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Abbreviations and Acronyms

Acronym	Description
3TG	Tin, Tungsten, Tantalum and Gold
AMD	Acid Mine Drainage
ASM	Artisanal and Small-Scale Mining
AWIM	Association of Women in Mining Madagascar
AWIMA	Association of Women in Mining in Africa
BCMM	Madagascar Mining Cadastre Office
CRAFT	Code of Risk-Mitigation for ASM engaging in Formal Trade
CRM	Critical Raw Materials
EIA	Environmental Impact Assessment
EPRM	European Partnership for Responsible Minerals
ESG	Environmental, Social and Governance
EU	European Union
FAC	Fund Allocation Committee
LCT (pegmatites)	Lithium-Cesium-Tantalum (pegmatites)
LOM	Life of Mine
MOSES	Mineral Output Statistical Evaluation System (Zambia)
NGO	Non-Governmental Organization
OECD	Organization of Economic and Cooperation Development
OHS	Occupational Health and Safety
PAYE	Pay as you Earn

PPE	Personal Protective Equipment
SDGs	Sustainable Development Goals
SML	Small-Scale Exploration License
TSF	Tailings Storage Facility
UN	United Nation
VAT	Value Added Tax
WP	Work Package
ZRA	Zambia Revenue Authority
ZAWIMA	Zimbabwe Association of Women in Mining Associations
ZELA	Zimbabwe Environmental Law Association
ZIMRA	Zimbabwe Revenue Authority

Executive Summary

This report consolidates the curriculum and training materials used in three capacity-building programs for the artisanal and small-scale mining (ASM) sector in Africa. These training programs were conducted in Zimbabwe, Madagascar, and Zambia, with the goal of promoting best practices for responsible mineral extraction and strengthening the resilience of the ASM sector and local communities against environmental, social, and governance (ESG) challenges. Designed and executed in close collaboration with local experts with extensive experience in the ASM sector, the training programs were tailored to address the specific needs and challenges identified in each country. The selection of topical areas was based on consultations with these experts to ensure relevance and impact.

The report begins with an introductory section that provides background information on the training programs, including their objectives, target audience, expected learning outcomes, duration, structure, teaching methodologies, and required resources. This is followed by detailed training modules covering six key topics:

- Module 1: National regulatory frameworks for the mining sector and ASM
- Module 2: International frameworks on responsible sourcing
- Module 3: Technical knowledge: Geology, mining and exploration techniques, processing and waste management
- Module 4: Management of environmental, health, safety, and social issues
- Module 5: Mining as a business
- Module 6: Access to finance

Each module includes interactive exercises and group activities to enhance learning and practical application. The concluding chapter reflects on the learning outcomes and provides templates for assessing the success and impact of the training programs.

While some topics of this training manual are universally applicable and can be directly used in future capacity building programs in other countries, others require adaptation based on the national context. Specifically, the modules on regulatory frameworks and regional geology have been customized for each country but can serve as templates for adaptation in different regions.

This report was developed in the frame of the Work Package 4, Task 4.3 of the AfricaMaVal project and compiled by the World Resources Forum (WRFA) with contributions from INTRAW and NUST. Other WP4 partners, AWIMA and SSSA, contributed to the design and execution of the in-country training sessions. The development of training materials was based on existing knowledge from other deliverables of the AfricaMaVal project, insights from local experts, and additional desk research.

Keywords

Artisanal and small-scale mining, capacity building, training, environmental protection, social issues, ESG, critical raw materials, Zimbabwe, Zambia, Madagascar, geology, occupational health and safety, regulatory frameworks, responsible sourcing, mining as a business, access to finance

1. Introduction

1.1. Background

Artisanal and small-scale mining (ASM) ranges from informal individual miners earning a subsistence livelihood to more formal and regulated small-scale entities producing minerals commercially (IGF 2017). While there is not a common definition for ASM due to regional and contextual differences, the Organization of Economic and Cooperation Development (OECD) defines ASM as “formal or informal mining operations with predominantly simplified forms of exploration, extraction, processing, and transportation. ASM is normally low capital intensive and uses high labour-intensive technology” (OECD 2016). As such, ASM unfolds as a multifaceted sector where a diverse array of actors, methodologies, and motivations converge. Understanding this intricate tapestry is pivotal for grasping ASM's nuanced dynamics. ASM provides livelihood for about 45 million people, with an additional 150 million individuals across more than 80 countries depending on the sector indirectly; using a multiplier, it is estimated that three times as many people work in supporting industries (World Bank 2022). While the sector is an important source of livelihood, the ASM operations are particularly prone to causing negative environmental, social and governance (ESG) impacts. Despite the sector’s significant importance to domestic and international economies, it has remained largely misunderstood and underrepresented when it comes to responsible sourcing and sustainable value chains (World Bank 2023).

In 2022, the EU-funded project AfricaMaVal was launched to foster EU-Africa value chain partnerships aimed at promoting the responsible sourcing of critical raw materials for European industries while ensuring sustainable local co-development under optimal ESG conditions. Acknowledging the critical role of ASM in Africa, the project has placed a strong emphasis on studying the sector from multiple perspectives. Key areas of research include the technical and economic potential of ASM (Vasters and Schütte 2023), country-specific regulatory frameworks (Awases et al. 2023; Sewepershad and Tufo, n.d.), investment opportunities (Albery et al. 2024), business models addressing ESG challenges (Falck et al. 2024) and the development of a comprehensive ESG framework for ASM (Ghezzi, Iannone, and Annunziata 2024).

As a complement to these approaches, the project aimed to promote best practices for responsible extraction and strengthen the resilience of local communities against ESG challenges by organizing in-country capacity-building programs. To achieve this, a two-pronged strategy was implemented, incorporating both bottom-up and top-down components.

The bottom-up approach focused on delivering practical, in-country training sessions for artisanal and small-scale miners working with critical raw materials. Meanwhile, the top-down approach sought to enhance institutional capacity through a "train-the-trainer" model, engaging local training institutions to ensure knowledge transfer and long-term impact. Beyond organizing these training sessions, the project established a collaborative platform designed to serve as a multiplier beyond the project's duration. The vision was to transition from individual-level capacity building to institutional-level capacity building, ensuring the sustainability and long-term impact of the training programs even after the project's conclusion.

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1.2. AfricaMaVal training programmes

In 2024, the AfricaMaVal project hosted three capacity building events for diverse artisanal and small scale mining (ASM) communities across Africa, with the theme "Making Just Transition Inclusive for All: Empowering ASM to actively participate in critical raw material value chains". These trainings were designed with the approach to co-create knowledge, utilizing local experts and together with the hands-on knowledge of the ASM participants, with the objective to collaboratively move the sector towards a more sustainable and inclusive future. This training manual has been developed in response to the input generated from these trainings and the artisanal and small-scale miners who participated.

In collaboration with the Zimbabwe Environmental Law Association (ZELA), the Zimbabwe School of Mines and the Zimbabwe Association of Women in Mining Associations (ZAWIMA), the first capacity building was held April 2024 in Bulawayo, Zimbabwe with the target audience of ASM extracting lithium from the regions' vast reserves. The ASM Academy covered several topics to address knowledge gaps within the sector. Specifically, the themes included: reducing environmental impacts, increasing geological knowledge on lithium, formalisation, mining as a business, access to finance, and health and safety.

The second capacity building occurred in August 2024 in French speaking Antananarivo, Madagascar and was organized together with the Association of Women in Mining Madagascar (AWIM). The trainees were those ASM working on lithium and other critical raw materials from the country's diverse geology. Specific themes included: national regulations and codes governing the sector, reduction in environmental impacts, health and safety, exploration and mining techniques for ASM, role of women in ASM, and accessing finance.

In collaboration with the Federation of Small-Scale Mining Associations of Zambia (FESSMAZ) and the Zambian Ministry of Mines and Minerals Development, a third capacity building was held in Mansa, Zambia in September 2024, for the region's manganese ASM miners, a small but important sector in the country's active mining. Specific themes included: national regulations governing the sector, international frameworks on responsible sourcing, the geology of manganese, reduction in environmental impacts, health and safety, exploration and mining techniques for ASM, mining as a business, and access to finance.

A fourth capacity building is currently in development for ASM miners working on copper extraction in Namibia, to be held in early June 2025. It is in cooperation with the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF), the Namibian Ministry of Mines and Energy and the Association of Women in Mining in Africa (AWIMA).

1.3. Training purpose

The training aims to build and develop the capacity of artisanal and small-scale miners to, on one hand, improve their legal and economic performance and, on the other hand, prevent potential hazards that could pose health, safety, and environmental risks to people, property, animals, and the wider environment. The training was designed to challenge and educate artisanal and small scale miners about the mining value chain cycle while instilling and instituting safer and more productive mining practices, thereby improving the miners' livelihoods.

Training artisanal and small-scale miners serves multiple crucial objectives. The following goals were carefully considered in the curriculum design:

- Increasing awareness of best mining practices and ensure miners are informed about safety protocols and health risks associated with mining activities that helps reduce accidents and long-term health issues.
- Increasing awareness of existing legislation that protects miners' rights, which can simultaneously lead to compliance with local laws and regulations, reducing the risk of illegal mining activities.
- Providing miners with technical skills and knowledge to improve their efficiency and productivity, leading to better economic outcomes.
- Improving ore extraction and metal recoveries by adopting efficient mining and mineral processing methods.
- Creating a clearer understanding of the minerals market and how miners can protect themselves against volatile mineral prices.
- Helping small-scale miners access to funding, legal support, and market opportunities, enabling them to grow their businesses and contribute to the local economy.

1.4. Training rationale (selection of topics)

The development of the training materials began with a needs assessment to identify the most relevant topics for the ASM sector, considering regional differences and the types of commodities mined. To achieve this, comprehensive discussions were held with project partners and local experts, including representatives from NGOs, government officials, and ASM stakeholders. Based on the insights gathered from these consultations, the learning materials were developed in close collaboration with local partners and supported by relevant literature sources.

A crucial consideration in developing the training materials was that the ASM sector operates across multiple stages of the mining value chain, including exploration, mining, trading, primary processing, secondary processing, and export. Each of these stages has the potential to cause environmental impacts, which can arise throughout the entire mining life cycle, from exploration to development, operation, closure, and post-closure. Figure 1 illustrates the mining life cycle for artisanal and small-scale operations.

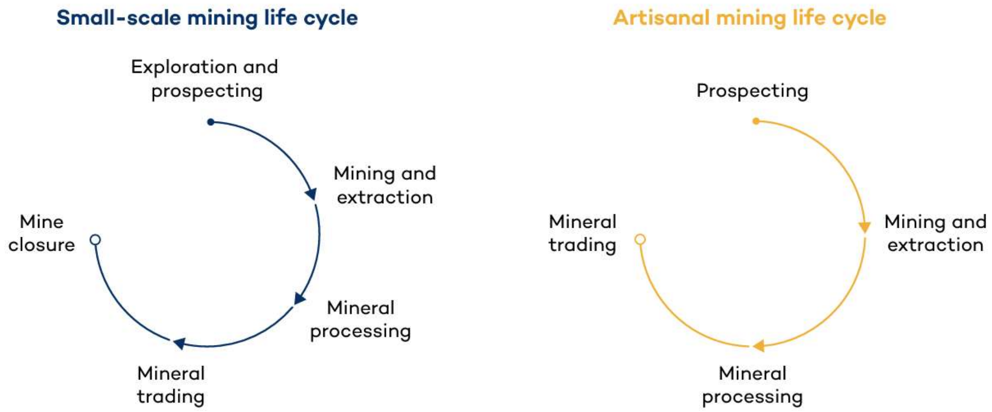

Figure 1. Mining life cycle for artisanal and small-scale operations. Source: IGF 2024

The curriculum provides both general knowledge and in-depth insights into the specific topics outlined below. While some topics are covered from a broad perspective, others have been adapted to reflect the local context to ensure relevance and applicability:

- Legal and Regulatory Frameworks
- International Framework on Responsible Sourcing
- Knowledge of Geology and Mineralogy
- Mining Value Chain
- Environmental management and mine closure
- Occupational Health and Safety
- Basic Business Appreciation
- Financial opportunities

Training miners in the ASM sector can enhance their understanding of the minerals value chain and equip them with strategies to minimize losses at each stage. The knowledge gained can help improve ore extraction and metal recovery by promoting the adoption of efficient, environmentally sustainable mining and mineral processing methods.

1.5. Target audience

This handbook serves as a practical tool for various groups of stakeholders as listed below:

- Artisanal and small-scale miners who seek to increase their knowledge depth and skills in the mineral value chain.
- Mining associations seeking to build and develop the capacity of their members.
- Government officials seeking to engage and assist ASMs in their operations.
- Civil Society Organisations seeking to build and develop the capacity of local beneficiaries in ASM.
- Community leaders and followers
- Train the trainer candidates

The materials can be adapted to specific local contexts to provide artisanal and small-scale miners with up-to-date information on key aspects of the mining value chain.

1.6. Expected learning outcomes

Upon completion of this training, the participants are expected to:

- Demonstrate a clear understanding of legal and regulatory frameworks applicable in their country.
- Recognize and apply sustainable mining practices.
- Develop a stronger grasp of geology and its significance for mining operations.
- Acquire technical competencies in mining, safety, and health practices.

- Understand the importance of miner health and well-being.
- Gain foundational business skills to support economic sustainability.
- Identify challenges related to financing the sector and explore available funding opportunities.

1.7. Duration and structure

The curriculum is designed to be delivered over three days of face-to-face workshops, followed by a one-day mine tour, ensuring a balance between theoretical learning and hands-on practical experience. The mine visit follows a "look-and-learn" approach, allowing participants to observe real-world applications of best practices.

The training follows a workshop style and is planned to be very interactive, maximising knowledge dissemination whilst considering the need to prevent ASM from missing out on their production targets for their operations. A preliminary assessment of their knowledge can be key in identifying the gaps and knowing which critical topics out of those covered they would require. The curriculum is based on a modular approach in which specific modules can stand on their own but with a focus on the mineral value chain.

1.8. Teaching and learning strategies

The constructive alignment approach is critical to ensure that learning occurs. The facilitators is encouraged to utilise simple and graphical learning activities and match these to the intended learning outcomes for the training. This constructive alignment approach reduces the gap between the broad spectrums of the miners attending the training workshop. The facilitators are expected to develop simple mechanisms using process mapping techniques to help the miners construct their understanding of the mining value chain and environmental, health, and safety by using simple examples and pictures that speak to their level of knowledge. They are expected to utilise diverse transformative teaching activities:

- Plenary discussions
- Probing questions
- Instant ideas or brainstorming
- Role-plays
- Four corners
- Reflective learning
- Icebreakers
- Case studies
- Peer-to-peer
- Group tasks or exercises and participants presentations

The above methods enhance the knowledge transfer to the miners rather than merely providing them with information. It is a fact that all ASM miners come from diverse backgrounds and learn differently. Hence, the facilitators will be equipped to present the material in different ways to meet the diverse needs of miners, considering how cultural factors contribute to the learning. Good teaching is about helping students make sense of new information. The VARK (Visual, Auditory Read-Write and Kinesthetic) will be utilised to launch students on a voyage of self-discovery, as shown in Figure 2. The approach is setting the ASM in class without making them realise that they are in class, and eventually, the learning will occur. The reading and writing may not be fully utilised out of the four styles, but it will still be handy in pictorial form with summary explanations for the course files.

Figure 2. Learning styles. Source: Growth Engineering, 2024

The training is designed to cater for groups of 20-25 trainees or participants per mining site. Such smaller groups allow effective and efficient participation of trainees, and facilitators can give enough attention to trainees, unlike larger groups. The training is highly participatory and takes serious consideration of the different capacity levels of the target group for ease of learning of the knowledge, information and skills in a participatory manner. The concretisation of concepts remains dominant in the approach to training. The training manual takes cognisance of the reduced concentration span of the target group. Thus, it is designed to ensure effective and efficient time allocation for training, allowing sustained concentration, focus, and motivation to learn.

1.9. Resources required

The following resources will be required to ensure that the teaching and learning are effectively and efficiently realised:

Material

- PowerPoint Presentations (or Handouts) and Flip Charts, Task Cards,
- Coloured Markers or highlighters for each group
- Ball pens and writing pads
- Videos, picture cards, photos
- Certificates for participation

Human Resources

- External Facilitators
- Local Facilitators (Qualified instructors with practical experience in mining and training methodologies)
- 20-25 targeted beneficiaries selected based on the type of commodity they mine and their mining region. Diversity and balance in gender and age were carefully considered.

Equipment and Furniture

- Laptop for facilitators
- Projector
- Camera or Phone
- First aid kit
- PPE
- Basic geology tools (e.g. hand lens, pencil magnet, rock hammer)
- Chairs
- Tables

Infrastructure

- Training Facilities
- A hall or a tent
- A shade

Financial

- Venue, equipment, materials including stationary
- Per diems for participants/ or daily transport to the venue/ site
- Meals and refreshments budget

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2. Training modules and contents

2.1. Module 1: National regulatory frameworks related to the mining sector and ASM

Module Title	National Regulatory Frameworks related to the Mining Sector and ASM
Module Aims	This module aims to provide participants with a comprehensive understanding of the policies, legal frameworks, and regulatory strategies that govern the mining sector and are relevant for artisanal and small-scale mining within a national context.
Specific Learning Outcomes	Upon completing the module participants will, through assessment activities, show evidence of their ability to: • Understanding the basic mining policies and regulations that guide the mining activities in the country. • Understand the fundamental policies that guide ASM activities, including environmental, social, and economic considerations. • Understand the legal obligations and compliance requirements for ASM operations, including licensing and permitting processes and the various tax and royalties applicable to their operations.
Comprehensive Learning Outcome	The course ultimately aims to build capacity among stakeholders involved in ASM, promoting safer, more sustainable, and legally compliant mining activities.
Module Content	1. National mining policies and regulations relevant to ASM 2. Process and requirements for acquiring mining rights, permits or licenses 3. Mining royalties and taxes relevant to ASM. Given the differences in national polices and regulations, this module is divided into three sections for Zimbabwe, Madagascar and Zambia.
Methods of Facilitating Learning	This module will be facilitated through modular lecturing, group discussions and presentations.
Reflection on learning outcomes	To reflect on the learning materials, the participants will be engaged in group work, including presentations and feedback from the trainees.
Student Support & Learning Resources	Group Exercise – Understanding various legal requirements (e.g. permits and licenses) & understanding various tax types applicable to the ASM sector PPT slides used during the training and additional information on relevant publications, internet resources and other reading material will be provided.

