Law* 222-232.

Tychsen, J, D Boamah, J Ahadjie, M Sandow Ali, S Alidu, P Awuah, I Quaicoe, et al. 2017. *ASM Handbook for Ghana.* Copenhagen: Geological Survey of Denmark and Greenland (GEUS).

UNECA -a. 2020. *ASM Zimbabwe.* 20 January. https://knowledge.uneca.org/ASM/zimbabwe.

UNECA -b. 2020. *Ethiopia ASM Profile.* Accessed January 2020. https://knowledge.uneca.org/ASM/Ethiopia.

UNIDO. 2018. *Follow the Money: Zimbabwe.* Vieanna: United Nations Industrial Development Organization .

Uongozi Institute . 2017. "Enhancing Value Addition In the Extractive Sector in Africa: Why is it Important and How can it be Achieved?" Accra : Uongozi Institute .

USGS -a. 2018. *Gold Statistics and Information.* Accessed July 26, 2018. https://minerals.usgs.gov/minerals/pubs/commodity/gold/.

USGS -b. 2018. *United States Geological Socitey Gold Statistics and Information.* Accessed August 18, 2018. https://minerals.usgs.gov/minerals/pubs/commodity/gold/.

Ushakov, Vladimir. 2017. *What is a Feasibility Study in Mining and Mineral Processing?* 23 April. Accessed 2020 April.

http://mineralprocessingconsultant.com/blog/what-is-a-feasibility-study-in-mining-and-mineral-processing.

WBCSD. 2011. *Collaboration, innovation, transformation: Ideas and inspiration to accelerate sustainable growth - A value chain approach.* World Business Council for Sustainable Development.

Wits University . 2015. “Mine Financial Valuation Course Notes .” Johannesburg, Gauteng : University of the Witwatersrand School of Mining Engineering , July.

Wits University. 2015. “Chapter 3: Geological and Resource Modeling .” In *Mineral Resource Management (MINN 7050)*, by School of Mining Engineering. Johannesbrug : University of the Witwatersrand .

World Bank . 2020. *World Bank Supports the Establishment of the Development Bank Ghana to Boost Access to Finance and Job Creation.* 29 October . https://www.worldbank.org/en/news/press-release/2020/10/29/world-bank-supports-the-establishment-of-the-development-bank-ghana-to-boost-access-to-finance-and-job-creation.

World Gold Council -a. 2018. *How much gold has been mined.* Accessed August 18, 2018. https://www.gold.org/about-gold/gold-supply/gold-mining/how-much-gold-has-been-mined.

World Gold Council -b. 2018. *Gold Price.* Accessed August 18, 2018. https://www.gold.org/data/gold-price.

World Gold Council -c. 2018. *Global gold demand.* Accessed July 26, 2018. https://www.gold.org/about-gold/gold-demand.

World Gold Council -d. 2018. *Gold supply and demand statistics.* Accessed February 10, 2019. https://www.gold.org/goldhub/data/gold-supply-and-demand-statistics.

Zamora, Elvira A. 2016. "Value Chain Analysis: A Brief Review." *Asian Journal of Innovation and Policy* 5 (002): 166-128.

LIST OF ANNEXURES

Annexure 1: Gold demand trend 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018		Year-on-year % change
Jewellery	2 055,1	2 098,1	2 145,1	2 710,1	2 510,4	2 426,3	2 067,9	2 200,9	2 200,0	▼	**0**
Technology	460,5	428,6	381,3	355,8	348,4	331,7	323,0	332,6	334,6	▲	**1**
Electronics	326,6	316,1	288,3	279,2	277,5	262,1	255,6	265,6	268,3	▲	**1**
Other Industrial	88,3	76,3	64,6	53,7	51,2	51,0	49,8	50,7	51,0	▲	**1**
Dentistry	45,6	36,2	28,4	22,8	19,6	18,6	17,6	16,3	15,4	▼	**-6**
Investment	1 625,1	1 694,6	1 618,5	823,3	892,6	967,6	1 646,2	1 251,6	1 159,1	▼	**-7**
Total bar and coin demand	1 204,2	1 502,1	1 311,1	1 729,6	1 065,2	1 090,1	1 071,3	1 045,2	1 090,2	▲	**4**
Physical Bar demand	921,1	1 189,6	1 014,5	1 357,3	780,4	790,4	797,0	781,9	781,6	▼	**0**
Official Coin	195,9	228,3	185,9	270,9	204,9	224,3	207,3	187,9	236,4	▲	**26**
Medals/Imitation Coin	87,2	84,2	110,7	101,4	79,8	75,5	67,0	75,4	72,1	▼	**-4**
ETFs & similar products*	420,9	192,5	307,4	-906,3	-172,6	-122,5	574,9	206,4	68,9	▼	**-67**
Central banks & other inst.	79,2	480,8	569,3	623,8	583,9	576,5	389,8	374,8	651,5	▲	**74**
Gold demand	4 219,9	4 702,0	4 714,2	4 513,1	4 335,3	4 302,2	4 426,8	4 159,9	4 345,1	▲	**4**
LBMA Gold Price, USD/oz	1 224,5	1 571,5	1 669,0	1 411,2	1 266,4	1 160,1	1 250,8	1 257,2	1 268,5	▲	**1**

Source: World Gold Council -d (2018)

Annexure 2: Comparative analysis of ASM definitions and legislation

Country	Separate definition for Artisanal and Small-scale Mining	Definition of Small-scale Mining	Definition of Artisanal Mining	(1) Main legislation governing mining sector (2) Does the legislation mention ASM	Legislation exclusively made to address ASM	Type of licence issued for ASM operators	Maximum allowable area for mining	Ease of acquiring a licence	(1) Management of Mining Cadastre system (2) Accessibility of Cadastre (3)Quality of Mining Cadastre	Comments
Zimbabwe	Yes	(1) Mining that involves individuals who won blocks of claims that may employ people (2) Driven by economic conditions, commodity prices	(1) Mining by individuals who do not own blocks of claims and mine on other people's claims or on unregistered land. Also includes small mines that exploit shallow deposits requiring manual labour (2) Driven by financial interests, operation performance	(1) Minerals and Mining Act (Chapter 21:05) (2) No	None	(1) Ordinary Claim for precious stones. Reserved for nationals. (2) Special Mining License reserved for companies legally registered in Zimbabwe Both licences are valid for 2 years and are renewable annually.	Ordinary claim maximum area is 10ha Special Mining License for maximum area of 25ha	Application forms collected from and submitted to the Ministry of Mines. There is no mention of district offices	(1) Manual system, not computerized (2) Very difficult (3) Very poor	None
South Africa	Yes	(1) Defined according to operational output, management structure, capital investment and number of employees. Definition differs from one commodity to another. (2) Driven by commercial factors	(1a) Small-scale mining involving the extraction of minerals with the simplest tools, on a subsistence level - Mineral Policy White paper description (1b) Small Businesses Act provides quantitative descriptions for micro, very small, small and medium sized mining businesses. (2) Driven by subsistence livelihoods and lack of employment	(1) Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) (2) No	None, ASM is only mentioned in the Minerals Policy White Paper of 1998	(1) Mining Permit is valid for 2 years renewable three times and valid for one year at a time (2) Mining Right valid for minimum of 30 years.	Mining permit issued for areas less than 5ha Mining Right is issued for mines that occupy areas greater than 5ha	Application can be submitted online or at regional DMR office	(1) Computerized online system - SAMRAD (2) Difficult to register as a user. Cannot view information without registration	ASM not defined in the MPRDA, only described in Mineral Policy White Paper. Small mining business defined in Small Business Act