Introduction

Understanding mining laws is crucial for artisanal and small-scale miners because it helps them operate legally, avoid fines or shutdowns, and secure mining rights. Compliance with regulatory frameworks can improve access to financial support, markets, and government assistance, while protecting miners from exploitation by illegal operators. Additionally, clear legal frameworks help ASM miners transition into formal, sustainable, responsible and more profitable operations. Mining laws facilitate development by maximizing benefits for miners and the nation while ensuring efficient, safe, and sustainable operations. Due to variations in regulatory frameworks across countries, each is explained in separate sub-chapters for the three target countries. The structure of this module can serve as a template for adaptation in different countries.

Unit 1: Zimbabwe

Main regulatory frameworks

Considering the key role of the mining industry in Zimbabwe, a set of regulations and strategies has been established to govern the sector. Zimbabwe's legal and policy framework for mining entails more than 40 acts of parliament regulating mining operations. ASM is directly affected by 24 of these acts and by the statutory instruments that fall under them (ZELA 2023). The most relevant ones are shown in Figure 3 and explained below.

The **Mines and Minerals Act** (last amendment in 2021) is the primary law to regulate the mining sector and aims to promote transparency, accountability, good governance and equity in the distribution of benefits of resources for all Zimbabweans (Awases et al. 2023). Among other topics, the Mines and Minerals Act defines procedures and requirements for gaining mining rights and issuing a license. Relevant regulations made under this Act include, the Mining General Regulations, the Mining Management and Safety Regulations, the Mining Health and Sanitation Regulation, and the Mines and Minerals Regulations[1].

In addition to the Mines and Minerals Act, there are other regulations and policies in place relevant to the mining sector such as the Zimbabwean Mining Development Act (1983), the Zimbabwe Mining Development Cooperation Act (last amended in 2001), Minerals Marketing Cooperation of Zimbabwe Act (1983), Environmental Management Act (2003), the Indigenization and Economic Empowerment Act (2008), and National Mineral Policy, which was launched in 2013 (Awases et al. 2023; ZELA 2023).

The increasing demand for lithium and other critical minerals has prompted Zimbabwe to enact a series of relevant legal and policy measures in recent years. In 2023, the **Mines and Minerals Amendment Bill** was gazetted, designating lithium, among other resources, as "strategic minerals"(ZELA 2023). As a result, lithium mining operations will be subject to the regulations specified in both the law and the Minister's Bill (ITA, 2024).

[1] https://iclg.com/practice-areas/mining-laws-and-regulations/zimbabwe

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The other recent policy in Zimbabwe is the ministerial ban on export of raw (or beneficiated) lithium or of any specified base mineral, the **Base Minerals Export Control Act**. This Statutory Instrument (213/2022) prohibits the exportation of lithium bearing ores from Zimbabwe to any other territory except under written permit of the Minister of Minerals. With this strategy, the government aims to encourage the mining companies and other investors to invest in beneficiation and refining processes and therefore contribute to value addition in the country (ZELA 2023).

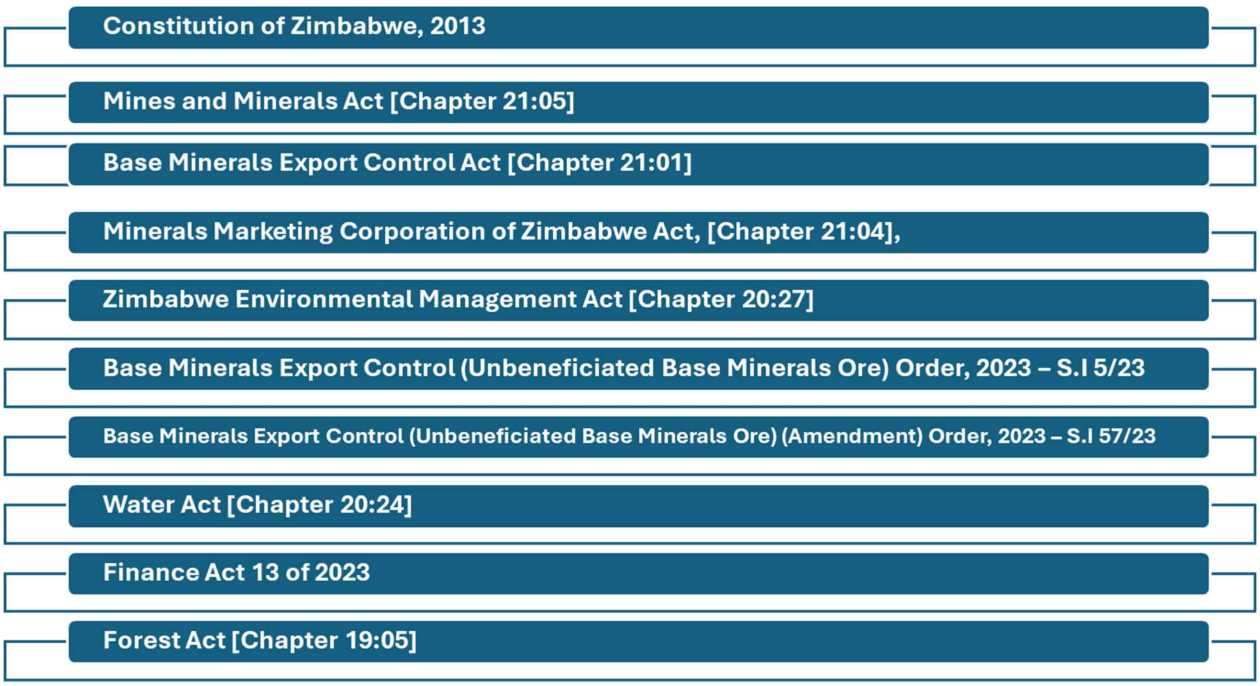

Figure 3. Key regulatory frameworks relevant to mining sector in Zimbabwe. Source: (ZELA, 2024)

While the ASM sector significantly contributes to the economy and output of minerals in Zimbabwe, there is no specific recognition for ASM miners in the Mines and Minerals Act or any other existing regulation. While the Act defines a **small-scale miner** as 'holder of a mining location who is not a large-scale miner', it doesn't provide any concrete definition for artisanal miners (Nyavaya 2021). According to Mines and Minerals Act, any permanent resident of Zimbabwe, aged 18 and above, is eligible to apply for a mining license. However, the lack of official recognition combined with the financial and administrative hurdles make it challenging for artisanal miners to apply or obtain a permit.

Given the importance of the ASM sector in the country, the government of Zimbabwe is currently considering developing an **Artisanal and Small-Scale Mining Policy** which will include policy position on the formalization of artisanal mining. However, as of now, this initiative has not yet been realized (ZELA 2023).

Another key regulatory framework that is applicable to ASM sector is the **Environmental Management Act**, administered by the Environmental Management Agency. Based on this Act, for any mining operation it is required to carry out an Environmental Impact Assessment (EIA) and apply for the corresponding certificate (Nyavaya 2021; ZELA 2023). The details for acquiring an EIA report are provided in the next section.

Mining rights and permits

Mining Rights

Mineral rights (or mining rights) are granted to individuals or organizations that intend to search, extract, process and dispose minerals (Pact 2019). Applying for a mining right in Zimbabwe involves a series of steps governed by the Mines and Minerals Act (Chapter 21:05) and issued by the Ministry of Mines and Mining Development. The process includes various steps as shown in Figure 4 and explained below:

Figure 4. Process for acquiring a mining claim in Zimbabwe. Source: Elaboration by authors based on (Pact 2019).

a. Obtain a prospecting license

This license provides the right to search for minerals and peg claims anywhere in Zimbabwe but not the right of removing or disposing of any mineral discovered (Mining Zimbabwe 2021). It entitles the holder (represented by a pegger or approved prospector) to peg one block for claims or precious or base metals. To obtain a prospecting license, the applicant must submit an application to the Ministry of Mines and Mining Development office and pay the prescribed fee to the Mining Commissioner (ICLG 2024). Any permanent resident of Zimbabwe aged 18 or over can apply for a prospecting license. The prospecting license in Zimbabwe is valid for two years and grants the holder the exclusive right to prospect and stake mining claims across the country. However, the license is non-transferable and cannot be sold, assigned, or donated to another party (Pact 2019).

b. Pegging the claim

Once a mineral deposit is identified, the applicant must appoint an agent or an approved prospector to peg the claim. The agent is responsible for physically marking the area by placing a discovery peg and posting prospecting, discovery, and registration notices on-site. These notices must be clearly visible to inform and alert other prospectors. Before posting the notices, the agent must notify or obtain consent from the landowner. If the prospecting site is on a farm smaller than 100 hectares, the prospector must seek explicit consent from the landowner. For larger areas, a written notification to the landowner is sufficient. Certain areas cannot be pegged, including those classified as restricted or reserved against prospecting, such as cultivated lands, dip tanks, and dams. Each prospecting license allows the holder to peg up to 10 claims, with each claim covering 1 hectare (10,000 square meters) (Mining Zimbabwe 2018).

c. Application for registration

Within 31 days of pegging, the applicant shall submit an application for registration to the Ministry of Mines and Mining Development offices. This application should include (Mining Zimbabwe 2018):

- Copies of prospecting license(s)
- Prospecting Notice (PN)
- Discovery notice (for base minerals)
- Notification of intention to prospect to the landowner
- A map to the scale of 1:25,000 in triplicate: This map can be obtained from Provincial Mining Director showing the area where the miner intends to prospect and all registered claims.

d. Inspection and approval

The Provincial Mining Director will review the application to verify compliance with all required procedures. If all conditions are met, a certificate of registration (mining claim) will be issued upon payment of the gazetted fee. This certificate grants the holder the right to commence mining operations, provided they fulfil additional obligations such as conducting an Environmental Impact Assessment (EIA) (Mining Zimbabwe 2018).

e. Obtaining the mining claim

All mining claims are valid for 12 months and must be renewed annually. To qualify for renewal, continuous work on precious mineral claims is required. Failure to renew the title will lead to forfeiture of the mining claim. If a mining claim is transferred or sold, the Ministry of Mines and Mining Development shall issue a Certificate of Registration After Transfer to the new owner (Mining Zimbabwe 2018).

After receiving a mining claim and during various stages of the mining operations a series of permits and documentation are required. The most important ones are the exploration permit and the environmental Impact assessment certificate as explained below (Pact 2019):

Exploration permit

This permit grants authorization to conduct a geological evaluation of a mineral deposit. Any individual or entity that has registered mining claims with the Ministry of Mines and Mining Development through the Provincial Mining Director must obtain an exploration permit to acquire blocks or a concession. The permit remains valid indefinitely, provided the prescribed fee is continuously paid (Pact 2019).

Environmental Impact Assessment (EIA) report

An Environmental Impact Assessment (EIA) is required to assess a project's potential effects on the environment and human health while establishing necessary monitoring and management plans for miners. The key steps and requirements for conducting an EIA are outlined in Figure 5. Upon completion and submission of the EIA report, a certificate is issued by the Director General, valid for two years from the date of issuance (Pact 2019). To ensure continuity, the renewal application must be submitted at least 60 days before the certificate expires (Farmonaut 2024).

Figure 5. The Environmental Impact Assessment process in Zimbabwe. Source: Elaboration by authors based on (Farmonaut 2024)

Mining royalties and taxes

There are different forms of fees and payments to the government which should be covered by the artisanal and small-scale miners active in Zimbabwe. The most relevant ones are explained below (Pact 2019).

Royalties

Mining royalties are mandatory payments made by mining companies to the state for the minerals they extract. These royalties are calculated as a percentage of the gross fair market value of the minerals produced and sold. They apply to all minerals and mineral-bearing products obtained from any mining location and disposed of by the miner or on their behalf. Royalties are chargeable regardless of whether the minerals are sold within Zimbabwe or exported (Pact 2019). Depending on the type of minerals mined, the rates of loyalties vary. These rates are defined on the official website of the Zimbabwe Revenue Authority (ZIMRA website[2]) and summarized in Table 1.

[2] https://www.zimra.co.zw/16-tax/company/876-mining-rates-of-royalties?utm_source=chatgpt.com

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Table 1. The rate of royalties for various minerals and metals in Zimbabwe (as defined on Zimbabwe Revenue Authority website, accessed February 2025)

Mineral / Metal	Royalty rate (%)
Precious stones	10
Gold	4.5
Platinum	5
Other precious metals	4
Base metals	2
Industrial metals	2
Coal bed methane gas	2
Coal	1

In 2022, the Zimbabwean government implemented a new regulation mandating that royalties for specific minerals should be paid partly in kind and partly in cash. Specifically, for minerals such as gold, diamonds, platinum group metals, and lithium, miners are required to pay royalties in two forms (Mining Zimbabwe 2022):

- **50% in kind**: This means miners must deliver the actual mineral extracted to the Reserve Bank of Zimbabwe.
- **50% in monetary form**: Of this monetary component, 40% is to be paid in Zimbabwean dollars (ZWL) and 10% in foreign currency.

These regulatory changes are designed to enhance the country's mineral reserves and reinforce its fiscal stability. Miners must submit royalty payments by the 10th day of each month. Non-compliance may lead to penalties, including fines or imprisonment for up to six months (Mining Zimbabwe 2022).

If royalty payments are not settled by the deadline, the miners are required to pay interest on the outstanding balance from the due date until full payment is made. The rate of this interest is determined by the Minister of Finance. Additionally, the Commissioner General of ZIMRA has the authority to enforce recovery actions for any unpaid or unremitted amounts as stipulated by law. According to Section 253(1) of the MMA, failure to pay royalties may lead to a ban on the sale or transfer of minerals or mineral-bearing products from the mining site operated by the non-compliant miner (Pact 2019).

Taxes

The main tax categories applicable to artisanal and small scale mining sector are listed below (Pact 2019). More details about various tax categories are available on Zimbabwe Revenue Authority website (ZIMRA website).

Income tax: Income tax is a tax imposed by the government on an individual's or entity's earnings, typically derived from salaries, business profits, investments, or other sources of income. This tax is used to fund public services, infrastructure, and government operations. Income tax is usually calculated as a percentage of taxable income. Holders of special mining leases have a taxable income of 25%, while general mining operations are taxed at 15%. The flat tax rate for mining income is 15% (Pact 2019).

Pay As You Earn (PAYE): PAYE also known as Employee tax, is a form of income tax charged on the income of employees. Mining companies are required to deduct PAYE from the salaries, allowances, and other benefits accruing to employees and pay this amount to ZIMRA. The rate is in accordance with the tax bands provided by the Minister of Finance in the National Budget for each year (Pact 2019).

Value Added Tax (VAT): VAT is an indirect tax on consumption, applied to the supply of taxable goods and services at each stage of production and distribution (ZIMRA website). It is charged on the value added through processing, packaging, or quality changes in goods, including intermediary, semi-finished, and finished products (Pact 2019). Unlike income tax, VAT is levied on transactions, including imported goods and services. Businesses must register with ZIMRA to charge, collect, and remit VAT. The VAT rate on minerals is 0%, while for other sales, it is 15%. To apply for refunds, it is obligatory for all taxpayers to complete the related forms provided by ZIMRA website, even if the minerals are zero rated (Pact 2019).

Customs duty: Mining operations in Zimbabwe often import raw materials, finished goods, and capital equipment. While most imported goods are subject to customs duty under the Customs and Excise Act, capital goods for mining may qualify for an exemption if an application for rebate is made. A rebate is a reduction or full waiver of customs duty, granted based on the nature and intended use of the imported goods. Mining companies can apply for this rebate, and if approved, the Commissioner General of ZIMRA may waive the duty entirely (Pact 2019).

Withholding tax: This is a tax on goods and services collected by appointed agents on behalf of the government under the Income Tax Act (Chapter 23:06). For listed companies, a 10% withholding tax applies to dividends paid to both residents and non-residents for companies listed on the Zimbabwe Stock Exchange (ZSE). A higher 20% withholding tax applies to dividends from all other companies (Pact 2019).

Capital gains tax: Capital Gains Tax (CGT) is imposed on the capital gain resulting from the sale or disposal of a specified asset. A specified asset includes immovable property (such as land and buildings) and any marketable securities (such as shares, bonds, debentures, unit trusts, and stocks). From February 1, 2009, if a specified asset is sold in foreign currency, any Capital Gains Tax due must be paid in foreign currency (ZIMRA website).

Unit 2 – Madagascar

Main Regulatory Frameworks

While the mining industry plays a key role in the Malagasy economy, the various crisis in the country has led to disruptions in governing the mining sector. However in the recent years, the government has made efforts and alliances with various partners to improve the governance conditions (Awases et al. 2023). For a better governance of the mining sector, the government has paid special attention to strategies to improve local development in particular maximisation of state revenues, community development, proper management and rehabilitation of the environment, promotion of the use of local goods and services (Awases et al. 2023).

The main regulatory framework governing the mining sector in Madagascar is the **Mining Code**, Law No. 2023-007 (2024). This recent legislation, also known as **New Code**, revises the previous Mining Code, establishing the main rules for mining activities, regulations for acquiring mining licenses, and outlining obligations and rights of license holders and other relevant parties involved in mining operations (Raharimamonjy and Solofohery 2025; Awases et al. 2023). The overarching objective of the New Code is to commit to promoting responsible and sustainable mining practices while attracting investment and fostering local economic growth. Among various focus topics the following can be highlighted (Dentons 2024):

- It requires environmental impact assessment and the implementation of mitigation measures to protect local communities and ecosystems.
- It establishes a Mining Fund for Social Community Investment to ensure that mining activities contribute to the development of local communities
- It outlines the fiscal regime applicable to mining operations, including taxes, royalties and duties, aiming to create a balance between attracting foreign investment and ensuring faire revenue distribution to the state and local communities.
- It requires permit holders to formulate a Corporate Social Responsibility Plan (PRSE)

In addition to the Mining Code, the other two relevant regulatory frameworks in the country are the Law on Major Mining Investments (LGIM) and the General Tax Code (CGI). LGIM is related to large-scale investments in the Malagasy mining sector and establishes a special regime for these types of investments. The General Tax Code provides tax provisions and procedural provisions related to the mining sector (Awases et al. 2023).

The main institution governing the mining sector in Madagascar is the **Ministry of Mines and Strategic Resources**. This Ministry is responsible for the management, supervision and control of mining activities. The other key governmental institution is the **Madagascar Mining Cadastre Office** (Bureau du Cadastre Minier de Madagascar, BCMM) responsible for the management and control of mining permits and the mining registry, including the preparation and documentation of the grant, renewal, transformation, transfer and cancellation of mining permits (Awases et al. 2023).

With regard to environmental protection and in addition to the New Mining Code and its specific provisions related to environmental protection, there are two other relevant regulations in Madagascar. The **Environmental Charter** (Law No. 2015-003) serves as the foundational environmental legislation in the country outlining the general principles for environmental management and protection. The other relevant policy is the **Inter-ministerial Order** 12032/2000 that regulates environmental protection within the mining sector, detailing their environmental obligations (Raharimamonjy and Solofohery 2025). The Ministry of Environment and Sustainable Development and the Ministry of Mines and Strategic Resources work collaboratively to ensure compliance with the rules aimed at the environmental protection by the holders of the mining Permits (Awases et al. 2023).

Mining rights, permits and licenses

To ensure transparency and equitable access to mineral resources, the ownership and licencing of mining activities are regulated in Madagascar. The agency that manages the issuance of all types of mining licenses is the Madagascar Mining Cadastre Office (BCMM). According to the mining law there are four types of mining licenses as summarized in Table 2 and explained below.

Table 2. Various types of mining licenses available for the mining sector in Madagascar. Source: (Awases et al. 2023)

License Type or Authorization	Description	Duration	Renewable
Exclusive Perimeter Reservation Authorisation (AERP)	Exclusive prospecting right. Maximum area 15’000 Km^2	3 months	Not renewable
Exploration permit (PR)	Exclusive right of prospecting and research. Maximum area: 1’000 Km^2	5 years	Renewable two (2) times for a period of three (3) years
Exploitation permit (PE)	Exclusive right of prospecting, research and mining. Maximum area: 10’000 Km^2	40 years	Renewable one or more times for a period of twenty (20) years each renewal
Small-scale mining permit (PRE)	Exclusive right of prospecting, research and mining.	8 years	Renewable one or more times for a period of four (4) years for each renewal

Exclusive Perimeter Reservation Authorisation (AERP)

An AERP is not a mining title but a simple authorization allowing an individual or a company to do some preliminary works in a specific area in which the prospector has the exclusive right to prospect. This authorisation is valid for three months and not renewable. It confers on the applicant the right to:

- Consult the authorities of the commune(s) in question for information on the nature of the environment and the existence or otherwise of minerals
- Inform the local authorities and, where appropriate, other miners of the possible future installation of an exploration or mining project
- Undertake prospecting work; and

- Initiate an Environmental Impact Assessment.

No environmental authorisation is required to undertake prospecting activities under an AERP (Transparency International Australia 2020; Sewpershad and Tufo 2024).

Exploration and Exploitation Permits

An exploration permit (PR) is issued to individuals or legal entities, granting them the right to conduct exploration within a specified area of up to 10,000 km². The permit is valid for 5 years and may be renewed twice, each renewal lasting 3 years (Transparency International Australia 2020).

An exploitation permit (PE) grants the holder exclusive rights to exploit the substance/s specified in the permit and to conduct prospecting and mining research within an area not exceeding 1000 km². This permit is valid for 40 years, with the possibility of renewal for successive 20-year periods (Transparency International Australia 2020)[3].

Small-scale mining permit

Among various license types, the **small-scale mining permit (PRE)** is the one with the highest importance for the ASM sector in Madagascar. This permit grants the holder the rights for prospecting and mining activities. The PRE is exclusively used by Malagasy individuals and small-scale mining groups organized in cooperatives. The concession holder of a PRE is allowed to explore and exploit the deposit at the same time. The extracted minerals can be sold to private business units. The maximum area for research and exploitation under this permit is 100 km²). The validity is for 8 years and can be renewed for 4 years upon each renewal and are granted by the Interregional Director of the Ministry in charge of Mines (Awases et al. 2023).

The main requirements for applying for a small-scale permit (PRE) in Madagascar are as follows:

- Develop a mining plan: This plan accompanied by a financing plan is aimed to inform the BCMM of the technical and financial capabilities of the applicant (Dentons 2024).
- Complete a permit form: Any request for a mining permit is written on a form to be obtained from the Mining Cadastre office. After correctly completing the form, the applicant submits the application to the office against receipt indicating the day, hour and minute of deposit, which are authentic (Article 43, Mining Code) (Vasters and Schütte 2023).
- Environmental Engagement Plan: with this plan the applicant confirms to not commence activities until it has obtained the necessary environmental authorisation.
- Code of Conduct
- The form for the engagement for the environmental impact

[3] The process map for acquiring an exploration and exploration permits are available here: https://transparency.org.au/publications/madagascar-mining-licence-process-map/

The application process for acquiring a PRE is shown in Figure 6 (Transparency International Australia 2020). To facilitate the process for many small-scale miners, the government has set a special mining regime called "zone d'encadrement", that permits a learning phase of 6 - 12 months for the small-scale mining groups or cooperatives aiming to fulfil the requirements of mining law in this period and finally to be granted with the PRE. During this time, ASM activities can be carried out. The participation in this zone shall be supported technically by the municipality where the mining takes place and by the regional office of the mining ministry (Vasters and Schütte 2023). With a renewed strategy for the ASM sector's development created in 2018, the government has been aiming to formalize the sector and increase government revenues (Awases et al. 2023).

It is important to note that the small-scale mining regime permits nationals to engage in exploration and exploitation activities using artisanal techniques for extraction, without processing minerals on-site. If an ASM moves beyond the use of artisanal methods in its exploration and/or mining operations, it becomes mandatory for the miner to request the conversion of their Small-Scale Mining License into a standard Exploration Permit (Sewpershad and Tufo 2024).

The Ministry of Mines and Strategic Resources plan to establish a Priority Plan. With the Priority Plan, the renewal of permits for small operators (PRE) will be examined first, followed by mining permits for research or (PR) and finally operating permits for large industries or (PE). The renewal of the PREs is prioritized because these permits are the majority. Furthermore, the plan to clean up the Mining Cadastre will be implemented (Awases et al. 2023).

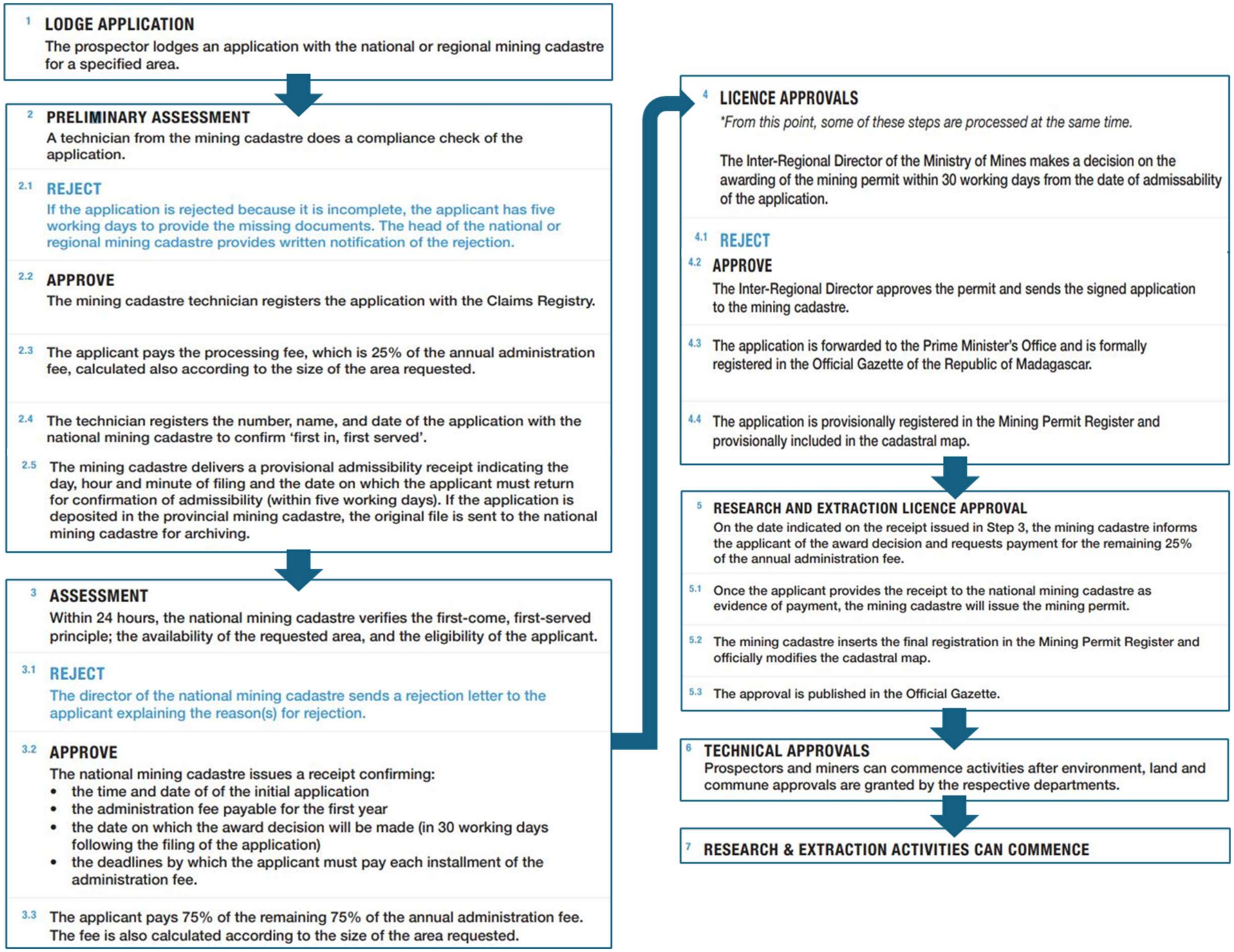

Figure 6. Process map for applying for a small-scale mining permit (PRE) in Madagascar (Transparency International Australia 2020)

Mining taxes and royalties

Various tax types

The different types of taxation applicable to mining activities in Madagascar and their rates are listed in Table 3 below (Picault, Charles, and Zammit 2023).

Table 3. Various tax types applicable to mining activities in Madagascar. Source: (Picault, Charles, and Zammit 2023)

Tax Type	Tax Rate
Income Tax	20% of the net profit
Non-Income Tax	20% of the net profit
Non-Resident Income Tax	Withholding tax of 10% of any income realised in Madagascar by a non-resident
Tax on dividends	10% with respect to dividents paid to non-resident shareholders
Salary Income Tax	20% of the salary
Tax on income from movable capital (Impôt sur les revenus des capitaux mobiliers)	20% on loan proceeds
Value-Added Tax	20%
Registration fees	From 0.5 to 5%, depending on the nature of the transaction

In addition to the tax categories explained above, there is a specific internal taxation which governs especially in the mining sector in Madagascar. These include (Awases et al. 2023):

- Excise Duty (Droit d'Accise, DA): is a tax imposed on products that are harvested, extracted, manufactured, or imported in Madagascar. For minerals, this duty applies to precious and semi-precious stones, precious metals (luxury products), and certain industrial stones used in high-tech industries.
- Special Duty on Mining Transactions (DSTM): This is an advance payment fee, which is non-refundable and is often categorized as a mining parafiscal tax.

Mining royalties

Mining royalties are tax on operators' gross profit, applied on the first invoicing of mining transactions and the rate of which is 2% according to Article 117 of the Mining Code (Sewpershad and Tufo 2024). These royalties are aimed to benefit the state and its divisions, based on the value of sales. Revenue from mineral deposits is designated for Madagascar's economic development (Dentons 2024).

A portion of these royalties is collected by government agencies and central organizations, and the remaining is allocated to Autonomous provinces, regions and communes. Based on the 2005 Mining Code, royalty rates vary for various types of minerals as listed below (Picault, Charles, and Zammit 2023):

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Table 4. Royalty rates for various types of minerals and metals in Madagascar. The rates are based on 2005 Mining Code. Source: (Awases et al. 2023)

Mineral / Metal	Royalty rate (%) based on 2005 Mining Code
Minerals such as nickel and cobalt	4
Precious metals	4
Precious stones (cut)	8
Industrial stones (cut)	3
Industrial stones (uncut)	6

Under the new Mining Code, the royalty rate increased from 2% to 5%, with a 30% reduction if products are locally transformed. The composition of the 5% royalty rate includes a 2% rebate for local communities and a 3% royalty for the State (Dentons 2024).

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Unit 3 - Zambia

Main Regulatory Frameworks

The most important mining regulation in Zambia is the **Mines and Minerals Development Act (MMDA)**[4] (No. 11 of 2015), which covers various aspects related to the mining operations in the country. Among other topics, MMDA defines procedures and requirements for:

- Mining Rights and Non-mining Rights (explained in more details below)
- Mining Rights and Surface Rights: This includes restrictions of rights of entry by holder of license or permit, Exercise of rights under license or permit, Rights to use and access water or gaze stock, Acquisition of use of land by holder of mining rights, Arbitration of disputes, Compensation for distribution of rights and Rights to building materials.
- Regulatory Provisions: including but not limited to provisions related to disposal of conflict minerals, restrictions on mining rights and mineral processing license, transfer of mining rights, suspension or revocation of mining right or mineral processing license, and renewal of mining or non-mining rights.
- Safety, Health and Environmental Protection
- Mineral Royalties and Charges
- Mining Appeals Tribunal
- Offences and Penalties
- General Provisions

In addition to MMDA, the country has other regulations and policies in place that are directly relevant to the mining sector such as the Explosives Act (Cap 115), Water Resources Management Act (2011), Environmental Management Agency Regulations, and Occupational Health and Safety Act (No, 36 of 2010).

One of the important polices related to the mining sector is the **National Mineral Resources Development Policy** (2022-2027) (NMRD Policy), published in 2022. The NMRD Policy is a comprehensive strategy designed to address regulatory gaps in Zambia's mining sector and promote both domestic and foreign investment in line with the country's socio-economic objectives. The policy aims to formalize the artisanal and small-scale mining sector and promote the establishment of cooperatives focused on gold, manganese, copper, gemstones, and industrial mineral exploration, thereby maximizing the sector's socio-economic impact. To mitigate the risks linked to illegal, informal, and unsustainable mining practices, the Zambian government seeks to provide artisanal and small-scale mining stakeholders with access to geological data, markets, capital, modern equipment, and partnerships with local and international investors. Furthermore, the policy aims to create sector-specific regulations to foster

[4] The Act reads together with two amendments the Mines and Minerals Development (Amendment) Act, No. 14 of 2016 and the Mines and Minerals Development (Amendment) Act, No. 29 of 2022

formalization and ensure sustainable growth within the artisanal and small-scale mining sector (Sewpershad and Tufo 2024).

the enforcement of the Mines and Minerals Development Act is the responsibility of the **Ministry of Mines and Mineral Development in Zambia**. This Ministry oversees the issuance and management of licenses and permits related to imports and exports, as well as the monitoring of mining operations. Additionally, it is tasked with collecting, compiling, and distributing data on mineral production, reconnaissance surveys, and the delineation of mining areas. Another key entity is the Mining License Committee, which evaluates applications, issues and coordinates mining and non-mining rights, and provides advice to the Minister of Mines and Mineral Development on related matters (Sewpershad and Tufo 2024).

The **Zambia Environmental Management Agency (ZEMA)** has the mandate to ensure the sustainable management of natural resources and protection of the environment, prevention and control of pollution.

Mining rights, permits and licenses

In Zambia, mineral exploration, mining, mineral processing, and gold panning are prohibited unless authorized by a mining right, mineral processing license, or gold panning certificate under the MMDA. The Ministry of Mines issues these licenses, granting individuals or companies permission to engage in mining activities. Additionally, anyone planning exploration, mining, or mineral processing activities must first obtain written approval for an environmental impact assessment related to their operation from the Zambia Environmental Management Agency (Section 29 of the Environmental Management Act, 2011).

These rights are divided into two main categories mining and non-mining rights and the related sub-categories as shown in Figure 7 and explained below.