	ASM Definition			ASM Legislation		ASM Licensing				
Country	**Separate definition for Artisanal and Small-scale Mining**	**Definition of Small-scale Mining**	**Definition of Artisanal Mining**	**(1) Main legislation governing mining sector** **(2) Does the legislation mention ASM**	**Legislation exclusively made to address ASM**	**Type of licence issued for ASM operators**	**Maximum allowable area for mining**	**Ease of acquiring a licence**	**(1) Management of Mining Cadastre system** **(2) Accessibility of Cadastre** **(3)Quality of Mining Cadastre**	**Comments**
Brazil	No	(1) A rudimentary form of mining carried out in mineral deposits, tailings deposits individuals, family working groups, partnerships, labour associations and cooperatives. (2) Economic hardship, commodity prices		(1) The Federal Constitution of 1988 and The Mining Code (Act 227) of 1967 (2) Yes	Garimpogen Law	(1) Mining Permits valid for 5 years and renewable thereafter.	Mining Permits Individual applicants are allowed 50 ha and cooperatives are allowed an unrestricted size but up to maximum of 10 000ha.	Mining permits are issued by the Ministry of Mines and Energy (no decentralisation) but environmental licences are issued by district offices	(1) Computerized online system on the Agência Nacional de Mineração (AMN) website (2) Very easily accessible online. User registration is required to view ownership information (3) Very good quality system	(1) The law encourages working in the form of cooperative groups (2) Demarcation of Artisanal Mining Reserves as specified in Constitution (3) Information about the Mining Cadastre could not be found.
Ethiopia	Yes	(1) Small-scale mining: Operations that produce an annual run-of-mine that is less than 100 000 m3 for silver, gold, platinum, semi-precious minerals and other precious minerals; *** the run-of-mine of other commodities are also provided (see section 2.5 of report)* (2) Special small-scale mining: activity carried out by individuals working for or owning small and micro-enterprises. Should be in possession of a valid ASM license and have adequate financial resources and the capability to use modern mining technology.	Any mining operation carried out by individuals or small micro enterprises that are mostly of a manual nature and does not involve the engagement of employed workers. Does not require financial or technical resources or professional competency	(1) The Constitution and the Mining Proclamation 678/2010 (2) Yes		Artisanal mining license valid for 3 years renewable twice for a minimum of 3 years each period. Small-scale mining license valid for 5 years renewable for 5 years thereafter Special small-scale mining license valid for 10 years, renewable for 5 years thereafter	Mining Proclamation does not specify the land area that is allocated for each license but it states that the maximum allowable area for a certificate of discovery is1000 ha	Application can be completed online or at regional offices.	(1) Computerized system called the FlexiCadastre. (2) Very easily accessible online. User registration is not required to view ownership information (3) Very good quality system	(1)Ethiopian artisanal and small-scale mining extraction of gold during processing does not use mercury and it does not harm the environment. (2)There is an affirmative action clause in the Proclamation promoting women in mining in ASM (3) The Mining Cadastre is mentioned in the Proclamation

Country	ASM Definition			ASM Legislation		ASM Licensing				
	Separate definition for Artisanal and Small-scale Mining	**Definition of Small-scale Mining**	**Definition of Artisanal Mining**	**(1) Main legislation governing mining sector (2) Does the legislation mention ASM**	**Legislation exclusively made to address ASM**	**Type of licence issued for ASM operators**	**Maximum allowable area for mining**	**Ease of acquiring a licence**	**(1) Management of Mining Cadastre system (2) Accessibility of Cadastre (3)Quality of Mining Cadastre**	**Comments**
Pakistan - Punjab Province	No	(1) Mining projects that have a capital investment that is no more than PKR 500 million (roughly US$ 32 000). Mining can either be mechanized or non-mechanized.	Not mentioned. The Province mainly refers to small-scale mining and does not mention artisanal	(1) Federal Constitution, National Mineral Policy of 2013 and the Punjab Province, the Minerals Policy of 2018, (2) Yes	Punjab Province, the Minerals Policy of 2018	Mining Permit or lease valid for 30 years	50 acres (for precious and semi-precious gemstones) to 200 acres (for industrial minerals and dimension stones), 500 acres for fuel minerals and metallic minerals and 3 000 acres for construction materials excavated for the cement industry	The process is well explained in the legislation and there are regional licensing authorities available to assist	(1) Manual system, not computerized (2) Very difficult (3) Very poor	None
International lessons and leading practices identified	**Separation of the definitons of artisanal mining and small-scale mining**: Threee out of the five countries provide separate definitions for artisanal mining and small-scale minng.	**Small-scale mining is commonly described as:** Any small mining opperaiton that uses any form of mechanisation to extract the mineral in the mining or processing stages. It requires a certain level of advanced technical and financial knowledge as well as planning and backing. It can be operated by locally registered partnerships that can include foreing ownerhsip.	**Most of the countries describe artisanal mining as**: Shallow depth mining that uses rudementary methods or the most basic techniques. Does not require any type of finanical or technical competency. Reserved mainly for nationals.	**Official recognition of ASM in main legislaiton:** Ethiopia and Brazil officially reognize ASM in the primary mining legislation. The constituiton of these countires also recognizes ASM.	**Legislation that exclusively addresses ASM:** Ethiopia and Brazil have separate policies that guides and focus exclusively on the ASM sector.	**Distiction between ASM and LSM licensing processes. Distinction between artisanal mining and small-scale mining licencing processes :** Separate licensing processes for LSM and ASM are provided by all countiresl. Ethiopia goes a step further and divides the sector providing a different licences.	**Reasonably sized land areas for artisanal mining and small-scale mining:** Brazil eencourages mining in cooperatives and small-scale mining respectively. The countries allocate larger land areas with this regard to make the options more attractive.	**Ease of obtaining licence**: Ethiopia offers a simpler process for obtaining licences for atrisanal mining compared to small-scale mining. Very little to no technical and finacial reporting is requried for artisanal mining	**Online system that provides information, allows applications, payments and application tracking**. **Ethipoia system** - significant amount of useful information, does not require registration to view infromation, offers a video turorial. **Brazil system** offers a step by step guidance and a database of varified consultants to assist	

Annexure 3: Marketing regulations for Tanzania, Ethiopia and Zimbabwe

Country	Licenses, permits and or certifications required for trading	Description of license, permit or certification	Cost related to license	Issuing office	Legislation
Tanzania	Dealers License	Authorizes one to buy, sell and store minerals	Gold - USD 1000 Diamonds - USD 2000	Mining District Office	Mining (Mineral Trading) Regulations (2010)
	Brokers License	Authorizes one to buy, sell and store minerals on behalf of another party	USD 88		
	Export Permit	Authorizes the export of minerals	USD 100		
Ethiopia	Brokerage License	Authorizes the purchase, holding, transportation and local sale of precious minerals	Determined by the various states	Regional Mining Bureau	Transaction of Precious Minerals Proclamation No.651
	Crafting License	Authorizes the purchase, holding, transportation and local sale of precious minerals. Allows crafting or lapidary of minerals as well as the purchasing and maintenance of jewellery.			
	Precious Minerals Trade Certificate of Competency	Allows the brokerage or crafting license holder to purchase precious minerals in bulk and sell their finished products locally.			
	Precious Minerals Export Certificate of Competency	Allows the brokerage or crafting license holder to purchase and export precious minerals.			
Zimbabwe	Gold dealing licence	Dealing in gold in any manner	ZWL 5000 = +/- USD 16	Ministry of Mines and Mining Development or or the Minister responsible for finance,	Gold Trade Act
	Gold recovery works licence	*Buying, receiving and selling of gold excluding alluvial, amalgam, retorted, smelted, or refined gold *Can only sell through the holder of a gold dealing license.	ZWL 2500 = +/- USD 8 / 5 yrs		
	Gold assaying licence	Receiving gold for testing assaying *Selling gold from their operations to holder of a gold dealing license			
	Licensed dealers	Deal with precious stones and export precious stones received	*Registration to deal in precious stones - ZWL 311= USD 1 / 5 yrs *Uncut diamonds - ZWL 250 = USD 0,8 per shipment * Cut, polished diamonds - ZWL 50 000 = USD 155,6 per shipment		Precious Stones Trade Act
	Permit holders	Deal with precious stones as specified in the permit.			
General Comments					
Tanzania	*District and regional offices (and assigned Zonal Officers) monitor sales and keep records. *Previously gold could only be sold to dealers and brokers. This presented challenges. The government set up regional trading centres to give ASM operators direct access to a regulated market. *The sale of all diamonds requires the Tanzania Kimberly Process Certificate				
Ethiopia	*According to the Mining Proclamation (2010), small-scale mining license holders have the right to market and sell the minerals they produce both locally and internationally. *The country has established Gold Purchasing Centres (Commercial Banks) in the major ASM areas to curb smuggling and lower marketing costs. The centres buy gold that is greater than 250 grams for 5% above the global market price. *Both legal and informal ASM operations can sell to the legal buyers. Gold can be traced back to the supplier *License renewal is based on tax compliance. The Regional Revenue Authority issues a letter to confirm tax compliance *Gold supply chain is audited by an international refinery (ARGOR) *The World Bank considers Ethiopia to have one of the most well developed and best controlled artisanal mining gold marketing systems.				
Zimbabwe	*Miners can only possess and sell gold that is produced by their operations. Tributors can only possess or sell gold produced by people mining on their concessions. *The ASM operators and tributors given a specific timeframe after production to deliver gold to a dealer (e.g. On the 10th day of every month) *Dealers required to keep a register containing the date, weight, price and the name of the parties involved in the transaction				

Sources: Economic Commision for Africa (2009); Ministry of Minerals – Tanzania (2010); Mining Regulations (2010); Ministry of Mines and Energy, (2010) Beyene, (2014) EEITI (2016); The World Bank (2016); Transaction of Precious Minerals Proclamation No.651, (2009); EEITI (2016); Ng'wanakilala (2019)

Annexure 4: The differences between legal and illegal small-scale mining

Factors	**Legal small-scale mining**	**Illegal small-scale mining**
Adherence to the riparian buffer zone policy	Compliant	Non-compliant
	• Located far from water bodies and infrastructure. • They adhere to the riparian buffer zone policy	• The mines are located inside rivers and on major infrastructure. • Do not adhere to the riparian buffer zone policy
Compliance to environmental regulations	More likely to comply	Less likely to comply
	• Good environmental conditions. • Mines attempt land rehabilitation. • Mines also have waste water management systems • Environmental compliance monitored as requirement for licence renewal.	• No environmental management systems in place. • Do not rehabilitate • Discharge contaminated water back into environment. • They do not comply to environmental regulations because they are not registered.
Mining method	Efficient and advanced	Less efficient, less advanced
	• Better equipped with knowledge and skills from prospecting to mining • Appreciation of good systems, rules and regulations • Use an improved version of the hydraulic mining method. • Organized, neat system f • Recover gold at higher grade	• Less knowledge, skills, less preparation, • No appreciation of systems and regulations • Focus on extracting lower grade areas that have been left behind. • They do not have efficient mining methods in place and their recoveries are very low.
Working conditions and mine health and safety	Good and safe	Poor and unsafe
	• Organized and operate in relatively clean working conditions. • Mine safety systems observed	Very disorganized, dangerous and unhygienic • No mine safety was observed
Camp facilities	Available	None
	• Camps quipped with support facilities and workshops	• No camp facilities on the mines.
Mining infrastructure	Good quality	Poor quality
	• Good quality infrastructure • Relevant resources to maintain infrastructure	The mining infrastructure did not appear to be in good working condition. There were no workshops observed on the sites.
Freedom to operate	Yes	None
	• Mines operate without obstructions from the Minerals Commission or government officials. • Consistent and uninterrupted work flow	• Mines start and stop constantly. Interrupted by the government officials because of their illegal nature • Inconsistent and frequently interrupted workflow.

Annexure 5: Gold purity calculation charts

Specific Gravity 25°/4°	Gold Content %	Specific Gravity 25°/4°	Gold Content %	Specific Gravity 25°/4°	Gold Content %
19.3	100	16.5	83	13.7	59
19.2	99	16.4	82	13.6	58
19.1	99	16.3	82	13.5	57
19.0	98	16.2	81	13.4	56
18.9	98	16.1	80	13.3	55
18.8	97	16.0	79	13.2	54
18.7	97	15.9	79	13.1	53
18.6	96	15.8	78	13.0	52
18.5	96	15.7	77	12.9	51
18.4	95	15.6	76	12.8	49
18.3	95	15.5	76	12.7	48
18.2	94	15.4	75	12.6	47
18.1	93	15.3	74	12.5	46
18.0	93	15.2	73	12.4	45
17.9	92	15.1	72	12.3	43
17.8	92	15.0	71	12.2	42
17.7	91	14.9	71	12.1	41
17.6	90	14.8	70	12.0	39
17.5	90	14.7	69	11.9	38
17.4	89	14.6	68	11.8	37
17.3	89	14.5	67	11.7	35
17.2	88	14.4	66	11.6	34
17.1	87	14.3	65	11.5	32
17.0	87	14.2	64	11.4	31
16.9	86	14.1	63	11.3	29
16.8	85	14.0	62	11.2	28
16.7	84	13.9	61	11.1	26
16.6	84	13.8	60	11.0	25

GOLD PURITY CHART

Karat	Parts Gold	Hallmark	Gold %
6	6/24	250	25%
8	8/24	333	33.3%
9	9/24	375	37.5%
10	10/24	417	41.7%
12	12/24	500	50%
14	7/12	583	58.3%
15	5/8	625	62.5%
18	3/4	750	75%
20	5/6	833	83.3%
21	7/8	875	87.5%
22	11/12	916	91.6%
24	24/24	999	99.9% or higher

Sources: Caley (1949); Abbot & Rinehart Jewelers (2017)