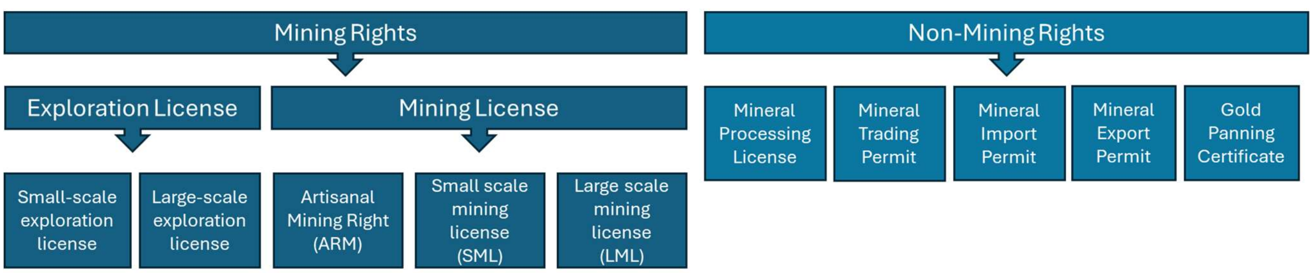

Figure 7. Classification of mining and non-mining rights in Zambia. Source: Elaboration by authors based on Ministry of Mines and Minerals Development website

Mining Rights

Mining rights cover the rights for conducting exploration (exploration license) and mining (mining license) activities as explained below (Ministry of Mines and Minerals Development website[5]):

Exploration License: This license permits the holder to explore minerals over a specified area and duration. The application for this license shall be made to the Director of Mining Cadastre in the prescribed form upon payment of the prescribed fees. An exploration license is valid for an initial period of four years.

[5] https://www.mmmd.gov.zm/?page_id=1097

On its expiry after 4 years, it can be renewed for two further periods not exceeding three years each. As such, the maximum period from initial grant of the license shall not exceed 10 years. Depending on the size of the area, there are two types of exploration licenses:

- Large Scale Exploration License: This license is intended for substantial exploration operations in an area of a minimum of three hundred and one cadastre units and not exceeding fifty nice thousand eight hundred units cadastre units. Requirements for applying for this type of license are available online on the official website of Ministry of Mines and Minerals Development.
- Small-Scale Exploration License (SML): This license is intended for exploration activities that cover an area of a minimum of three cadastre units and not exceeding three hundred cadastre units. This license is granted to companies with minimum 5% Zambian shareholding.

The steps and requirements for applying for a small-scale exploration license (SML) are shown in Figure 8.

1	Duly completed Form I with geographical coordinates of the area of interest which should fit the predefined cadastral grid as. Form I is available online, on the official website of Ministry of Mines and Minerals Development
2	Proposed programme of Exploration operations (Should include an estimate of the investment commitment in the approved format.
3	Proposals for employment and training of citizens of Zambia
4	Proposal for promotion of local business development
5	Valid Tax clearance certificate (Issued under Income Tax Act Cap 323)
6	Proof of consent from appropriate authorities if activity is in a national park or game management area
7	Environmental commitment plan
8	Articles of association
9	Certificate of incorporation, certificate of share capital
10	NRC/ Passport copy (ies) for all Shareholders / Cooperative registered under Cooperatives societies act 1998

Figure 8. Steps and requirements for applying for a small-scale exploration license in Zambia. Source: Elaboration by authors based on Ministry of Mines and Minerals Development website

Mining License: According to MMDA, any person who intends to carry on any artisanal, small-scale or large-scale mining shall apply for a mining license. The application for a mining license shall be made to the Director of Mining Cadastre in the prescribed manner and form upon payment of the prescribed fees. There are three forms of mining licenses:

- Large Scale Mining License (LML): This type of license applies to an area of a minimum of one hundred and twenty-one cadastre units and not exceeding seven thousand, four hundred and eighty-five cadastre units.
- Small Scale Mining License (SML): This type of license applies to an area of a minimum of three cadastre units and not exceeding one hundred and twenty cadastre units and is only granted to companies with minimum 5% Zambian shareholding.
- Artisanal Mining License (AMR): This type of license applies to an area of a minimum of one cadastre unit and not exceeding two cadastre units. Artisanal mining shall only be undertaken by a citizen or registered cooperative wholly composed of Zambian citizens.

The requirements for applying for an Artisanal Mining License (AML) are summarized in Figure 9.

1	Duly completed Form I with geographical coordinates of the area of interest which should fit the predefined cadastral grid as. Form I is available online, on the official website of Ministry of Mines and Minerals Development
2	Copy of relevant prospecting permits and prospecting reports
3	Proposed programme for mining operations (Should include forecast of capital investment, the estimated recovery rate of ore and mineral products, and the proposed treatment and disposal of ore and minerals recovered)
4	Description of the mineral deposit in the area over which the licence is sought
5	Statement of duration for which licence is sought (should not exceed 10 years)
6	Valid Tax clearance certificate (Issued under Income Tax Act Cap 323)
7	Approved Environmental Project Brief (EBP from ZEMA)
8	Proposals for employment and training of citizens of Zambia
9	Proposals for promotion of local business development
10	Pegging Certificate

Figure 9. Steps and requirements for applying for an artisanal mining license in Zambia. Source: Elaboration by authors based on Ministry of Mines and Minerals Development website

The requirements for applying for a Small-Scale Mining License (SML) are summarized in Figure 10.

1	Duly completed Form I with geographical coordinates of the area of interest which should fit the predefined cadastral grid as. Form I is available online, on the official website of Ministry of Mines and Minerals Development
2	Environmental commitment plan
3	Program of intended mining operations (should include proposals for the proper conservation and use of mineral resources in mining area in the national interest)
4	Proposed programme for mining operations (Should include an estimate of the investment commitment in the approved format)
5	Proposals for employment and training of citizens of Zambia.
6	Proposal for promotion of local business development.
7	NRC/ Passport copy (ies) for all Shareholders / Cooperative registered under Cooperatives societies act 1998.
8	Valid Tax clearance certificate (Issued under Income Tax Act Cap 323)
9	Any other information which the Director of Mining Cadaster may require.

Figure 10. Steps and requirements for obtaining an artisanal mining license in Zambia. Source: Elaboration by authors based on Ministry of Mines and Minerals Development website

Non-Mining Rights

For further relevant activities on minerals mined, additional licenses classified under non-mining rights are required. As shown in Figure 7, non-mining rights refer to authorization related to mineral processing, trading, import and export as explained below.

Mineral processing License: This license is required for any person who wishes to undertake the processing of any minerals. The application for this license shall be made to the Director of Mining Cadastre in the prescribed form upon payment of the prescribed fee. This license is valid for 25 years and subject to renewal after 1 year. The steps and documents required for obtaining a mineral processing license are shown in Figure 11.

1	Duly completed Form I with geographical coordinates of the area of interest which should fit the predefined cadastral grid as per form I
2	Description and Plan of Surrounding Developments
3	Feasibility Study for Processing Operations (Should include a forecast of capital Investment, Proposed Plant Capacity, the Estimated Recovery rate of Mineral Products and the Proposed Treatment Methods and disposal of Ore and Minerals Recovered)
4	Environmental Management Plan (Should Include Proposals for the Prevention of Pollution, Treatment of Waste, Protection and Reclamation of land and Water Resources and for Eliminating or Minimizing Adverse effects on the Environment)
5	Details of Expected Infrastructure Requirements
6	Proposals for employment and training of citizens of Zambia during the renewal period
7	Valid Tax clearance certificate (Issued under Income Tax Act Cap 323)
8	Documentation on Title to Land or Written Consent of Legal Occupier of Land
9	Consent from existing Mining Rights Holder if the area over a Mining right Holder
10	Articles of association
11	Certificate of incorporation, certificate of share capital
12	NRC/ Passport copy (ies) for all Shareholders / Cooperative registered under Cooperatives societies act 1998
13	Any other information which the Director of Geological Survey may require

Figure 11. Steps and requirements for obtaining a mineral processing license in Zambia. Source: Elaboration by authors based on Ministry of Mines and Minerals Development website

Mineral Trading Permit/license: This permit can be used for buying and selling various minerals and does not apply to holder of a mining license. It can be issued to an indigenous Zambian as well as a registered limited company.

Types of trading permits:

- Precious Metals (Gold, Silver and Platinum)
- Gemstones (including Emeralds, Clear Quartz and Amethyst stones)
- Base Metals (including Copper, Cobalt, Manganese, Lead, Zinc, Tin, etc.)
- Industrial minerals (including Coal, Gypsum, Aluminum, Feldspar, Fluorine-Fluorite, etc.)

Requirements for applying for a mineral trading permit include:

- Certified copies of the national registration card or passport
- Bank account statement or letter from the bank
- Copies of proposed business plan or capital outlay
- Tax clearance certificate

A mineral trading permit is valid for a period of 3 years and is renewable.

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Minerals Export Permit: This permit allows the holder of a trading license and the holder of a mineral processing license to export minerals outside the country. In addition to the application costs, for acquiring an export permit the applicant should cover the costs for preparing a mineral analysis and evaluation report.

The application for an export permit should be done through a platform called MOSES (Mineral Output Statistical Evaluation System). This is an integrated framework designed to monitor mineral resources throughout their value chain with the aim to increase transparency and overcome illicit financial flows in the industry.

The requirements for applying for an export permit are as follows:

- The applicant must be a holder of a trading license/Mineral Processing License;
- Registration and application through MOSES System (The application for Industrial Minerals for the purposes of import and export, is done outside the MOSES system, i.e. Manually).
- A mineral analysis and valuation certificate issued by the Director of Geological Survey;
- A verification report from the Commissioner and General of the payment of the mineral royalty
- Security clearance by the Police;
- The production returns made in respect of the mineral, ore and mineral products by the holder
- The mining right or mineral processing licence which is the source of the mineral, ore or mineral product

A mineral export permit is valid for a period of one year and is limited to the quantities specified on the permit.

Mineral Import Permit: This permit allows the holder of a trading permit or mineral processing license to bring in minerals into the country. Requirements for applying for this permit are as follows:

- The applicant must be a holder of a trading license/permit;
- Certificate of incorporation.
- Valid tax clearance
- Copy of sales contract
- Invoice

A mineral import permit is valid for a period of one year and is limited to the quantities specified on the permit.

Mining royalties and taxes

There are different forms of fees and payments to the government which should be covered by the artisanal and small-scale miners active in Zambia. The most relevant ones are explained below.

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Royalties

Mining royalty is a tax imposed on the gross value of minerals extracted within the country and is required to be paid by holders of mining license. This payment serves as compensation to the government for the depletion of natural resources and contributes to national revenue.

The mineral royalty is applicable to the following stakeholders (Zambia Revenue Authority 2023):

Mineral royalties should be paid by the following groups:
a) Holders of the following mining rights and licenses: i. Large-scale mining license ii. Large-scale gemstone license iii. Small-scale mining license iv. Small-scale mining license v. Artisan's mining rights vi. Mineral trading permit
b) Any person without a mining right but in possession of minerals extracted from the Republic on which mineral royalty has not been paid by the supplier of the minerals.
c) All persons carrying out quarrying of industrial minerals; this includes the quarrying of gravel, clay and sand.
d) All persons that mine minerals for use as inputs or raw materials in their manufacturing process e.g. cement and lime manufacturers.

The loyalties are calculated based on the percentage of the gross sales value of minerals extracted and sold and should be paid to Zambia Revenue Authority (ZRA). Depending on the type of minerals being mined the rates vary. The rates for some of the key minerals produced or recoverable under the license are given below (Zambia Revenue Authority 2023):

- Base metals (except copper, cobalt or vanadium): 5% of the norm value
- Copper: 5.5% (when the norm price is below $4,500 per ton), 6.5% (between $4,500 and $6,000 per ton), 7.5% (between $6,000 and $7,500 per ton), 8.5% (between $7,500 and $9,000 per ton) and 10% (above $9,000 per ton)
- Cobalt or vanadium: 8% of the norm value
- Precious metals: 6% of the norm value
- Gemstones: 6% of the gross value
- Energy and industrial minerals (e.g., limestone, clay): 5% of the gross value

Mineral Royalty is due and payable within fourteen days after the end of the month in which the sale of minerals is done. Late return submission and late payments will attract penalties and interest. Mineral

Royalty payable or paid is deductible when computing company income tax when arriving at the gains and profits of a person carrying on mining operations[6].

What is the difference between norm value, norm price and gross value?

The term "**norm value**" means:

- the monthly average of London Metal Exchange cash price per tons multiplied by the quantity of the metal or recoverable metal sold
- the monthly average Fastmarkets MB cash price per tonne multiplied by the quantity of the metal sold or recoverable metal sold when the metal price is not quoted on the London Metal Exchange
- the monthly average cash price per tonne, at any other exchange market approved by the Commissioner-General, multiplied by the quantity of the metal sold or recoverable metal sold when the metal price is not quoted on the London Metal Exchange or in the Fastmarkets MB.
-

The term "**norm price**" means the monthly average

- London Metal Exchange cash price per tonne of the metal or recoverable metal sold;
- Fastmarkets MB cash price per tonne of metal sold or recoverable metal sold to the extent that the metal price is not quoted on the London Metal Exchange
- Cash price per tonne, at any other exchange market approved by the Commissioner-General of the metal sold or recoverable metal sold to the extent that the metal price is not quoted on the London Metal Exchange or Fastmarkets MB.

The term "**gross value**" means the realised price for a sale, free on board, at the point of export from Zambia or point of delivery within Zambia.

Source : Zambia Revenue Authority website: https://www.zra.org.zm/tax-information/#mineral-royalty

Taxes

The various tax categories relevant to ASM sector are explained in detail on the Zambia Revenue Authority Website[7]. Some of the key categories are highlighted below (ZRA website):

Income tax: This is the tax charged on income. Income includes:

- gains or profits from any business for whatever period of time carried on;
- emoluments;
- annuities;
- dividends;
- interest, charges and discounts;

[6] https://www.zra.org.zm/tax-information/#mineral-royalty
[7] https://www.zra.org.zm/tax-information/#income-tax

- royalties, premiums or any like consideration for the use or occupation of any property; and
- income from the letting of property.

Under the Income Tax Act, all taxpayers in receipt of income, other than emoluments from employment or office, are required to make advance payments in the course of the tax year, on account of their estimated tax liability. This estimated liability is referred to as Provisional Tax.

Value Added Tax (VAT): VAT may be defined as a consumption-based tax that is levied in the supply chain at each point were value is added to a good or service. Since it is consumption based, the primary legal way of avoiding VAT is by not consuming any goods or services that are standard rated. The other is by consuming only zero-rated or exempt supplies. By its nature, Value Added Tax is incurred by the final person in the chain of supply who is not registered for VAT.[8].

Pay as you Earn (PAYE) Tax: This is a method of deducting tax from employees' emoluments in proportion to what they earn. Under this system, the employer is empowered to:

a) calculate tax payable by every employee

b) deduct tax due from the emoluments, and

c) remit tax deducted to ZRA

The term "emoluments" means total earnings of an employee from employment. These include wages, salaries, overtime, leave pay, commissions, fees, bonuses, gratuities and any other payments from employment or office[9].

Withholding tax: Withholding Tax is not a tax **but** a means of collecting that tax. Withholding Tax is deductible from a payment by the person who is liable to make payment (**the payer**) at the point in time the person to whom it is due to be made (**the payee**) becomes legally entitled to it (**date of accrual**). The payer is required to pay the tax deductible to the Zambia Revenue Authority by reference to the date of accrual no matter how, when or where payment is made[10].

Group work or exercise

Group Exercise – Preparing the participants for a discussion about permits and licenses

Group Exercise - Understanding various tax and royalties applicable to the ASM sector

[8] https://www.zra.org.zm/tax-information/#VAT
[9] https://www.zra.org.zm/tax-information/#paye
[10] https://www.zra.org.zm/tax-information/#wht

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Group Exercise: Understanding various permits and licenses applicable to the ASM sector

Objective:

The objective of this exercise is to engage participants in a competitive yet collaborative quiz about mining laws, licenses, and permits. This activity prepares them for a later discussion by encouraging teamwork and comparison of knowledge. This can ultimately lead to peer learning and sharing information.

Setup & Rules

- Number of Groups: 2 (Team A & Team B)
- Duration: 45 minutes
- Materials needed: Quiz sheets, pens, flipchart or whiteboard

Step 1: Quiz Round (20 minutes)

- Both groups receive the same set of questions related to mining laws, permits, and licenses.
- Each group discusses and writes down their answers without sharing them with the other team.
- If applicable, they could provide real examples related to their own operations.

Sample Questions: These sample question can be modified based on national or local context

- What is the main difference between a mining exploration license and a mining production license?
- What key environmental permit is required before starting mining operations?
- Who is responsible for enforcing mining regulations in [country/region]?
- What are two common legal challenges that ASM face?
- What could happen if a miner operates without a proper permit?
- What penalties can be imposed for violating mining safety regulations?

Step 2: Answer Comparison & Debate (15 minutes)

- The facilitator reads out the first question.
- **Team A** shares their answer first, explaining their reasoning.
- **Team B** then presents their answer.
- The facilitator or an expert provides the correct answer and clarifies any misunderstandings.
- The process repeats for all questions.

Scoring (Optional)

- Each correct answer earns **1 point**.
- Bonus points for well-argued reasoning.
- The group with the most points wins!

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Group Exercise: Understanding various tax (and royalties) applicable to the ASM sector

Objective:
This interactive exercise will help participants understand different types of tax and royalties applicable to their operations. By working in groups, participants will analyze case studies and engage in a simulated application process to reinforce their learning. The same exercise can be performed about royalties.

Materials Needed:

- Handouts with various types of taxes and levies based on the national context
- Flipcharts and markers

Introduction & Briefing (5 minutes)

- Facilitator explains the objective and format of the group exercise

Exercise Instructions:

Step 1: Group Formation (5 min)

- Divide participants into **four groups**.
- Assign each group a different **tax type** applicable to ASM (depending on the national context, these could be different):
    1. **Income Tax**
    2. **Withholding Tax**
    3. **Customs Duty**
    4. **Value Added Tax (VAT)**

Step 2: Tax Exploration (10 min)

- Each group receives a **brief explanation** of their assigned tax type (from pre-prepared descriptions).
- Groups discuss:
    - **What is this tax?**
    - **Who pays it?**
    - **How does it affect ASM?**

Step 3: Scenario Challenge (15 min)

- Each group receives a **scenario card** describing a common situation in ASM (e.g., exporting minerals, buying mining equipment, paying workers).
- The task:

- Identify which tax applies.
- Explain how it is calculated.
- Discuss possible exemptions or benefits.