Annexure 6: Discounted cashflow for 0,21g/m^3 recovery: Worst case scenario one

			Years	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
				0	1	2	3	4	5	6	7	8	9	10	*Total*
Quantity	**Capital Expenditure**														
2	CAT Excavator - machine ownership	529 815	USD												
2	Washing Plant and sluice box	32 063	USD												
2	Diesel Water pump	6 750	USD												
2	Capital investment required for excavator rental	276 000													
	CAPEX from sponsor (Machine Ownership)	568 628	USD	-	(568 627,75)	-	-	-	-	-	-	-	-	-	
	CAPEX from sponsor (Machine Rental)	314 813	USD	-	(314 812,50)	-	-	-	-	-	-	-	-	-	
	Gold recovery														
	Volume of material moved		m³	-	6 125	12 250	61 248	61 248	61 248	61 248	61 248	61 248	61 248	61 248	***447 110***
	Gold per unit volume	0,21	g/m³												***-***
	Gold recovery		g	-	1 286	2 572	12 862	12 862	12 862	12 862	12 862	12 862	12 862	12 862	***93 893***
		1000	kg	-	1	3	13	13	13	13	13	13	13	13	***94***
		35,274	oz	-	45	91	454	454	454	454	454	454	454	454	***3 312***
	Gold price (24k gold) - 2020/24/02		USD/oz	1774	1700	1600	1550	1525	1500	1550	1600	1650	1700	1701	***16 149***
	Gold Price (25% - 6k gold)	25%	USD/oz	444	425	400	388	381	375	388	400	413	425	425	***4 037***
	Gold buyer overhead cost	8%	USD/oz	35	34	32	31	31	30	31	32	33	34	34	***323***
	Gold buyer purchase price		USD/oz	408	391	368	357	351	345	357	368	380	391	391	***3 714***
	Exchange rate		GHS/oz	5,3	5,4	5,5	5,3	5,4	5,5	5,3	5,4	5,5	5,3	6,3	***54***
	Gold Revenue		USD	-	17 740	33 392	161 743	159 134	156 525	161 743	166 960	172 178	177 396	177 500	***1 206 811***
			GHC	-	95 794	183 657	857 238	859 325	860 890	857 238	901 587	946 979	940 196	1 118 249	***6 502 903***
	Total Labour Costs	**Parameters**		**-**	**3 271**	**6 158**	**29 825**	**29 344**	**28 863**	**29 825**	**30 788**	**31 750**	**32 712**	**32 731**	***222 536***
7	Pit workers - Production workers, engine operators (7)	0,36%	USD	-	447	841	4 076	4 010	3 944	4 076	4 207	4 339	4 470	4 473	***30 412***
1	Income due to miner / site manager (1)	12%	USD	-	2 129	4 007	19 409	19 096	18 783	19 409	20 035	20 661	21 287	21 300	***144 817***
2	Pit supervisor (1), Engineering foreman (1)	0,8%	USD	-	284	534	2 588	2 546	2 504	2 588	2 671	2 755	2 838	2 840	***19 309***
2	Excavator operators (2)	0,6%	USD	-	213	401	1 941	1 910	1 878	1 941	2 004	2 066	2 129	2 130	***14 482***
2	Engineering Technicians (2)	0,36%	USD	-	128	240	1 165	1 146	1 127	1 165	1 202	1 240	1 277	1 278	***8 689***
2	Supporting staff (2)	0,2%	USD	-	71	134	647	637	626	647	668	689	710	710	***4 827***
	Machinery and equipment (Ownership)			-	9 310	18 619	93 097	93 097	93 097	93 097	93 097	93 097	93 097	93 097	***679 608***
	Machinery and equipment (Rental)			-	43 241	86 482	432 411	432 411	432 411	432 411	432 411	432 411	432 411	432 411	***3 156 599***
USD/m³	Excavator operating costs (Rental)	6,91	USD	-	42 322	84 645	423 224	423 224	423 224	423 224	423 224	423 224	423 224	423 224	***3 089 533***
USD/m³	Excavator operating costs (ownership)	1,37	USD	-	8 391	16 782	83 910	83 910	83 910	83 910	83 910	83 910	83 910	83 910	***612 541***
USD/m³	Water pumping	0,15	USD	-	919	1 837	9 187	9 187	9 187	9 187	9 187	9 187	9 187	9 187	***67 067***
	Total Operating Costs - Ownership		USD	-	12 581	24 777	122 922	122 441	121 960	122 922	123 884	124 847	125 809	125 828	***902 144***
	Total Operating Costs - Rental		USD	-	46 512	92 640	462 236	461 755	461 274	462 236	463 198	464 161	465 123	465 142	***3 379 135***
	EBIT - Machine Ownership		**USD**	**-**	**(563 469)**	**8 615**	**38 821**	**36 693**	**34 565**	**38 821**	**43 076**	**47 331**	**51 587**	**51 672**	***(263 960)***
	EBIT - Machine Rental		**USD**	**-**	**(343 585)**	**(59 248)**	**(300 493)**	**(302 621)**	**(304 749)**	**(300 493)**	**(296 238)**	**(291 982)**	**(287 727)**	**(287 642)**	***(2 487 137)***
	Royalties paid	5%	USD	-	887	1 670	8 087	7 957	7 826	8 087	8 348	8 609	8 870	8 875	***60 341***
	Taxable income - Machine Ownership		USD	-	-	6 946	30 733	28 736	26 739	30 733	34 728	38 723	42 717	42 797	***240 055***
	Taxable income - Machine Rental		USD	-	-	-	-	-	-	-	-	-	-	-	***-***
	Minerals sector tax rate	35%													***-***
	Tax Payable - Machine Ownership		USD	-	-	2 431	10 757	10 058	9 359	10 757	12 155	13 553	14 951	14 979	***84 019***
	Tax Payable - Machine Rental		USD	-	-	-	-	-	-	-	-	-	-	-	***-***
	Cashflow after Tax														***-***
	Operation that buys machinery		USD	-	(564 356)	4 515	19 977	18 679	17 380	19 977	22 573	25 170	27 766	27 818	***(408 320)***
	Operation that rents machinery		USD	-	(344 472)	(60 917)	(308 580)	(310 578)	(312 575)	(308 580)	(304 586)	(300 591)	(296 597)	(296 517)	***(2 547 477)***
	Interest Rate	14%													***-***
	Discounted Cashflow														***-***
	Operation that buys machinery		**USD**	**-**	**(495 049)**	**3 474**	**13 484**	**11 059**	**9 027**	**9 101**	**9 021**	**8 823**	**8 538**	**7 504**	***(415 018)***
	Operation that rents machinery		**USD**	**-**	**(302 169)**	**(46 874)**	**(208 283)**	**(183 887)**	**(162 342)**	**(140 585)**	**(121 724)**	**(105 375)**	**(91 206)**	**(79 984)**	***(1 442 428)***
	NPV				***Check*										
	Operation that buys machinery		**USD**	**(415 018)**	(415 018)										
	Operation that rents machinery		**USD**	**(1 442 428)**	(1 442 428)										
	IRR														
	Operation that buys machinery		**USD**	**-27%**											
	Operation that rents machinery		**USD**	**#NUM!**											

Annexure 7: Discounted cashflow for 1,05g/m3 recovery: Worst case scenario two

			Years	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
				0	1	2	3	4	5	6	7	8	9	10	*Total*
Quantity	**Capital Expenditure**														
2	CAT Excavator - machine ownership	529 815	USD												
2	Washing Plant and sluice box	32 063	USD												
2	Diesel Water pump	6 750	USD												
2	Capital investment required for excavator rental	276 000													
	CAPEX from sponsor (Machine Ownership)	568 628	USD	-	(568 627,75)	-	-	-	-	-	-	-	-	-	
	CAPEX from sponsor (Machine Rental)	314 813	USD	-	(314 812,50)	-	-	-	-	-	-	-	-	-	
	Gold recovery														
	Volume of material moved		m³	-	6 125	12 250	61 248	61 248	61 248	61 248	61 248	61 248	61 248	61 248	***447 110***
	Gold per unit volume	1,05	g/m³												***-***
	Gold recovery		g	-	6 431	12 862	64 310	64 310	64 310	64 310	64 310	64 310	64 310	64 310	***469 466***
		1000	kg	-	6	13	64	64	64	64	64	64	64	64	***469***
		35,274	oz	-	227	454	2 268	2 268	2 268	2 268	2 268	2 268	2 268	2 268	***16 560***
	Gold price (24k gold) - 2020/24/02		USD/oz	1774	1700	1600	1550	1525	1500	1550	1600	1650	1700	1701	***16 149***
	Gold Price (25% - 6k gold)	25%	USD/oz	444	425	400	388	381	375	388	400	413	425	425	***4 037***
	Gold buyer overhead cost	8%	USD/oz	35	34	32	31	31	30	31	32	33	34	34	***323***
	Gold buyer purchase price		USD/oz	408	391	368	357	351	345	357	368	380	391	391	***3 714***
	Exchange rate		GHS/oz	5,3	5,4	5,5	5,3	5,4	5,5	5,3	5,4	5,5	5,3	6,3	***54***
	Gold Revenue		USD	-	88 698	166 960	808 715	795 671	782 627	808 715	834 802	860 890	886 978	887 499	***6 034 057***
			GHC	-	478 968	918 283	4 286 189	4 296 624	4 304 450	4 286 189	4 507 933	4 734 895	4 700 982	5 591 246	***32 514 514***
	Total Labour Costs	**Parameters**		**-**	**16 356**	**30 788**	**149 127**	**146 722**	**144 316**	**149 127**	**153 938**	**158 748**	**163 559**	**163 655**	***1 112 680***
7	Pit workers - Production workers, engine operators (7)	0,36%	USD	-	2 235	4 207	20 380	20 051	19 722	20 380	21 037	21 694	22 352	22 365	***152 058***
1	Income due to miner / site manager (1)	12%	USD	-	10 644	20 035	97 046	95 481	93 915	97 046	100 176	103 307	106 437	106 500	***724 087***
2	Pit supervisor (1), Engineering foreman (1)	0,8%	USD	-	1 419	2 671	12 939	12 731	12 522	12 939	13 357	13 774	14 192	14 200	***96 545***
2	Excavator operators (2)	0,6%	USD	-	1 064	2 004	9 705	9 548	9 392	9 705	10 018	10 331	10 644	10 650	***72 409***
2	Engineeirng Technicians (2)	0,36%	USD	-	639	1 202	5 823	5 729	5 635	5 823	6 011	6 198	6 386	6 390	***43 445***
2	Supporting staff (2)	0,2%	USD	-	355	668	3 235	3 183	3 131	3 235	3 339	3 444	3 548	3 550	***24 136***
	Machinery and equipment (Ownership)			-	9 310	18 619	93 097	93 097	93 097	93 097	93 097	93 097	93 097	93 097	***679 608***
	Machinery and equipment (Rental)			-	43 241	86 482	432 411	432 411	432 411	432 411	432 411	432 411	432 411	432 411	***3 156 599***
USD/m³	Excavator operating costs (Rental)	6,91	USD	-	42 322	84 645	423 224	423 224	423 224	423 224	423 224	423 224	423 224	423 224	***3 089 533***
USD/m³	Excavator operating costs (ownership)	1,37	USD	-	8 391	16 782	83 910	83 910	83 910	83 910	83 910	83 910	83 910	83 910	***612 541***
USD/m³	Water pumping	0,15	USD	-	919	1 837	9 187	9 187	9 187	9 187	9 187	9 187	9 187	9 187	***67 067***
	Total Operating Costs - Ownership		USD	-	25 666	49 407	242 224	239 819	237 413	242 224	247 035	251 845	256 656	256 752	***1 792 288***
	Total Operating Costs - Rental		USD	-	59 597	117 270	581 538	579 133	576 727	581 538	586 348	591 159	595 970	596 066	***4 269 279***
	EBIT - Machine Ownership		**USD**	**-**	**(505 596)**	**117 554**	**566 491**	**555 852**	**545 214**	**566 491**	**587 768**	**609 045**	**630 322**	**630 748**	***3 673 141***
	EBIT - Machine Rental		**USD**	**-**	**(285 712)**	**49 691**	**227 177**	**216 538**	**205 900**	**227 177**	**248 454**	**269 731**	**291 008**	**291 434**	***1 449 965***
	Royalties paid	5%	USD	-	4 435	8 348	40 436	39 784	39 131	40 436	41 740	43 045	44 349	44 375	***301 703***
	Taxable income - Machine Ownership		USD	-	-	109 206	526 055	516 069	506 083	526 055	546 028	566 000	585 973	586 373	***3 881 469***
	Taxable income - Machine Rental		USD	-	-	41 343	186 741	176 755	166 769	186 741	206 714	226 687	246 659	247 059	***1 438 409***
	Minerals sector tax rate	35%													***-***
	Tax Payable - Machine Ownership		USD	-	-	38 222	184 119	180 624	177 129	184 119	191 110	198 100	205 091	205 230	***1 358 514***
	Tax Payable - Machine Rental		USD	-	-	14 470	65 359	61 864	58 369	65 359	72 350	79 340	86 331	86 471	***503 443***
	Cashflow after Tax														***-***
	Operation that buys machinery		USD	-	(510 030)	70 984	341 936	335 445	328 954	341 936	354 918	367 900	380 883	381 142	***2 012 924***
	Operation that rents machinery		USD	-	(290 147)	26 873	121 382	114 891	108 400	121 382	134 364	147 346	160 328	160 588	***644 819***
	Interest Rate	14%			0,877	0,769	0,675	0,592	0,519	0,456	0,4	0,351	0,308	0,27	***5***
	Discounted Cashflow														***-***
	Operation that buys machinery		**USD**	**-**	**(447 395)**	**54 620**	**230 797**	**198 610**	**170 848**	**155 781**	**141 839**	**128 971**	**117 124**	**102 811**	*854 006*
	Operation that rents machinery		**USD**	**-**	**(254 515)**	**20 678**	**81 929**	**68 025**	**56 299**	**55 300**	**53 697**	**51 654**	**49 302**	**43 318**	*225 687*
	NPV				**Check*										
	Operation that buys machinery		**USD**	**854 006**	854 006										
	Operation that rents machinery		**USD**	**225 687**	225 687										
	IRR														
	Operation that buys machinery			**30%**											
	Operation that rents machinery			**15%**											