Step 4: Presentation & Discussion (15 min)

- Each group presents their scenario and tax application.
- Other groups ask questions or challenge responses.
- Facilitator provides clarifications and additional insights.

Step 5: Reflection & Wrap-Up (10 min)

- Groups reflect on:
  - Key takeaways from the exercise.
  - Challenges ASM miners face regarding taxation.
  - Ways to improve tax compliance and benefits for small-scale miners.

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2.2. Module 2: International Frameworks on Responsible Sourcing

Module Title	**International Framework on Responsible Sourcing**
Module Aims	This module aims to equip participants with a comprehensive understanding of global standards, principles, and best practices for responsible sourcing across supply chains, with a particular focus on critical raw minerals. More specifically, it seeks to inform participants about the stringent environmental, social, and governance (ESG) requirements expected from downstream companies and investors, which, in turn, impact the integration of ASM into official value chains.
Specific Learning Outcomes	Upon completing the module, participants will show evidence of their knowledge in: • The international frameworks related to business and human rights, and responsible sourcing expectations • The traceability, transparency, and accountability requirements in global supply chains to mitigate issues such as child labor, forced labor. • How responsible sourcing practices contribute to broader sustainable development goals by minimizing environmental damage, respecting human rights, and promoting fair labor practices. • The implications of these international regulatory frameworks for the ASM sector
Comprehensive Learning Outcome	The course ultimately aims to equip ASM practitioners to embrace and champion responsible sourcing practices, thereby fostering more ethical, sustainable, and transparent supply chains globally.
Module Content	• Definition of responsible sourcing • International principles, guidelines and framework • Case studies
Methods of Facilitating Learning	This module will be facilitated through modular lecturing, group discussions and presentations.
Reflection on learning outcomes	Participants will be actively involved in the discussions during the presentation.
Student Support & Learning Resources	Workshop manuals, presentations, short videos (if possible) Information will be provided on relevant publications, internet resources and other reading material.

Introduction

Extraction and use of raw materials is associated with various negative environmental, social and governance impacts and challenges. In response to these issues, international actors and stakeholders, including policy makers, investors, financial institutions, industry associations, civil society organizations and consumers are pushing the upstream (from extraction and mining to smelters and refiners), downstream (including manufacturing to sale of end products) (Franken and Schütte 2022) as well as commodity trading industries to adhere to environmental, social and governance requirements. Specifically, these businesses are required to adopt responsible practices in procuring and sourcing their raw materials and place importance on due diligence, transparency, traceability and accountability throughout their supply chains. See Text Box below for definition of the terms 'responsible sourcing' and 'due diligence' in mineral value chains.

Responsible Sourcing is a contributory factor to sustainable development and economic growth and focuses on behavior of companies and their operations. Despite its importance, there is no common definition for responsible sourcing and several stakeholders (from businesses, civil society organizations, policy makers and academia) have formulated diverse definitions for this approach. In some cases, the focus of responsible sourcing has been on management of ESG impacts, while in other cases it has been on management of supply chains including responsible purchasing/procurement practices, or transparency and due diligence. Two common dimensions in these definitions are: 1) the management of organizations and supply chains through supplier monitoring, and 2) development of data and information on production location and processes (van den Brink et al. 2022, Farooki, 2024). Based on the result of the EU funded project, RE-SOURCING, responsible sourcing can be defined as: *"… a process where **duty-bearers** (i.e. companies, financial investors, governments) ensure policies, processes and compliance mechanisms exist to deliver the **environmental, social, and economic rights**, as prioritized by **stakeholders who are impacted** by the activities within a mineral supply chain"* (Farooki 2023).

Due Diligence is defined as "*The processes through which companies can identify, prevent, mitigate actual and potential adverse human rights and environmental impacts, as well as monitor and report on how they address these impacts. The due diligence process covers both the impacts a company causes through its own operations, and those to which it contributes through its business partnerships and value chain relations. To be effective and commensurate with a company's circumstances, context and associated risks, the due diligence process has to be an integral part of companies' policies, business strategy and risk management systems (European Union, 2022).*"

In response to these challenges, various initiatives, agreements, and instruments at international, regional, national and sectoral level have been developed to ensure responsible sourcing and due diligence is respected in raw materials value chains. These instruments implement various approaches from developing principles with a broad sustainability scope, to the development of regulatory or voluntary frameworks, standards or reporting templates for a specific sector or commodity or establishment of alliances. Consequently, key stakeholders involved in the development of these initiatives may vary between international institutions and governments to industry associations, industry representatives (i.e. companies) and civil society associations (Farooki et al. 2023). Table 5 presents examples of various types of approaches to responsible sourcing, showcasing examples for each group. Each approach is then briefly explained, accompanied by an in-depth exploration of a particularly relevant example to provide a richer understanding of its practical application.

Table 5. Types and examples of responsible sourcing approaches. Source: Elaboration by authors based on (Farooki et al. 2023)

Type of responsible sourcing approach	Name of initiative
International principles and guidelines	• UN Guiding Principles on Business and Human Right (2012) • OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas (2016) • Chinese Due Diligence Guidelines for Responsible Mineral Supply Chains (2016) • International Labor Organization (ILO) Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy (updated in 2022) • OECD Due Diligence Guidance for Responsible Business Conduct (2018) • EU Principles for Sustainable Raw materials (2021) • Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) – Guidance documents: IGF Guidance for Governments: Managing ASM (2017) • International Council on Mining and Metals (ICMM) – Mining Principles (updated 2023) • OECD Guidelines for Multinational Enterprises on Responsible Business Conduct (2023) • OECD Handbook on Environmental Due Diligence in Mineral Supply Chains (2023) • ....
Regulatory frameworks	EU level: • EU Taxonomy for Sustainable Activities (2020) • EU Conflict Minerals Regulation (2021) • EU Battery Regulation (2023) • EU Corporate Sustainability Reporting Directive (2023) • EU Critical Raw Materials Act (2023) • EU Corporate Sustainability Due Diligence Directive (2024) • ..... International level: • US Dodd Frank Act (2010) • France – Duty of Vigilance Act (2017) • The Netherlands – Child Labour Due Diligence Act (2019) • Chile - Extended Producer Responsibility Law (2020) • Germany – Act on Corporate Due Diligence in Supply Chains (2023) • .....
Standards and certification schemes	• Extractive Industries Transparency Initiative (EITI) Standard (2023) • Global Industry Standard on Tailings Management (2020)

Type of responsible sourcing approach	Name of initiative
	• International Finance Corporation (IFC) Performance Standards on Environmental and Social Sustainability (2012) • Initiative for Responsible Mining Assurance (IRMA) • Fairmined Standard for Gold and Associated Precious Metals (2014) & Fairmined Certification • Aluminium Stewardship Initiative (ASI) Performance Standard (2023) • Responsible Jewellery Council Code of Practice Standard (2019) & Chain of Custody Standard (2017) • Global Reporting Initiative (GRI) Sustainability Reporting Standard on Mining (updated 2024) • Copper Mark Criteria for Responsible Production (2023), The Joint Due Diligence Standard for Copper, Lead, Molybdenum, Nickel and Zinc (2022), Chain of Custody Standard (2022) • RMI Responsible Minerals Assurance process (RMAP) • CRAFT: Code of Risk-Mitigation for ASM engaging in Formal Trade (2020) • …….
Alliances and other collaborative initiatives	• Responsible Business Alliance / Responsible Minerals Initiative • The Fair Cobalt Alliance • European Raw Materials Alliance (ERMA) • European Battery Alliance / Global Battery Alliance • Alliance for Responsible Mining (ARM) • European Partnership for Responsible Minerals (EPRM) • Conflict Free Smelter Initiative (CFSI) • International Tin Supply Chain Initiative (ITSCI) • Responsible Jewellery Council (RJC) • ………

International principles and guidelines

At international level, guidelines and frameworks such as the UN Guiding Principles on Business and Human Rights (UNGP), the OECD Due Diligence for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas, International Labor Organizations (ILO) Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy, Chinese Due Diligence Guidelines for Responsible Mineral Supply Chains (2016), EU Principles for Sustainable Raw Materials[11] (2021) and OECD Handbook on Environmental Due Diligence in Mineral Supply Chains (2023) can be highlighted. These instruments provide voluntary principles and guidelines for states and companies to address and remedy environmental, social and governance issues in their operations and identify, mitigate and manage risks throughout their entire supply chains.

[11] https://courses.edx.org/assets/courseware/v1/c20ad25d3aca38ac2396a46a153889cf/asset-v1:DelftX+CRAM1x+1T2022+type@asset+block/ET0221867ENN_072021_EU_principles_for_responsible_sourcing.en.pdf

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One of the key international guidelines being broadly used and referenced is the OECD Due Diligence Guidance for Responsible Minerals Supply, which clarifies how companies can identify and better manage risks throughout the entire mineral supply chain, from miners, local exporters and mineral processors to the manufacturing and brand name companies that use these materials in their products. The Guidance is applicable to all minerals and global in scope. It is designed to support the operationalization of due diligence by following a 5-step framework as shown in Figure 12.

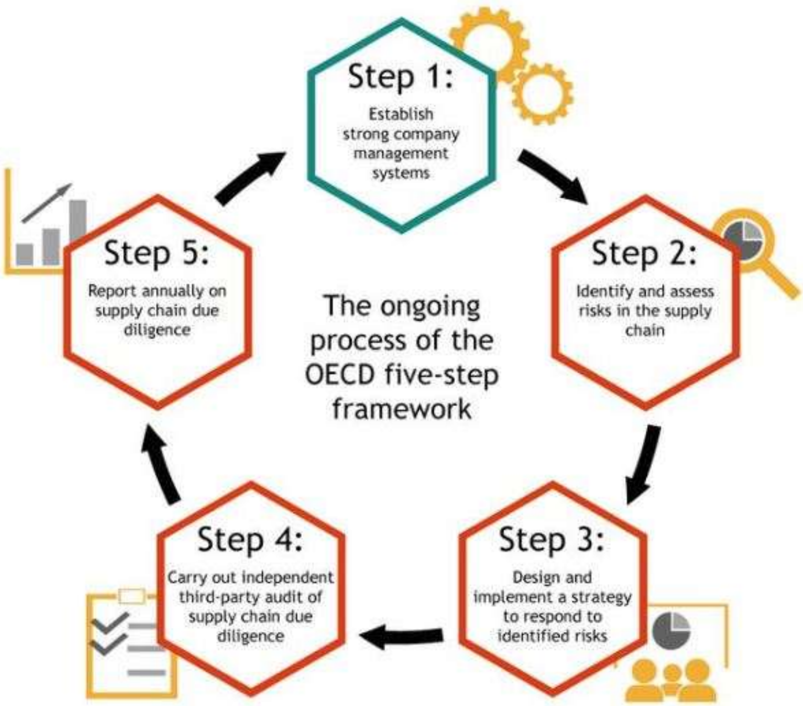

Figure 12. Five steps of the OECD Due Diligence Guidance for Responsible Minerals Supply. Source: [EPRM website]

Regulatory frameworks

In line with these guidelines and principle, regulations and mandatory policy frameworks are being set at national and regional level, to ensure wider implementation of such requirements and to influence business behaviour with regard to environmental, social and governance standards (Franken and Schütte 2022; Farooki et al. 2023). Some examples at the European Union (EU) level are EU Conflict Minerals Regulation[12] (2021), EU Battery Regulation[13] (2023), EU Critical Raw Materials Act[14] (2023) and. At international level, the US Dodd Frank Act passed in 2010 can be considered as one of the pioneering regulations in the areas of responsible sourcing. This Act requires the US companies to carry out proper process for their supply chain when sourcing tin, tungsten tantalum and gold (3TG) from the DRC or neighbouring countries. A similar law at the EU level is the EU Conflict Minerals Directive which is a

[12] https://policy.trade.ec.europa.eu/development-and-sustainability/conflict-minerals-regulation_en
[13] https://eur-lex.europa.eu/eli/reg/2023/1542/oj
[14] https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials/critical-raw-materials-act_en

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compliance- based instrument that sets rules for upstream and downstream companies to ensure they import 3TG from responsible and conflict free sources.

The most recent regulation at the EU level is **Corporate Sustainability Due Diligence Directive**[15] (CSDDD) (2024), which requires large EU limited companies and partnerships as well as large non-EU companies with turnover in EU[16] to identify and address potential and actual adverse human rights and environmental impacts in their operations, their subsidiaries and those of their business partners (when related to their value chains). Key provisions include obligations for companies to conduct due diligence on issues such as forced labor, deforestation, and pollution, establish grievance mechanisms, and integrate sustainability into corporate governance. Failure to comply with the provisions may lead to penalties, harm to reputation, or exposure to civil liability (European Commission 2024). In February 2025, the European Commission proposed a series of amendments to this Directive alongside two other relevant regulations, the Taxonomy Regulation and the Corporate Sustainability Reporting Directive (CSRD). The aim of this amendment is to simplify and harmonize the ESG requirements and facilitate the implementation of these regulations[17].

Standards and certification schemes

In alignment with these international guidelines and governmental regulations, various voluntary standards and certification schemes are developed by industry associations or international or regional forums. Such standards offer a more concrete framework than guidelines, specifying the actions, processes, or outcomes that must be achieved. For instance, while guidelines may recommend that companies adopt a risk-based due diligence approach to prevent minerals linked to human rights abuses from entering their supply chains, standards mandate explicit actions and reporting procedures to ensure that minerals are free from any association with forced or child labor (Farooki et al. 2023). Among various standards, the ISO 26000 standard on social responsibility[18], International Finance Corporation (IFC) Performance Standards on Environmental and Social Sustainability[19] (2012), Global Industry Standard on Tailings Management[20] (2020), Extractive Industries Transparency Initiative[21] (EITI) Standard, Initiative for Responsible Mining Assurance[22] (IRMA), **Fairmined Standard for Gold and Associated Precious Metals**

[15] https://commission.europa.eu/business-economy-euro/doing-business-eu/sustainability-due-diligence-responsible-business/corporate-sustainability-due-diligence_en
[16] The Directive applies to large EU limited liability companies and partnerships with more than 1000 employees and more than 450 million turnover (net) worldwide, and non-EU companies with more than 450 million turnover (net) in EU.
[17] https://finance.ec.europa.eu/publications/commission-simplifies-rules-sustainability-and-eu-investments-delivering-over-eu6-billion_en
[18] https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100258.pdf
[19] https://www.ifc.org/content/dam/ifc/doc/2010/2012-ifc-performance-standards-en.pdf
[20] https://globaltailingsreview.org/wp-content/uploads/2020/08/global-industry-standard_EN.pdf
[21] https://eiti.org/eiti-standard
[22] https://responsiblemining.net/what-we-do/standard/

(2014) & Fairmined Certification[23], and CRAFT - Code of Risk-Mitigation for ASM engaging in Formal Trade (CRAFT 2.1)[24] (2024) can be highlighted.

The latter document, **CRAFT Code**, is one of the key standards relevant to the **ASM sector**. The Code is created as a response to the critical challenge of disengagement with the ASM sector in mineral supply chains and is intended to use and convert the due diligence process into an instrument for connecting the industry with the sector. More specifically, the Code aims to facilitate collaboration between ASM and downstream players to support the sector in formalizing their operations, respecting human rights in mining communities and committing to the improving the overall conditions of the sector. The CRAFT Code is a voluntary, progressive performance standard created based on the OECD Due Diligence Guidelines and establishes guidance for ASM producers to meet the requirements of formal supply chains. Complementary to the CRAFT Code is the CRAFT Scheme which is a supply chain scheme that uses, incorporates, or builds upon the rules of the Code and defines the templates and process that are necessary for the implementation of the Code[25] (CRAFT Code 2024). The organizational scope of CRAFT is illustrated in Figure 13.