Annexure 8: Discounted cashflow for 3,87/m3 scenario: Most likely case scenario

			Years	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
				0	1	2	3	4	5	6	7	8	9	10	*Total*
Quantity	**Capital Expenditure**														
2	CAT Excavator - machine ownership	529 815	USD												
2	Washing Plant and sluice box	32 063	USD												
2	Diesel Water pump	6 750	USD												
2	Capital investment required for excavator rental	276 000													
	CAPEX from sponsor (Machine Ownership)	568 628	USD	-	(568 627,75)	-	-	-	-	-	-	-	-	-	
	CAPEX from sponsor (Machine Rental)	314 813	USD	-	(314 812,50)	-	-	-	-	-	-	-	-	-	
	Gold recovery														
	Volume of material moved		m³	-	6 125	12 250	61 248	61 248	61 248	61 248	61 248	61 248	61 248	61 248	***447 110***
	Gold per unit volume	3,87	g/m³												***-***
	Gold recovery		g	-	23 703	47 406	237 030	237 030	237 030	237 030	237 030	237 030	237 030	237 030	***1 730 317***
		1000	kg	-	24	47	237	237	237	237	237	237	237	237	***1 730***
		35,274	oz	-	836	1 672	8 361	8 361	8 361	8 361	8 361	8 361	8 361	8 361	***61 035***
	Gold price (24k gold)- 2020/24/02		USD/oz	1774	1700	1600	1550	1525	1500	1550	1600	1650	1700	1701	***16 149***
	Gold Price (25% - 6k gold)	25%	USD/oz	444	425	400	388	381	375	388	400	413	425	425	***4 037***
	Gold buyer overhead cost	8%	USD/oz	35	34	32	31	31	30	31	32	33	34	34	***323***
	Gold buyer purchase price		USD/oz	408	391	368	357	351	345	357	368	380	391	391	***3 714***
	Exchange rate		GHS/oz	5,3	5,4	5,5	5,3	5,4	5,5	5,3	5,4	5,5	5,3	6,3	***54***
	Gold Revenue		USD	-	326 915	615 369	2 980 692	2 932 616	2 884 541	2 980 692	3 076 843	3 172 995	3 269 146	3 271 069	***22 239 809***
			GHC	-	1 765 339	3 384 528	15 797 668	15 836 129	15 864 974	15 797 668	16 614 955	17 451 472	17 326 475	20 607 736	***119 839 208***
	Total Labour Costs	**Parameters**		**-**	**60 283**	**113 474**	**549 640**	**540 774**	**531 909**	**549 640**	**567 370**	**585 100**	**602 831**	**603 185**	***4 101 021***
7	Pit workers - Production workers, engine operators (7)	0,36%	USD	-	8 238	15 507	75 113	73 902	72 690	75 113	77 536	79 959	82 382	82 431	***560 443***
1	Income due to miner / site manager (1)	12%	USD	-	39 230	73 844	357 683	351 914	346 145	357 683	369 221	380 759	392 298	392 528	***2 668 777***
2	Pit supervisor (1), Engineering foreman (1)	0,8%	USD	-	5 231	9 846	47 691	46 922	46 153	47 691	49 229	50 768	52 306	52 337	***355 837***
2	Excavator operators (2)	0,6%	USD	-	3 923	7 384	35 768	35 191	34 614	35 768	36 922	38 076	39 230	39 253	***266 878***
2	Engineeirng Technicians (2)	0,36%	USD	-	2 354	4 431	21 461	21 115	20 769	21 461	22 153	22 846	23 538	23 552	***160 127***
2	Supporting staff (2)	0,2%	USD	-	1 308	2 461	11 923	11 730	11 538	11 923	12 307	12 692	13 077	13 084	***88 959***
	Machinery and equipment (Ownership)			-	9 310	18 619	93 097	93 097	93 097	93 097	93 097	93 097	93 097	93 097	***679 608***
	Machinery and equipment (Rental)			-	43 241	86 482	432 411	432 411	432 411	432 411	432 411	432 411	432 411	432 411	***3 156 599***
Unit of parameter															
USD/m³	Excavator operating costs (Rental)	6,91	USD	-	42 322	84 645	423 224	423 224	423 224	423 224	423 224	423 224	423 224	423 224	***3 089 533***
USD/m³	Excavator operating costs (ownership)	1,37	USD	-	8 391	16 782	83 910	83 910	83 910	83 910	83 910	83 910	83 910	83 910	***612 541***
USD/m³	Water pumping	0,15	USD	-	919	1 837	9 187	9 187	9 187	9 187	9 187	9 187	9 187	9 187	***67 067***
															-
	Total Operating Costs - Ownership		USD	-	69 593	132 093	642 737	633 871	625 006	642 737	660 467	678 197	695 928	696 282	***4 780 629***
	Total Operating Costs - Rental		USD	-	103 524	199 956	982 051	973 185	964 320	982 051	999 781	1 017 511	1 035 241	1 035 596	***7 257 620***
	EBIT - Machine Ownership		**USD**	**-**	**(311 306)**	**483 275**	**2 337 956**	**2 298 745**	**2 259 534**	**2 337 956**	**2 416 377**	**2 494 798**	**2 573 219**	**2 574 787**	***16 890 553***
	EBIT - Machine Rental		**USD**	**-**	**(91 422)**	**415 413**	**1 998 642**	**1 959 431**	**1 920 221**	**1 998 642**	**2 077 063**	**2 155 484**	**2 233 905**	**2 235 473**	***14 667 377***
	Royalties paid	5%	USD	-	16 346	30 768	149 035	146 631	144 227	149 035	153 842	158 650	163 457	163 553	***1 111 990***
	Taxable income - Machine Ownership		USD	-	-	452 507	2 188 921	2 152 114	2 115 307	2 188 921	2 262 534	2 336 148	2 409 761	2 411 234	***16 106 214***
	Taxable income - Machine Rental		USD	-	-	384 644	1 849 607	1 812 800	1 775 994	1 849 607	1 923 220	1 996 834	2 070 447	2 071 920	***13 663 154***
	Minerals sector tax rate	35%													***-***
	Tax Payable - Machine Ownership		USD	-	-	158 377	766 122	753 240	740 358	766 122	791 887	817 652	843 416	843 932	***5 637 175***
	Tax Payable - Machine Rental		USD	-	-	134 625	647 362	634 480	621 598	647 362	673 127	698 892	724 657	725 172	***4 782 104***
	Cashflow after Tax														***-***
	Operation that buys machinery		USD	-	(327 652)	294 129	1 422 799	1 398 874	1 374 950	1 422 799	1 470 647	1 518 496	1 566 345	1 567 302	***10 141 388***
	Operation that rents machinery		USD	-	(107 768)	250 019	1 202 245	1 178 320	1 154 396	1 202 245	1 250 093	1 297 942	1 345 791	1 346 748	***8 773 282***
	Interest Rate	14%			0,877	0,769	0,675	0,592	0,519	0,456	0,4	0,351	0,308	0,27	
	Discounted Cashflow														***-***
	Operation that buys machinery		**USD**	**-**	**(287 414)**	**226 323**	**960 349**	**828 246**	**714 106**	**648 208**	**587 726**	**532 323**	**481 663**	**422 770**	***5 114 299***
	Operation that rents machinery		**USD**	**-**	**(94 533)**	**192 381**	**811 481**	**697 660**	**599 557**	**547 726**	**499 584**	**455 005**	**413 841**	**363 277**	***4 485 980***
	NPV				**Check*										
	Operation that buys machinery		**USD**	**5 114 299**	5 114 299										
	Operation that rents machinery		**USD**	**4 485 980**	4 485 980										
	IRR														
	Operation that buys machinery			**166%**											
	Operation that rents machinery			**344%**											

Annexure 9: Discounted cashflow for 6,69g/m3 scenario: Best case scenario

			Years	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
				0	1	2	3	4	5	6	7	8	9	10	
Quantity	**Capital Expenditure**														***Totals***
2	CAT Excavator - machine ownership	529 815	USD												
2	Washing Plant and sluice box	32 063	USD												
2	Diesel Water pump	6 750	USD												
2	Capital investment required for excavator rental	276 000													
	CAPEX from sponsor (Machine Ownership)	568 628	USD	-	(568 627,75)	-	-	-	-	-	-	-	-	-	
	CAPEX from sponsor (Machine Rental)	314 813	USD	-	(314 812,50)	-	-	-	-	-	-	-	-	-	
	Gold recovery														
	Volume of material moved		m³	-	3 062	12 250	12 250	61 248	61 248	61 248	61 248	61 248	61 248	61 248	***395 050***
	Gold per unit volume	6,69	g/m³												***-***
	Gold recovery		g	-	20 487	81 950	81 950	409 749	409 749	409 749	409 749	409 749	409 749	409 749	***2 642 882***
		1000	kg	-	20	82	82	410	410	410	410	410	410	410	***2 643***
		35,274	oz	-	723	2 891	2 891	14 453	14 453	14 453	14 453	14 453	14 453	14 453	***93 225***
	Gold price (24k gold) - 2020/24/02		USD/oz	1774	1700	1600	1550	1525	1500	1550	1600	1650	1700	1701	
	Gold Price (25% - 6k gold)	25%	USD/oz	444	425	400	388	381	375	388	400	413	425	425	
	Gold buyer overhead cost	8%	USD/oz	35	34	32	31	31	30	31	32	33	34	34	
	Gold buyer purchase price		USD/oz	408	391	368	357	351	345	357	368	380	391	391	
	Exchange rate		GHS/oz	5,3	5,4	5,5	5,3	5,4	5,5	5,3	5,4	5,5	5,3	6,3	
	Gold Revenue		USD	-	282 566	1 063 777	1 030 534	5 069 562	4 986 454	5 152 669	5 318 884	5 485 100	5 651 315	5 654 639	***34 040 861***
			GHC	-	1 525 855	5 850 773	5 461 830	27 375 634	27 425 498	27 309 148	28 721 976	30 168 048	29 951 968	35 624 226	***183 790 729***
	Total Labour Costs	**Parameters**		**-**	**52 105**	**196 160**	**190 030**	**934 827**	**919 502**	**950 152**	**980 802**	**1 011 452**	**1 042 102**	**1 042 715**	***6 277 135***
7	Pit workers - Production workers, engine operators (7)	0,36%	USD	-	7 121	26 807	25 969	127 753	125 659	129 847	134 036	138 225	142 413	142 497	***857 830***
1	Income due to miner / site manager (1)	12%	USD	-	33 908	127 653	123 664	608 347	598 375	618 320	638 266	658 212	678 158	678 557	***4 084 903***
2	Pit supervisor (1), Engineering foreman (1)	0,8%	USD	-	4 521	17 020	16 489	81 113	79 783	82 443	85 102	87 762	90 421	90 474	***544 654***
2	Excavator operators (2)	0,6%	USD	-	3 391	12 765	12 366	60 835	59 837	61 832	63 827	65 821	67 816	67 856	***408 490***
2	Engineeirng Technicians (2)	0,36%	USD	-	2 034	7 659	7 420	36 501	35 902	37 099	38 296	39 493	40 689	40 713	***245 094***
2	Supporting staff (2)	0,2%	USD	-	1 130	4 255	4 122	20 278	19 946	20 611	21 276	21 940	22 605	22 619	***136 163***
	Machinery and equipment (Ownership)			-	4 655	18 619	18 619	93 097	93 097	93 097	93 097	93 097	93 097	93 097	***600 475***
	Machinery and equipment (Rental)			-	21 621	86 482	86 482	432 411	432 411	432 411	432 411	432 411	432 411	432 411	***2 789 050***
USD/m³	Excavator operating costs (Rental)	6,91	USD	-	21 161	84 645	84 645	423 224	423 224	423 224	423 224	423 224	423 224	423 224	***2 729 793***
USD/m³	Excavator operating costs (ownership)	1,37	USD	-	4 195	16 782	16 782	83 910	83 910	83 910	83 910	83 910	83 910	83 910	***541 218***
USD/m³	Water pumping	0,15	USD	-	459	1 837	1 837	9 187	9 187	9 187	9 187	9 187	9 187	9 187	***59 257***
	Total Operating Costs - Ownership		USD	-	56 760	214 780	208 650	1 027 924	1 012 599	1 043 249	1 073 899	1 104 549	1 135 199	1 135 812	***6 877 610***
	Total Operating Costs - Rental		USD	-	73 726	282 643	276 513	1 367 238	1 351 913	1 382 563	1 413 213	1 443 863	1 474 513	1 475 126	***9 066 185***
	EBIT - Machine Ownership		**USD**	**-**	**(342 822)**	**848 997**	**821 884**	**4 041 638**	**3 973 855**	**4 109 420**	**4 244 985**	**4 380 550**	**4 516 115**	**4 518 827**	***26 594 623***
	EBIT - Machine Rental		**USD**	**-**	**(105 972)**	**781 134**	**754 021**	**3 702 324**	**3 634 541**	**3 770 106**	**3 905 671**	**4 041 236**	**4 176 801**	**4 179 513**	***24 659 863***
	Royalties paid	5%	USD	-	14 128	53 189	51 527	253 478	249 323	257 633	265 944	274 255	282 566	282 732	***1 702 043***
	Taxable income - Machine Ownership		USD	-	-	795 808	770 357	3 788 160	3 724 532	3 851 787	3 979 041	4 106 295	4 233 550	4 236 095	***25 249 530***
	Taxable income - Machine Rental		USD	-	-	727 945	702 495	3 448 846	3 385 218	3 512 473	3 639 727	3 766 981	3 894 236	3 896 781	***23 077 921***
	Minerals sector tax rate	35%													
	Tax Payable - Machine Ownership		USD	-	-	278 533	269 625	1 325 856	1 303 586	1 348 125	1 392 664	1 437 203	1 481 742	1 482 633	***8 837 336***
	Tax Payable - Machine Rental		USD	-	-	254 781	245 873	1 207 096	1 184 826	1 229 365	1 273 904	1 318 443	1 362 982	1 363 873	***8 077 272***
	Cashflow after Tax														
	Operation that buys machinery		USD	-	(356 950)	517 275	500 732	2 462 304	2 420 946	2 503 661	2 586 377	2 669 092	2 751 807	2 753 462	***16 055 244***
	Operation that rents machinery		USD	-	(120 101)	473 165	456 621	2 241 750	2 200 392	2 283 107	2 365 823	2 448 538	2 531 253	2 532 908	***14 880 548***
	Interest Rate	14%			0,877	0,769	0,675	0,592	0,519	0,456	0,4	0,351	0,308	0,27	
	Discounted Cashflow														
	Operation that buys machinery		**USD**	**-**	**(313 114)**	**398 027**	**337 980**	**1 457 881**	**1 257 364**	**1 140 634**	**1 033 613**	**935 674**	**846 203**	**742 729**	***7 836 991***
	Operation that rents machinery		**USD**	**-**	**(105 352)**	**364 085**	**308 206**	**1 327 296**	**1 142 815**	**1 040 153**	**945 471**	**858 357**	**778 380**	**683 236**	***7 342 648***
	NPV				**Check*										
	Operation that buys machinery		**USD**	**7 836 991**	7 836 991										
	Operation that rents machinery		**USD**	**7 342 648**	7 342 648										
	IRR														
	Operation that buys machinery		**USD**	**166%**											
	Operation that rents machinery		**USD**	**375%**											