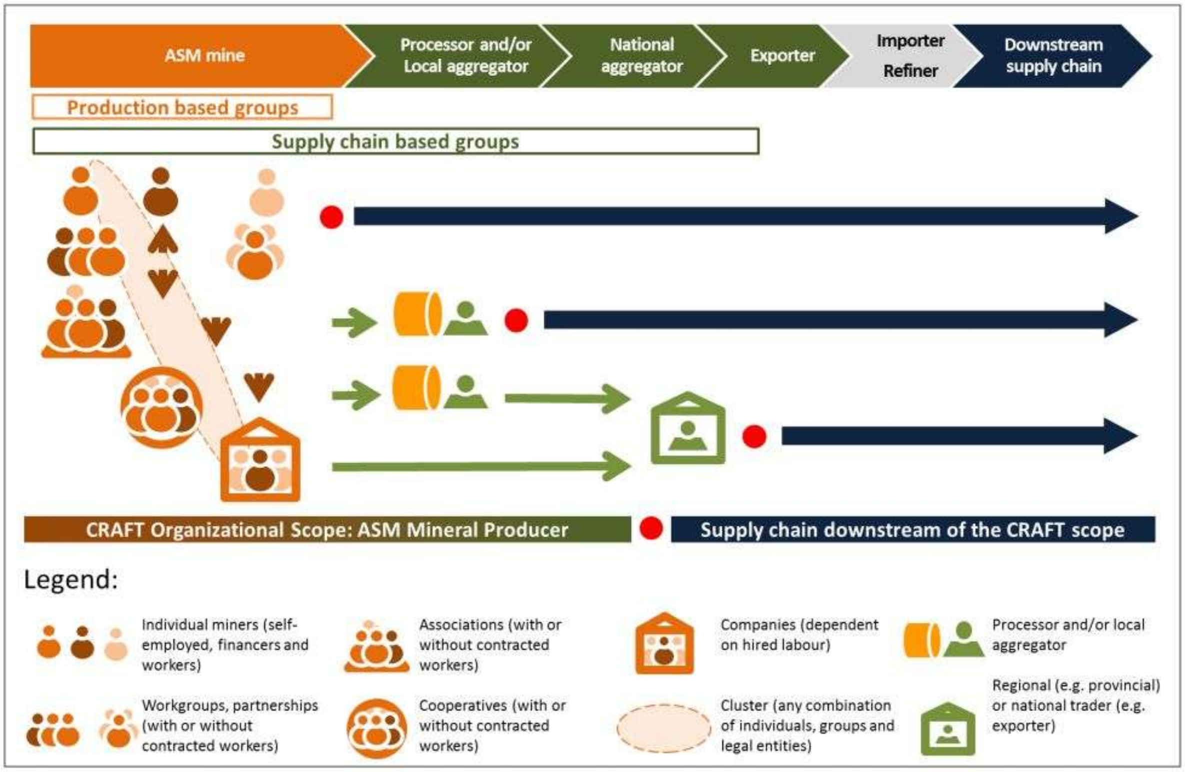

Figure 13. The organizational scope of CRAFT covers miners, processors and/or aggregators at the upstream end of the supply chain, down to the red point (point of assurance) where the mined and eventually processed product enters the supply chain downstream beyond the CRAFT scope. Source: (CRAFT Code 2024)

[23] https://fairmined.org/the-fairmined-standard/
[24] https://www.craftmines.org/en/what-is-craft/
[25] An easy explanation of the CRAFT Code is available in this video: https://www.youtube.com/watch?v=EMrxOjZJvfs

Alliances and other collaborative initiatives

In addition to developing guidelines, regulatory frameworks and standards, stakeholders involved in minerals value chains have in some cases formalized collaborative efforts or established entities to understand, develop, promote and/or implement responsible sourcing practices. The main objective of such alliances, platforms or collaborative initiatives is to engage and discuss with other concerned stakeholders the challenges associated with implementing responsible sourcing, find solutions and promote the uptake of these solutions. To ensure inclusivity and transparency, actors from different materials chains, different stages of the value chain and those addressing different sustainability aspects, should be part of the same alliance (Farooki 2021). As listed in Table 5, some of the key existing alliances are the Responsible Business Alliance[26] (RBA)/ Responsible Minerals Initiative[27] (RMI), The Fair Cobalt Alliance[28], European Raw Materials Alliance[29] (ERMA), European Battery Alliance[30]/Global Battery Alliance[31], Alliance for Responsible Mining[32] (ARM) and European Partnership for Responsible Minerals[33] (EPRM).

The latter initiative, **EPRM**, is established with the main objective to increase the share of responsibly produced and sourced minerals from ASM communities, in line with international frameworks and standards such as the EU Conflict Minerals Regulation, the OECD Due Diligence Guidelines and the EU Battery Regulation. While the initial focus of the initiative has been on tin, tungsten, tantalum and gold (3TG) from conflict affected and high-risk areas (CAHRAs), EPRM is broadening its minerals and geographical scope. To achieve its objective, EPRM has concrete activities including: a) Support mine sites to adopt responsible mining practices through funding broad range of projects, b) Provide tools to mid- and downstream companies to support them improving their due diligence practices and source 3TG in a more responsible way, c) Establish exchange and linkages between actors along the supply chain to stimulate the creation of responsible supply chains. As of January 2024, EPRM has awarded projects in Honduras, Columbia, Brazil, Peru, Bolivia, Burkina Faso, DRC, Uganda, Kenya and Rwanda, Zimbabwe and Zambia with a focus on minerals such as gold, copper, cobalt, tin, tungsten and tantalum. List of ongoing and completed projects are available on the EPRM website[34].

Key takeaway: One of the primary consequences of these regulations, frameworks and agreements is that downstream companies as well as investors will not be able to procure their raw materials from sources with high risks. This entails that investors will conduct due diligence and risk assessment on their operations and their value chains to identify potential human rights, environmental and social impacts and will accordingly design mitigation measures. Supply chains sourcing from ASM are often quite

[26] https://www.responsiblebusiness.org/
[27] https://www.responsiblemineralsinitiative.org/
[28] https://www.faircobaltalliance.org/
[29] https://erma.eu/
[30] https://www.eba250.com/
[31] https://www.globalbattery.org/
[32] https://www.responsiblemines.org/en/
[33] https://europeanpartnership-responsibleminerals.eu/
[34] https://europeanpartnership-responsibleminerals.eu/page/view/98fd21da-cd6a-4a71-9e36-5c94b50abac7/eprm-project-locations

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complex, and implementing due diligence for these supply chains is not easy. Combined with legal and reputational risks, this has created a situation where many downstream actors and investors are reluctant to source from or provide funding to the ASM sector (CRAFT Code 2024).

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2.3. Module 3: Technical knowledge: Geology, mining and exploration techniques, processing and waste management

Module Title	**Technical knowledge: Geology, mining and exploration techniques, processing and waste management**
Module Aims	This module aims to provide participants with geological and technical knowledge of the materials frequently mined by the artisanal and small-scale mining sector.
Specific Learning Outcomes	Upon completing the module participants will, through assessment activities, show evidence of their ability to: • Become familiar with the fundamentals of identification of the rock forming-, oxide-, and common ore minerals and common igneous, sedimentary, and metamorphic rocks across Africa • Have a general understanding of the geology of the country and the region (in this report the focus has been on Zimbabwe, Madagascar and Zambia) • Understand fundamental mining and exploration techniques and have a first impression of some fundamental material handling and ore processing techniques • Understand fundamental issues of waste disposal and tailings storage
Comprehensive Learning Outcome	The course ultimately aims to build scientific capacity among ASM workers on geological, geotechnical and environmental themes.
Module Content	1. Geology 2. Mining techniques and material handling 3. Processing and beneficiation 4. Waste disposal
Methods of Facilitating Learning	This Module will be facilitated through modular lecturing, group discussions and presentations, and laboratory exercises.
Reflection on learning outcomes	Group presentations and feedback from the trainees on ranking the relevancy of themes presented, soliciting responses on if they expect the content presented and lessons learned to be impactful.
Student Support & Learning Resources	Student Support Training Worksheet – Rock & mineral identification sheet provided Training Exercise - Rock & mineral identification laboratory Information will be provided periodically on relevant publications, internet resources and other reading material.

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Unit 1: Geology

The Rock Forming Minerals

Minerals are defined as a substance composed of a naturally occurring, inorganic, crystalline substance that is chemically and physically unique. A crystalline substance is defined as being an orderly, three-dimensional arrangement of the atoms or molecules making up the mineral. In geology, the rock forming minerals are generally accepted by geologists to be the minerals that make up rocks and determine their classification into igneous, sedimentary and metamorphic rock classes. These minerals tend to be composed of the most abundant elements naturally found in the Earth's crust. The most common rock forming minerals are composed of one of the following groups of minerals: silicates, carbonates, oxides, sulfates and sulfides, and clay minerals. The silicate minerals are the most important family of rock forming minerals for identification of ore deposits.

Silicate Minerals – The most common rock forming minerals, silicates represent minerals whose crystal structure contains the basic ionic unit SiO_4, or the silicate tetrahedra, either isolated or joined through one or more of the oxygen atoms in a combination of tetrahedra chains or sheets and / or combined in complex structures with other metallic elements. The combination of the silicate tetrahedra determines the family in which the mineral belongs. Silicon and oxygen are the two most abundant elements found in the earth's crust. The following common rock forming mineral groups all contain the silicate tetrahedra, making them all silicate minerals.

Quartz

Arguably the most important and most common rock forming mineral, quartz is abundant in many rocks. Its chemical formula is SiO_2 and forms either as transparent to coloured hexagonal crystals that are terminated with a six-sided pyramid, or as crystalline or microcrystalline masses with a general glassy lustre. Commonly produces a conchoidal fracture with sharp edges when broken. Its colour varies: colourless and transparent to White (*milky quartz*), purple – *Amethyst*; pink – *rose quartz*; clear-yellow – *Citrine*; pale brown to black – *smoky quartz*.

Image source: Robin Gilli

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Feldspar

Feldspars are a group of some of the most common rock forming minerals in the earth's crust. Their general chemical formula is (K, Na, Ca, Ba, Rb, Sr, Fe)$(Al,Si)_3O_8$ and can form a series of minerals with different elemental combinations. The silicate tetrahedra are bonded together in a complex framework. Their crystal structure is blocky rectangular and commonly forms masses and the structure commonly breaks with two directions forming 90^o angles with the crystal surfaces appearing to have faint striations. The crystal colour varies: white – *albite* or *anorthite*; pink – *orthoclase*; blue-green – *microcline* also called *amazonite*; rainbow – *labradorite*.

Image source: Wikimedia Commons

Image source: Robin Gilli

Pyroxene

The pyroxene group of rock forming minerals are commonly found in igneous and metamorphic rocks. The crystals are characterized by generally dark coloured, short, stubby, blocky or stout shapes that break in two directions forming approximately 90^o angles. Their general chemical formula is (Mg, Fe^{+2}, Ca, Na)(Mg, Fe^{+2}, Al)Si_2O_6 where the silicate tetrahedra are bonded in single chains in the crystal. The colour is generally dark with some exceptions: most commonly black to dark green, greyish green – a*ugite or hedenbergite*; apple green – j*adeite*; white to grey or yellow - *spodumene*.

Image source: Eisco Labs

Image source: Eisco Labs

Amphibole

Another group of rock forming minerals, the amphibole group consist of elongated column shaped crystals that generally are dark in colour and have a splintery or fibrous-like appearance or in masses. Their general chemical formula is $(Mg, Fe, Cal, Na)_2(Mg, Fe^{+2}, Al, Fe^{+3})_5(Si,Al)_8O_{22}(OH)_2$ where the silicate tetrahedra are

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bonded in double chains. The crystals break in two directions forming at approximately 56°/124° angles. The crystal colour slightly varies with the most commonly grey, black or dark brown – *hornblende*, green – *actinolite*; dark blue grey – *glaucophane*.

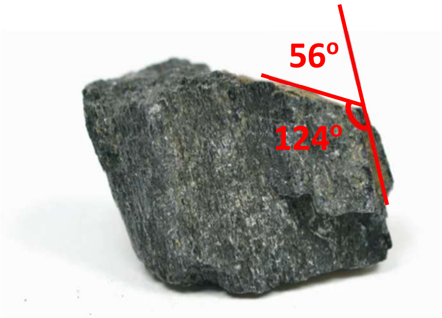

Image source: Fischer Scientific

Image source: Robin Gilli

Mica

A group of common rock forming minerals, micas have distinct crystal structures. The silicate tetrahedra are bonded in complex sheet structures. Thus, these minerals form flat, tabular sheets of various sizes, that when viewed from the side appear as the pages of a book. These sheets are easily peeled away from the crystal, into flakes- Its chemical formula varies (K,Na,Ca) (Mg, Fe, Li, Al)$_{2\text{-}3}$(Al, Si)$_4$O$_{10}$(OH,F)$_2$ giving it a range of colours from colourless or pearly to black. Generally, colourless to various shades pearly brown – *muscovite*; dark brown to black – *biotite*; green – *chlorite*; pink to purple – *lepidolite*. Micas can appear to "sparkle" in the light.

Image source: Wikipedia

Image source: Robin Gilli

Oxide Minerals – A very diverse range of rock forming minerals, oxides represent minerals whose crystal structures all contain the oxygen anion (O^{2-}) unit in some combination bound to one or more metal atoms. The silicate tetrahedra is not present in oxide minerals, thus oxide minerals are also referred to as "non-silicates". The following common rock forming minerals all contain the oxygen anion, making them all oxide minerals.

Magnetite

Magnetite is one of the most common oxide minerals and is widely distributed in many environments. Its chemical formula is $(Fe^{+2},Fe^{+3})_2O_4$ (also commonly written as Fe_3O_4), and is an important ore of iron. With the presence of Fe^{+2} in its formula, it is strongly magnetic. It does not exhibit a range of colours, rather it occurs exclusively as a silvery black opaque minerals, most commonly found in masses but occasionally occurring as octa- or dodecahedrons shaped crystals. Can contain trace amounts of manganese, nickel, chromium or titanium.

Image source: A. Pobedinskiy-iStock/Getty Images

Image source: Rob Lavinsky, iRocks.com

Hematite

Another common rock forming iron-oxide is hematite. Its chemical formula is Fe_2O_3 in which the iron is in the "oxidized" form of Fe^{+3} thus making hematite is only weakly magnetic. It forms crystals most commonly found in masses but also as fibrous, tabular, granular aggregates, in a botryoidal or in earthy fine-grained forms. The colour is generally found in an earthy red colour but can also be found in a metallic shiny form – *specular hematite*. Along with magnetite, hematite is a primary ore of iron.

Image source: Wikimedia Commons

Image source: Mindat.org

The Ore Minerals - Lithium

Spodumene

Easily the most sought after lithium bearing ore mineral, spodumene is primarily mined for use in lithium-ion batteries. It is a member of the pyroxene family of silicate minerals, with a chemical formula of $LiAlSi_2O_6$; thus, it generally forms blocky, tabular or rectangular crystal shapes that when broken, form 90^O angles. Crystals can appear to have striations on the surface. Also commonly forms masses. It is frequently mistaken to be a member of the feldspar family. It generally occurs in white, pink to sometimes green coloured crystals that can range from small to those even exceeding a meter in size. Can form gem varieties when crystals are particularly clear: clear with pink hue – *kunzite*; green – *hiddenite.*


Image source: Robin Gilli

Image source: Robin Gilli

Petalite

Another important ore mineral of lithium is Petalite. Its chemical formula is $LiAlSi_4O_{10}$, making it actually a member of the mica family of silicate minerals. Unlike other micas, petalite forms blocky, long, often tabular shaped crystals. It's generally found colourless, white or light pink with a milky to semi-glassy lustre. When broken, it appears to have circular "conchoidal" fracture with dull to semi-sharp edges. Petalite is commonly mined for use in lithium ion batteries.


Image source: mindat.org


Image source: Robin Gilli

Lepidolite

Lepidolite is perhaps a slightly less important ore of lithium, as it is not commonly mined for use in lithium ion batteries. Nonetheless lepidolite is often found together with other lithium ore minerals like spodumene. With a chemical formula of $K(LiAl)_3Si_4O_{10}(OH)_2$, lepidolite also belongs to the mica family of silicate minerals. It most commonly forms aggregate masses of very small crystals, that give the


Image source: Robin Gilli


Image source: Robin Gilli

appearance of “scales”, can also form the large, flat and tabular flakes as with other micas, that when viewed from the side appears like pages of a book. Its colour varies from commonly pink to light purple but can also be white and has a pearly lustre. In the light it can appear to “sparkle”.

The Ore Minerals - Manganese

Pyrolusite

The most common ore mineral of manganese, pyrolusite and is commonly formed sedimentary and metamorphic rock environments. The chemical formula is MnO_2, making it an oxide mineral of manganese. Rarely is pyrolusite found in well-formed crystals, it is rather found in sooty, powdery, fibrous or granular masses and is exclusively found black to steel grey, sometimes with a bluish hue and a metallic to dull lustre. Commonly forms dendritic patterns in sedimentary rocks.

Image source: Robin Gilli

Image source: Robin Gilli

Psilomelane

Another common manganese ore mineral is psilomelane, a mineral that is thought to be composed of a mixture of manganese oxide minerals, each with a slightly different composition. The general chemical formula is $Ba(Mn^{+2})(Mn^{+4})_8O_{16}(OH)_4$, meaning it is also an oxide mineral of both manganese and barium; however, the exact composition is not specifically determined. Psilomelane is commonly found together with pyrolusite and is difficult to distinguish between the minerals. It often forms botryoidal or earthy, powdery masses or crusts. It is commonly black to bluish- or brownish black in colour, with a dull to submetallic lustre. Commonly forms dendritic patterns in sedimentary rocks.

Image source: Wikimedia Commons

Image source: Rob Lavinsky, iRocks.com

Sugilite

An uncommon, but often strikingly beautiful manganese mineral that can seldom be found with manganese ore deposits is sugilite. Its chemical formula is $KNa_2(Fe, Mn, Al)_2Li_3Si_{12}O_{30}$. Because it contains the silicate tetrahedra, sugilite is a silicate mineral containing both manganese and lithium as well as other metals. When found, it is usually in a massive form but can potentially be found with hexagonal shaped crystals. Its colour is its distinguishing feature, where it can appear from brownish yellow to vibrant purple, violet, or pale pink with a semi- to glassy lustre. It is **not** a common ore mineral of either manganese or lithium but if found, can hold value to gem and mineral collectors.

Image source: RDCnet Smithsonian

Image source: Rob Lavinsky, iRocks.com

Common Rocks found across Africa

Rocks are defined as solid materials composed of aggregates of one or more mineral crystals, grains or fragments. They are generally classified into igneous, sedimentary or metamorphic classes based on the nature of their formation on Earth. A conceptual model called the **rock cycle** describes how all rocks can be formed, deformed, destroyed or reformed as a result of tectonic, erosional, weathering, environmental natural earth processes. The rock cycle suggests that all rocks can be infinitely recycled over and over again.

Igneous Rocks

An igneous rock is defined as one that has solidified from molten material, when magma (said of molten rock while it is underground) or lava (said of molten rock after it has erupted to the earth’s surface) cools into a solid material. Igneous rocks consist of tightly intergrown aggregate masses of crystals of generally more than one mineral and are of various sizes, ranging from fine-, medium- to coarse-grained crystal textures. In general, a fine-grained crystal textured igneous rock consists of individual mineral crystals with an average diameter less than 1 mm, coarse-grained with an average individual crystal diameter greater than 5 mm, and subsequently a medium-grained texture with an individual crystal diameter between 1-5 mm. The crystal sizes of igneous rocks generally reflect the manner in which the molten rock cooled.