Annexure 10:Summary of feedback from the stakeholder engagements

Theme	Summary of the feedback
The understanding of ASM in Ghana	• There is a good understanding of ASM, however stakeholders would like to see the legislation and description of ASM updated to accommodate semi mechanized small-scale mining activity
The perception of ASM in Ghana	• The general perception of ASM is negative because of the historical background of the sector, and the way it is managed. People frown upon ASM • Despite the negative perception, hopes for the sector are high and people believe that it has great potential.
Perceived ASM push and pull factors	**Push Factors** • Weak alternative livelihoods that produce a very small fraction of income compared to ASM • Lack of economic opportunities, the few opportunities that are available are not lucrative • Retrenchments. **Pull Factors** • Consistent and relatively high income from ASM
Views on the ASM licensing process	Dissatisfaction with the current licence application process. • It is viewed as difficult, expensive and time consuming. It discourages people from applying. • It is considered to be outdated with too much paperwork • The centralized application system has long processing times and applications are difficult to track. • The closure of some of the district offices has increased the application backlog
The challenges or factors limiting ASM	The stakeholders identified the following to be the top challenges: • Political interference • Lack of education and skills • Difficulties in accessing capital • Low recovery rates • A lack of areas designated for ASM
ASM support from government	• There is currently only regulatory support from government. • In the past there was a revolving ASM fund, however it was dissolved • The “once in a while” training that is offered by government is considered to be insufficient.
ASM success stories	• ASM has created other economic linkages in some of the communities. Legal ASM has provided with consistent long term employment for some people. • CSR programs by registered small-scale mines in host communities. • Enabled people to expand their mining operations and venture into other economic sectors • Ability to collaborate with community members on projects • Enabled people to establish informal mining consultation businesses
The 2016 temporary ban on small-scale mining.	• The need and importance of the temporary ban are well understood. However, the stakeholders disagree with the way in which the ban was executed • The ban included all forms of small-scale mining (legal and illegal) • Some groups believe that the ban did more harm than good to the sector • Infrastructure of legal operations was destroyed during the ban

Annexure 11: Summary of the PASE framework

Pillar	Sub-themes or smaller Goals	Description / Details
1. Re-defining and restructuring the small-scale mining sector	None	• Incorporating the more mechanized forms of small-scale mining into the legislation. • Following the lead of Ethiopia and Brazil by re-arranging the small-scale mining sector to have the sub categories of artisanal mining and semi-mechanized or junior mining. Re-defining the sub categories as follows: ○ **Artisanal mining**: *"Mining methods at use rudimentary tools and equipment and no forms of mechanization. These tools and equipment can be powered by gravity or physical human effort"*. Artisanal miners would be considered to be individuals, families and cooperatives that mine for subsistence purposes. This mining would be informal and driven by the need to survive. ○ **Semi-mechanized or junior mining**: *"Mining methods that use any form of mechanisation or automation. This includes machinery and equipment powered by, electric, fuel, battery, or green energy"*. These miners would have to be registered companies that mine for commercial production or larger economic gain. This mining would be formal, and market driven.
2. Introducing licensing reforms	2.1. Modernizing the licensing system	• Bringing the electronic mining repository to full functionality • Setting up the electronic system to receive first time applications, allow renewal of applications, and receive electronic payments. • Creating a "one-stop information shop" for new and existing applicants and potential investors.
	2.2. Decentralizing the licensing process	• Allowing the Minerals Commission district offices to facilitate and process small-scale mining applications from beginning to end. • Allowing the Minerals Commission district offices to issue mining licences • Setting up QA/QC systems to ensure that the district offices follow the correct processes and maintain the required standard.
	2.3. Separating the licences for artisanal mining and semi-mechanized mining	• Separate licences and licensing processes for artisanal miners and semi-mechanized or junior miners • Artisanal miners: ○ Simpler licensing process that requires less paperwork and lower barriers to entry ○ Applications limited to mining host community members that plan on mining as individuals, families or cooperatives

		◦ Application processes can be facilitated by the community leaders, overseen, processed and issued by Minerals Commission district offices. ◦ Artisanal mining licence can be valid for 5 years and the land size can be reduced to between 10 and 15 acres. ◦ These licences can be reserved for areas with lower grades • Junior Miners: ◦ A more stringent and formal licensing process for junior miners ◦ Eligible for all Ghanaians that have registered companies ◦ Applications facilitated and processed by Minerals Commission district offices. ◦ Licences designated for areas with higher grade ◦ Licences can be valid for 10 years, and the land size of 30 acres
	2.4. Inclusion of community consultations in the licence application process	• Community consultations should be a prerequisite in the application of small-scale mining licences, especially for semi-mechanized operations • There should be meaningful consultations between the host communities and the licence applicants in this process
3. Improving training and Education	3.1. Community based education and training programs	• The commissioning of regional and community based small-scale mining training programs • The programs should be community driven to entrench the culture of small-scale mining education in the local community • Training programs can be facilitated by community members and traditional authorities and managed or overseen by the Minerals Commission district offices
	3.2. Training as a prerequisite to obtaining a licence	• Basic training requirements for artisanal miners and more advanced training requirements for semi-mechanized small-scale or junior miners • The introduction of a certificate of competency for junior miners.
	3.3. Inclusion of small-scale mining in national service programs	• The creation of a small-scale mining National Service program for graduates that cannot be absorbed by the large scale mining sector • Placing graduates that cannot be absorbed by large-scale mining companies into this program • Grooming graduates from the small-scale National Service program to enter a consultancy pool of small-scale mining experts • Graduates that complete the SSM National Service program can also be encouraged to become entrepreneurs and apply for mining licences.

4. Strengthening the technical function	4.1. Creation of a national small-scale mining consultancy pool	• The creation of a national pool of local consultants and experts that offer technical services to small-scale miners • Consultant pool can be customized to meet the affordability and needs of the small-scale mining sector • The sector can source consultants on an intermittent basis to do specific work • Mining graduates and other young professionals can be encouraged to join this pool after competing National Service
	4.2. Investing in small-scale mining research and development	• Building on existing knowledge, creating new knowledge, and promoting innovation • Documenting, learning from, and improving the existing small-scale mining methods. Discovering new methods. • The investment into small-scale mining research and development in Ghana should match the magnitude of the activity • Ghana should be one of the world leaders in small-scale mining research, and it should offer knowledge, solutions and technology
5. Strengthening the small-scale mining life cycle and value chain	5.1. Strengthening exploration	• Creation of a National Exploration Program (NEP) • Government owned program with collaborative effort between the Minerals Commission and the Ghana Geological Survey Authority (GSSA) • National Exploration Program can include drilling as well as simpler exploration methods that do not require drilling. • Ghana can use exploration information to delineate zones for small-scale mining. • Incorporating graduates in the national service into the program as field workers
	5.2. Strengthening feasibility studies	• Adapting mining feasibility studies for small-scale mines • Giving small-scale miners access to the skills that can assist them with feasibility studies
6. Improving the business function and image	6.1. Operating small-scale mines and Small as Medium-sized Enterprises (SMEs)	• Viewing, treating and developing small-scale mines as Small and Medium-sized Enterprises • Applying SME policies, best practices, and tax regulations to small-scale mining • Introduction of tax incentives that favour the emergence, growth and sustainability of small-scale mines • Embedding SME sustainability principles into the culture of the small-scale mines.

	6.2. Access to finance	• The creation of a pool for local investors who would like to invest in legal small-scale mining projects. Minerals Commission would match projects on the database with suitable investors. • Creating latitude for foreign investment in the category of mechanised small-scale mining or junior miners • Matching registered, reputable semi-mechanized small-scale mining projects with the Ghana Stock Exchange. An opportunity to create a subsidiary around raising capital for indigenous small-scale miners • Educating miners about access to and the management of finance
	6.3. Improving the public perception of small-scale mining	• Enhancing the image of the small-scale mining sector as a valid subsidiary of the mining business and mining engineering • Drawing attention to the positive attributes of the sector • Creation of awareness campaigns, community engagement sessions, and infographics that can be run on a national scale (via radio, broadcast and print media, internet etc.) to highlight the positive attributes of small-scale mining. • Encouraging and empowering small-scale miners to run their operations like legitimate mining businesses • Increasing levels of competency in the small-scale mining sector to attract official recognition. • Training and educational support from government, and assistance with access to skilled professionals to increase competency of SSM.