Granite

Granite is a common igneous rock found in the earth's crust. It forms when molten magma cools slowly underground. The rock is subsequently brought to the earth's surface via tectonic forces. When magma cools underground, the minerals grow **large** and can then be **seen with the naked eye**. When the crystals are exceptionally large (minerals that are several centimetres or larger) the granite is said to be a pegmatite. The minerals in granite commonly are interlocking commonly consisting of white and pink feldspars, dark grey to black amphiboles and pyroxene, clear to white or glassy *quartz*, pearly brown to black micas (common with both *muscovite* and *biotite*). Quartz typically makes up anywhere from 10 - 50% of mineral composition of granite. Granites tend to be resistant to erosion and thus form prominent structures on the earth's surface.

Image source: nagra.ch

Image source: geologyscience.com

Image source: US National Parks Service

Basalt

Another common igneous rock is basalt, a dark coloured rock formed when molten magma has erupted on to the earth's surface to become lava and cools above ground. The lava then cools more rapidly, forming smaller crystals that are barely to not visible with the naked eye. The primary minerals found in basalt are white feldspars (commonly *plagioclase* or *labradorite*), and dark pyroxenes (commonly *augite or hedenbergite*) and amphiboles (commonly *hornblende*). Basalt as a whole, appears most commonly black that with time and weathering can appear brownish black and often can appear to have vesicles, or "holes", where volcanic gas was once present when the magma was cooling.

Image source: Robin Gilli

Image source: Robin Gilli

Metamorphic Rocks

A metamorphic rock is defined as any rock derived from a **preexisting rock** that has been deformed from one form to another by intense heat, pressure, temperature and/or hot fluids interacting with the existing rock. These conditions thus differ from those of the rocks' original formation. This can cause the minerals in the rock to recrystalize, flow, fracture, change colour or align themselves in specific directions, but **do not melt**.

Gneiss

Gneiss is a common metamorphic rock formed in tectonic environments of high temperatures and pressures. The rock appears to have bands (also called "foliations") of alternating dark (often *biotite* mica or *hornblende* amphibole) and light coloured (white: *quartz* and *albite* or *anorthite* feldspar, sometimes pink: *orthoclase* feldspar). Often bands appear folded, caused by continuous deformation of the original rock. Like granite, gneiss tend to be resistant to erosion and thus form prominent structures on the earth's surface. Its "parent" rock is generally igneous rocks like granites, but can also be formed from sedimentary rocks.

Image source: nagra.ch

Image source: sciencephoto.com

Schist

Another common metamorphic rock is called schist composed of medium size crystals that can easily be seen with a hand magnifying glass. Similar to gneiss, schists tend to have a foliations but rather forms flattened layers. The rock is abundantly composed of shiny, flat mica minerals (black – *biotite*, brown pearly – *muscovite*), black to green minerals of amphibole (*hornblende* or *actinolite*) and commonly occurs with valuable trace minerals like *garnets*, *emeralds*. The mica minerals present can make the rock appear to "sparkle" in the light. Schists tend to be less resistant to erosion and tends to form somewhat prominent albeit unstable structures. Its "parent" rocks are generally sedimentary rocks like sandstones or mudstones, but can also be formed from some volcanic rocks.

Image source: Robin Gilli

Image source: Robin Gilli

Greenstone

Unlike gneiss and schist, greenstones are metamorphic rocks that do not typically display any banding or foliation. Greenstones are typically dense massive rocks where crystals are fine- to medium grained in size that can be easily seen with a hand magnifying glass but often more difficult to see with the naked eye. The colour varies from grey green, yellowish green or dark green and is abundantly composed of green to black amphibole minerals (*actinolite or hornblende*), white feldspars (*albite*), and small green mica minerals (*chlorite*). Its "parent" rocks are generally igneous, such as basalt and tends to form somewhat erosion resistant, more prominent structures.

Image source: Wikipedia

Sedimentary Rocks

A sedimentary rock is defined as a layered rock resulting from the consolidation of sediments, or fragments of other rocks, mineral crystals, plants and / or animal fragments are cemented together. Additionally, a sedimentary rock can be formed from the chemical precipitation of minerals from water to form a solid material.

Sandstone

Sandstones are the typical sedimentary rocks, composed of granular, medium-grained, sand sized particles (0.05 – 2 mm diameter grains) of a wide range of various minerals. Grains of sand are held together by compaction and in the presences of a mineral acting as a cement. Thus, sand grains are difficult to see with the naked eye, but easy to see with a hand magnifying glass. Particles often look glassy and rounded, can often appear "layered" or "banded", can contain fossils. Sandstone is generally rough and gritty to the touch. Most common minerals making up the sand are glassy to white *quartz* and white to pink feldspars (*albite* or *anorthite*, or *orthoclase*). Sandstones tend to be less resistant to erosion and tends to form somewhat prominent structures.

Image source: geologyscience.com

Image source: nagra.ch

Shales and Mudstones

Similar to sandstone, shales and mudstones are also sedimentary rocks but are composed of sediments that are clay-sized particles (<0.002 mm). These particles cannot be seen with the naked eye. Mudstones are essentially mud that is solidified into a stone. Mudstones are compacted and can often form massive layers, often exhibiting paleo ripple marks from the time in which the mud was being deposited in a near shore environment and often contain fossils. Mudstones are not particularly resistant to erosion and easily erode away by wind and water acting on the rock.

Images source: geologyin.com

Image source: Parks Canada

Geology of Madagascar and its lithium potential

The geology of Madagascar represents billions of years of tectonic evolution of the micro-continent. Major geological events forming the rocks and shaping its landscape include the formation of the Precambrian super continent Gondwana during the East African Orogeny and more recently the rifting of Madagascar from the African continent during the breakup of Pangea around 160 million years ago. Madagascar can roughly be divided into three geological domains, the older metamorphic and igneous pegmatite units found in the central and eastern regions, and the younger, predominantly sedimentary units found in the western third of the island (Collins and Windley 2002).

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Madagascar is endowed with several important ore deposits, including those of the minerals nickel, cobalt and graphite, critical for battery production. More recently the island's pegmatites (see Figure 14) have been in focus for containing minerals bearing lithium. In general, the main lithium containing pegmatite found in Madagascar is the lithium-caesium-tantalum (known as LCT) type pegmatite [citation]. The LCT type are heterogeneous in nature, generally consisting of a quartz core with zones of feldspars and micas where spodumene, petalite, and amblygonite, among other minerals of value are found. A less heterogeneous LCT pegmatite is also found and consists of feldspar rich, flat-bedded deposits also containing spodumene as well as lepidolite (Vasters and Schütte 2023). The majority of these pegmatites are of Precambrian age and are associated with intense tectonic activity.

The lithium bearing pegmatites that are scattered across the central and western regions of Madagascar generally show lower grades of Li_2O than what is commonly sold on the world market. Some well-known Li-bearing deposits are those of the Berere-Tsaratanana, Vohambohitra, Betsiriry, Antsirabe-Itasy, Ibity-Sahatany, and the Antandrokomby pegmatite fields (Figure 14). Samples collected of lepidolite from the Berere-Tsaratanana and the Ibity-Sahatany pegmatite fields confirmed concentrations of lithium-oxide at 4.65% and 2.95% Li_2O, respectively (Vasters and Schütte 2023). Generally, the majority of pegmatites in Madagascar range from 2-4% Li_2O. Despite this relatively low grade, Madagascar pegmatites could nevertheless become an important source of lithium ore, should the global demand for lithium in Li-ion batteries continue to increase in the coming years.

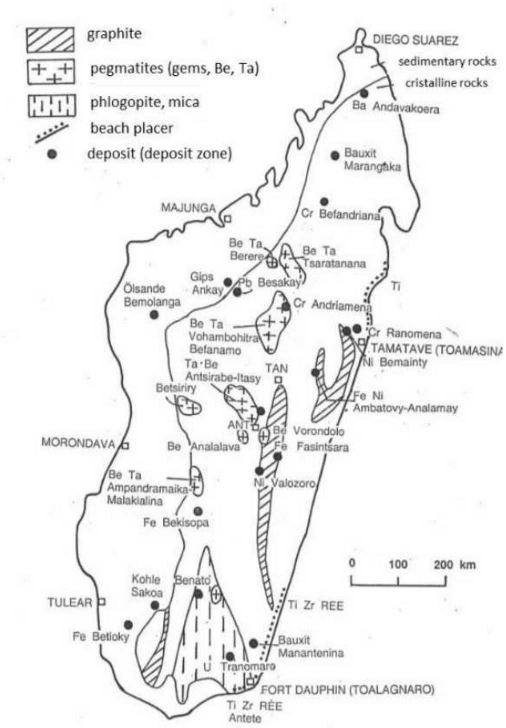

Figure 14. Generalized geologic map of Madagascar, showing the mineralization zones, including the known locations of pegmatites. Source: (Vasters and Schütte 2023)

Geology of Zimbabwe and its lithium potential

Zimbabwe is a mineral rich country with great potential for future discoveries. The geology of Zimbabwe is fascinatingly old with a tectonic evolutionary story as old or older than the first known, microscopic forms of life on the planet. The country is dominated by terranes of the Zimbabwe Craton, the basement rock underlying the majority of the country. Some of these cratonic terranes are so old, they were formed during one of Earth's major continental forming events.

The country in general consists of vast and diverse assemblages of various rock types. The rocks in Zimbabwe range from gneissic-granitic-greenstone assemblages, banded-iron formations, to the famous Great Dyke – a cross-cutting igneous intrusion that extends almost the length of the country (Kusky 1998; Schlüter 2006). Embedded within many of these rock units are significant enrichments of numerous critical and valuable raw materials such as gold, platinum group metals, chromium, and a host of stunning precious gemstones. Likewise, Zimbabwe possesses an enormous capacity to provide a large quantity of lithium for the global battery value chain.

The lithium ores in Zimbabwe are particularly interesting. They are found mostly in the vast pegmatites that naturally endow these cratonic terranes. In fact, no other country in Africa is known to have more lithium reserves than Zimbabwe. Many of these pegmatites scattered across the country contain lithium bearing mineral assemblages (Dittrich et al. 2019), with the most sought after being those bearing the minerals spodumene, petalite and lepidolite. Pegmatites are exceptionally coarse-grained, intrusive igneous rock bodies that are characterized by large interlocking crystals that can exceed several centimeters in size. In general, often pegmatites include rare minerals rich in lithium, but also materials like caesium, tantalum, niobium and a host of other important elements (Shaw et al. 2022).

Pegmatites tend to have granitic compositions but differ in that, as the classical explanation of their formation suggests, they are the last and most hydrous portion of the magma to crystalize (Phelps, Lee, and Morton 2020). While pegmatites in general can be found in many regions around the world, the pegmatites of Africa, specifically those of Zimbabwe, have the potential to provide the world with a considerable amount of lithium.

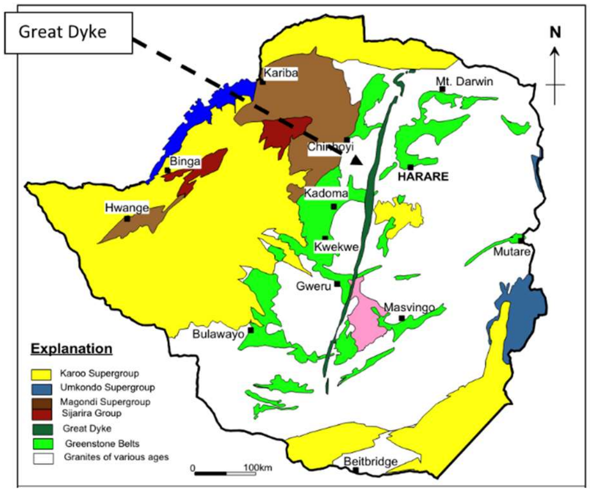

Figure 15. Generalized geologic map of Zimbabwe, showing its main geologic units, including its most prominent formation, the Great Dyke. Map after ZEPARU 2017.

Geology of Zambia and its manganese potential

As with many other countries in Sub-Saharan Africa, the geology of Zambia is complex and reflects billions of years of geological evolution. Some of the oldest units in Zambia are found in the crystalline basement rocks, dating back to the Precambrian times. These rocks are highly metamorphosed and very structurally complex, and range from granites, gneisses, schists and other moderately to highly deformed rocks (Schlüter 2006). Similarly, the Precambrian Muva Supergroup are mostly sedimentary deposits, are slightly less metamorphosed. The basement and the Muva Supergroup rocks underly much of the eastern, northern and southern portions of the country, including some regions of the famous Zambian mineralization of the central region Figure 16.

Zambia is probably best known for its rich and diverse mineralization, particularly for its vast deposits of copper and to a lesser extent cobalt. Zambia's Copperbelt is a part of the larger Central African Copperbelt, which notably also extends into the neighbouring Democratic Republic of the Congo (DRC). The copper mineralization in Zambia is hosted in the rocks of the Katanga Supergroup, a sequence of Neoproterozoic sedimentary complexes, comprised mostly of sandstones, shales and carbonates (Cailteux et al. 2005). Within the Katanga is a group of siliciclastic and carbonate sediments called the Roan Group, that are the primary hosts for the copper and cobalt.

North of the Copperbelt and hugging the border with the DRC, in the region around the Luapula Province and the Mansa District, the Katanga Supergroup here also notably hosts vast manganese deposits. The manganese deposits are believed to be a result of deposition into a marine basement, where the conditions were right for the formation of manganite, hausmannite, pyrolusite, psilomelane and a mixture of other manganese minerals into deposits ranging from fibrous, botryoidal to massive mineralization (Vasters and Schütte 2023). These deposits, while on a regional scale might only account for a small percentage of manganese resources in Africa, around 2% according to (Guo et al. 2024), they are particularly high in grade, with reports of having greater than 50% concentrations of manganese (Vasters and Schütte 2023).

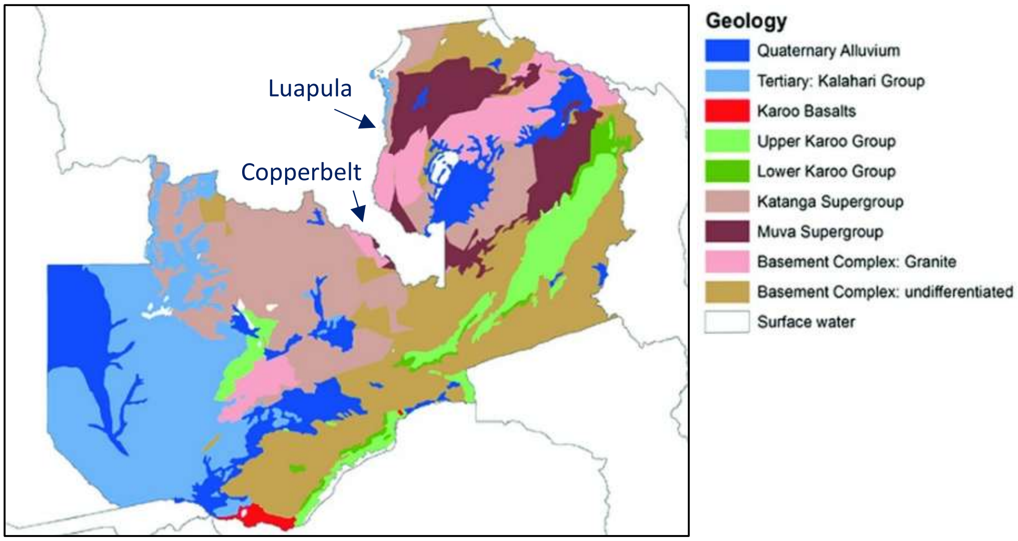

Figure 16. Generalized geologic map of Zambia, showing its main geologic units, the Copperbelt and Luapula mineralization regions. After (Thieme and Johnson 1975)

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Unit 2 – Mining techniques and material handling

Exploration techniques

The geological and tectonic processes that form an ore deposit of any mineral of interest is complex and a full understanding of the geological landscape of a particular area is necessary to identify the orebody. The process of finding an economically exploitable ore deposit is called mineral exploration and often takes years to complete. A few common techniques have been developed that remain the go-to for geologist looking for a first approximation of mineralization of a region. In addition, modern technology has aided in the ability to detect large scale ore deposits. The following is a description of the most common methods for ore exploration of lithium and manganese (or of Zimbabwe and Madagascar's lithium and Zambia's manganese deposits?).

Surface Exploration and Mineral Identification

Arguably the oldest known method for mineral exploration, surface exploration and mineral identification remains key to understanding the mineralization of the surrounding region. This method is based on the collection of petrological and structural observations through fields surveys. Surface exploration starts with sound geological knowledge about the rock types and structures visible. This includes mapping the boundaries of rock units and their strike and dip (inclination) in order to generate a geological model of the exposed terrain and make predictions on its projection underground. Geologic maps are generally drawn onto topographic maps to link geologic features to landmarks and features in the landscape. An example generalized geologic map and its relationship to topography and surface features is shown in Figure 17 and full geologic maps of Madagascar, Zimbabwe and Zambia are shown in Figure 14, Figure 15 and Figure 16.

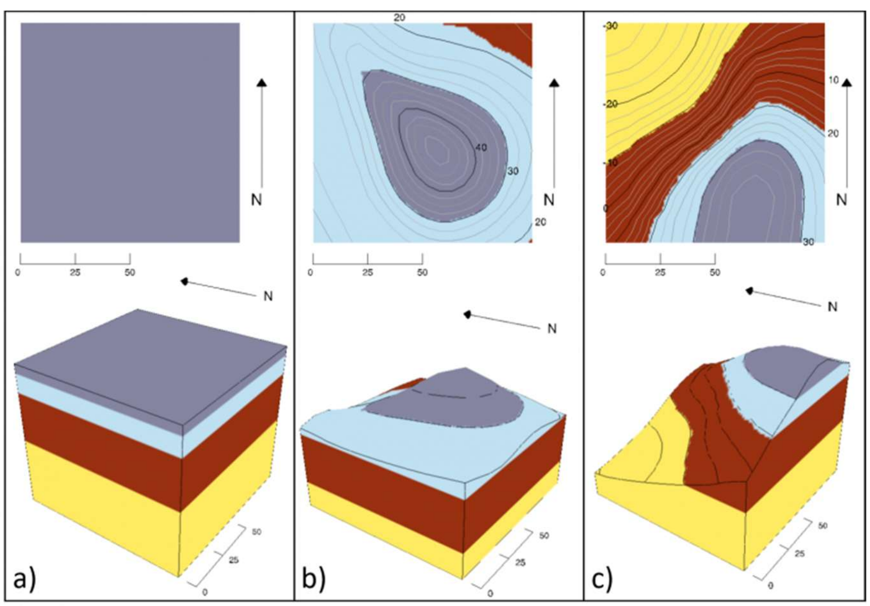


Figure 17. Map view (top row) and block view (bottom row) showing the same geology of flat lying, horizontal layers and the influence of topography (three different landscapes shown in a-c) on the geologic map (McGoldrick 2020).

Once an idea of the geology of the region of interest is explored via geologic mapping, a plan for sampling and subsurface investigation can be developed. This includes rock and mineral identification of the exposed rock units, sampling the stream sediments or initial drilling into an area of interest and sampling the subsequent rock core. This generates initial mineralogical and petrological composition of exposed rocks and of stream sediments, weathered from surface outcrops and provides first evidence of immediate subsurface units and their structure and orientation.

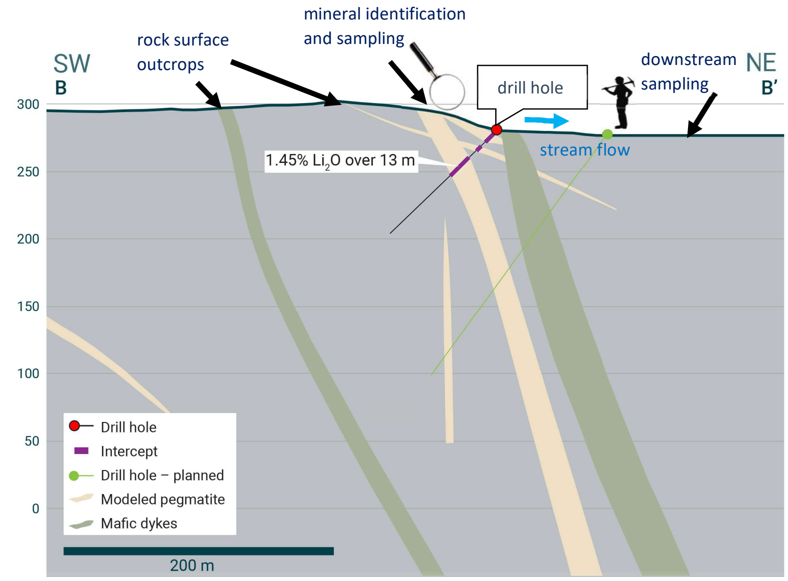


Figure 18. Schematic diagram representing a hypothetical exploration plan of lithium bearing pegmatites and other exposed rock units. Modified after Li-FT Power Ltd.

Surface Trenching

Trenching is an inexpensive way to obtain quick information on the immediate subsurface of a region of interest. This is especially useful technique when the rock of interest is near the surface. This can be done with heavy machinery such as a bulldozer, excavator or backhoe, provided that there are the necessary permits in place by the explorer. The lithology of the surface can often dictate which machinery is best. Trenching through overburden materials like soil, and into unconsolidated sediments or weathered rock can easily be done with a backhoe; however, it can reach a depth of only a few meters. Excavators and bulldozers tend to have more power to dig through rock than a backhoe and generally has the ability to penetrate about one meter into a hard rock unit. Depending on the strength of the material, a trench can provide the geologist not only with material for sampling, but also enable a view of any structures making up the initial subsurface (Marjoribanks 2010). Most countries have regulations for safe trenching that must be followed.

When digging trenches for immediate subsurface exploration, there are a few important logistics to consider (Marjoribanks 2010):

First, all overburden materials, such as soil or sediments, should be placed into piles far away from the trench edges. This material should be separated by lithology as best as possible the equipment operator and geologist. The approximate depths of each lithology type should be recorded by the geologist in a log.

The separation of piles allows the geologist to sample the material found at approximate depths of subsurface and provides a material assessment without need for entering the trench.

Second, for safety reasons, an unsupported trench greater than 1.5 meters should not be entered by the geologist given that collapse of fresh trenches or during or immediately after rainfall are common. Trenches should be designed by an **experienced professional** to ensure their proper design and installation of any wall support. In addition, trenches can be designed with benches or steps to prevent collapse and allow for safer trench entry.

Third, should a supported trench be designed for entry, there should be structural ramps or ladders designed and installed for safe entry and exit.

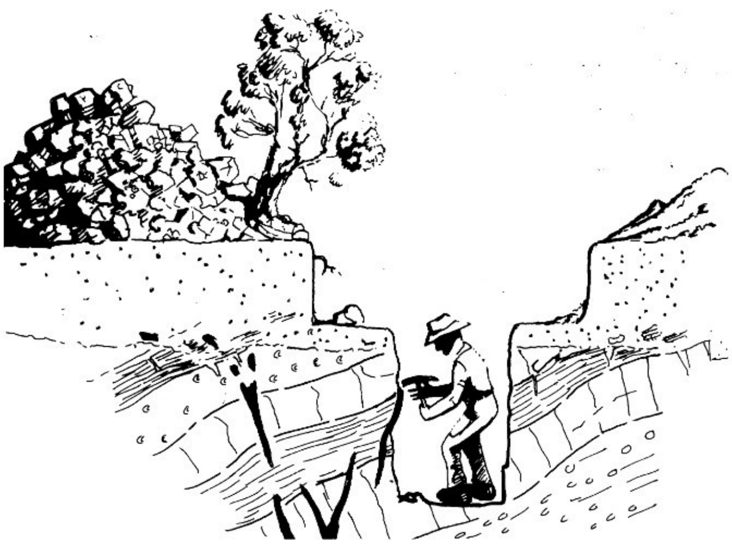


Figure 19. An illustration of a safe trench for geological exploration. Source: (Marjoribanks 2010).

Drilling – Reverse circulation and diamond core

Mineral exploration drilling is very commonly used in the mining industry to discover and map new mineral deposits. After initial surveying and sampling has produced positive and promising results, there are two primary drilling techniques that can be employed for exploration at depth. The most commonly used techniques are reverse circulation and diamond core drilling.

Reverse circulation (RC) drilling is a very common air drilling technique, that involves the use of compressed air to drive a rotation percussion drill bit into the subsurface at specific intervals. An air driven hammer with a tungsten-steel drill bit, pulverises rock as it advances. A compressed air system forces the rock fragments to the surface through an inner pipe, where it is directed into a cyclone splitter at the surface and emptied into bags for a geologist to log the lithology of the rock cuttings (Tilley 2021). This technique is optimally used between 300 – 500 m depth (Harlsan Industries 2024).

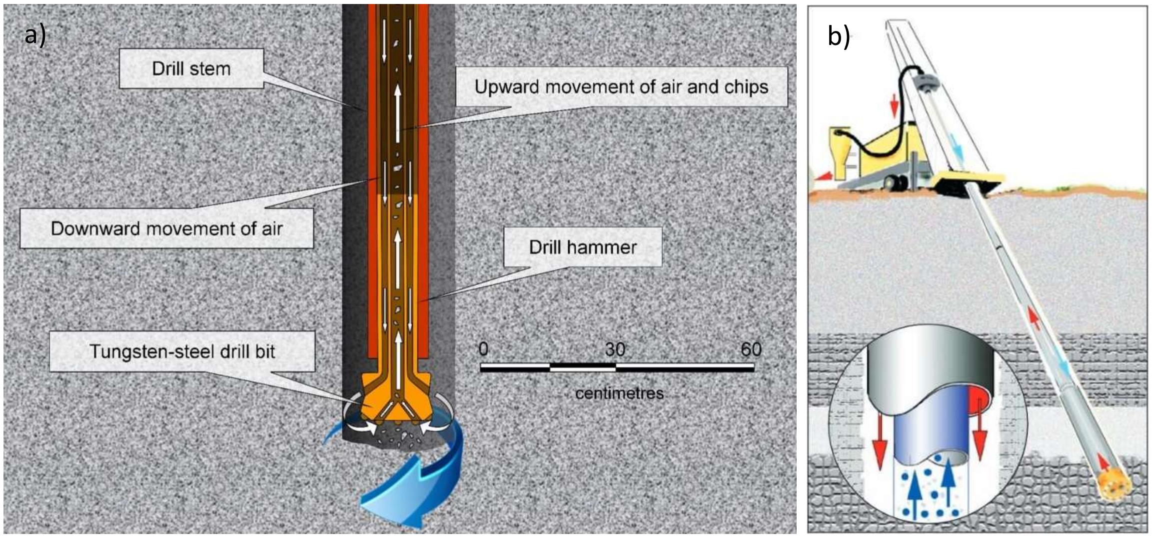


Figure 20. Schematic of the RC drill, a) white arrows display the direction of air flow and blue arrow the direction of the rotating drill bit, b) drill system as a whole. Source: (Atlas Copco 2007; Tilley 2021).

Another important drilling technique especially for ores found in hard rocks such as granites or gneiss is that of diamond core drilling. This technique is used when an intact rock core is desired to provide the most precise mineralogic and geotechnical information on the rock at depth, without the uncertainty that comes along with interpreting broken fragments from a technique like RC drilling. It can be used to explore the inner structures and mineralization of a large, hard rock deposit as well as provide a first estimation of the size of the mineral resource and reserves.

The technique works by utilizing an industrial diamond impregnated, rotating, water lubricated drill bit on the end of hollow steel rods (see Figure 21a). The hollow nature of the rods means that a solid cylinder of rock core is captured inside the rods and pushed into an inner tube called the core barrel as the drill advances. Once the core barrel is full, the drilling is temporarily halted for extraction of the core (Figure 21b), where it is subsequently laid out on the surface for the geologist to examine and log their observations. (Marjoribanks 2010). Care must be taken by the driller and the planers to ensure the correct direction and angle is maintained (Figure 21c). This technique is much more expensive and generally is slower, thus a significant amount of logistical planning, permitting, resource modelling and gathering of other exploration data needs to first be conducted to ensure successful implementation (Tilley 2021).

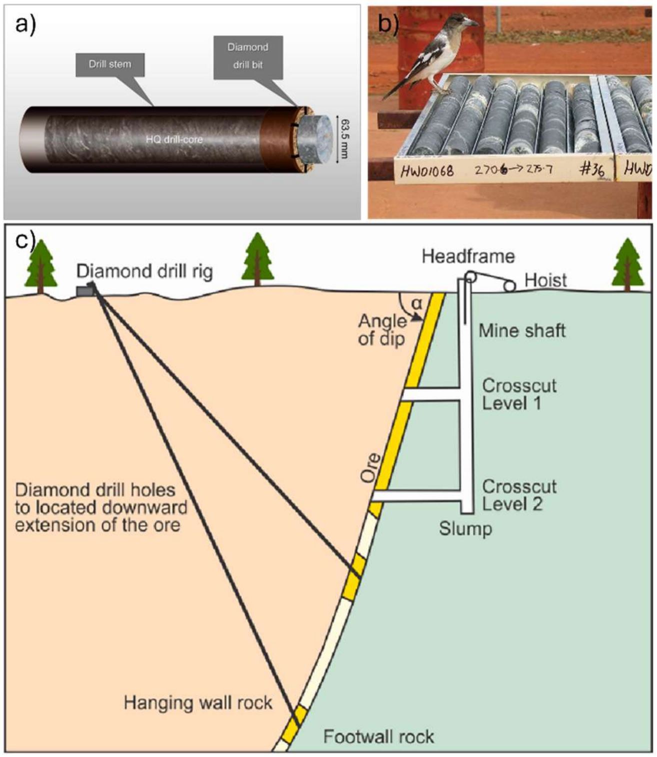


Figure 21. Diamond core drilling a) drill bit showing the capture of the drill core, b) example core box for geologic evaluation and logging, and c) hypothetical investigation using diamond drilling to reach a specific ore body. Modified after (Ghorbani et al. 2023; Tilley 2021).

Geophysical Surveys

There are various geophysical survey that can be conducted to provide information on the subsurface geology of an area of interest that do not require heavy machinery or manual labour. Often these methods can be employed when surface clues do not exist, such as rock outcroppings or other physical landscape features. Such surveys are also non-invasive and have a minimal impact on the area of interest. Some commonly used geophysical surveys include electromagnetic (EM) surveys useful tools for lithium exploration while electrical resistivity tomography (ERT) can aid in manganese exploration.

Electromagnetic Surveys

Electromagnetic Surveying is an important geophysical technique for exploration of ore bodies and has been successfully used in lithium exploration. This method (involves generating and measuring induced electromagnetic fields in the ground. The method uses a transmitter coil to generate the electromagnetic field into the ground, and induces electrical currents, known as eddy currents, in conductive subsurface materials, like metal ores, or clay layers. A secondary EM field generate a second EM field, interacting with the primary field. The receiver coil measures the fields and identifies variations in subsurface conductivity generating a model or map of subsurface electrical properties and the presence of conductive materials. Properties such as rock mineral content affect the subsurface conductivity or geological structures that can be associated with lithium pegmatite deposits (Haldar 2017; Marjoribanks 2010).

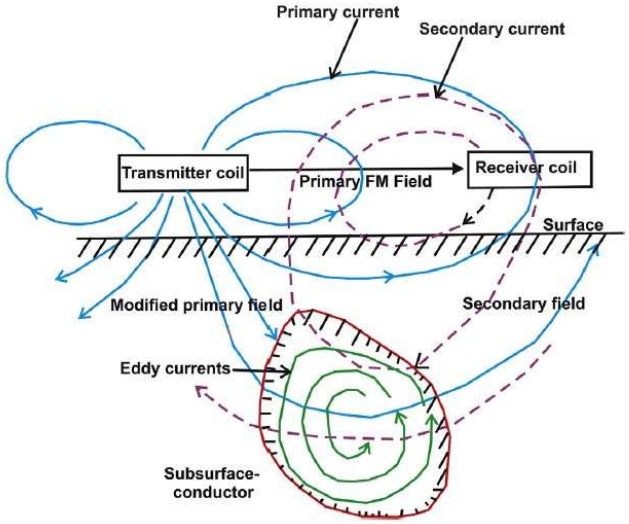


Figure 22. Conceptual diagram on electromagnetic surveying function of generating a subsurface model or map in presence of conductive materials. Source: (Haldar 2017)

Electrical Resistivity Tomography

Electrical resistivity tomography (ERT) is an exploration method that utilizes a direct current (DC) to image the electrical resistivity of the subsurface via a grid electrode system on the surface. A current is passed through the ground between the electrode pairs and measures their potential differences at other electrode pairs. The physical properties of the subsurface influence the electrical resistivity and thus a map of the subsurface resistivity distribution. The method is influenced by the placement of the electrodes. Manganese rich ores will exhibit a distinct resistivity contrast as compared to the host country rock and thus can assist in the identification of ore bodies. The method can also be used for estimating the ore reserves (Zaid et al. 2022). Such techniques could be useful in deposits such as those in the Luapula Province in Zambia, as the ore is generally found near the surface (Vasters and Schütte 2023). Similarly, ERT can assist in identifying pegmatites, as they can show distinct contract between it and the country host rock (Tassisa et al. 2024). Other common geophysical surveys are summarized in Table 6.

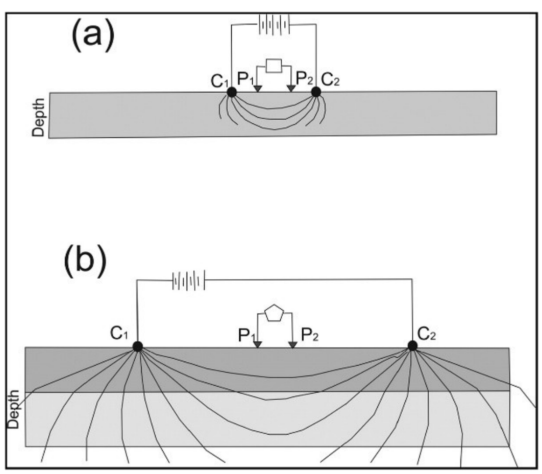


Figure 23. Conceptual diagram of ERT where C1 and C2 are current- and P1 and P2 are potential electrodes. Source (Nabi et al. 2020)

Table 6. Common geophysical surveying methods for ore body exploration and their application characteristics for underground mining. Sources: (Erkan 2008; Ghorbani et al. 2023; Jetschny, Bohlen, and Kurzmann 2011; Likkason 2014; Moon, Whateley, and Evans 2005; Wang et al. 2019)

Geophysical methods	Description and application characteristics
Magnetic surveys	Preferred where orebody to host-rock variation in magnetic properties is of interest. This method is used to discover deposits that host iron in magnetite, nickel in pentlandite, and titanium in ilmenite.
Electromagnetic surveys	Important where variations in electrical conductivity in the subsurface can be used to map geological structures and locate mineral deposits such as sulphides containing copper or lead, magnetite, pyrite, graphite, and certain manganese minerals.
Pure electrical surveys	Measures the differential flow of electricity in the subsurface in order to discover mineral deposits at shallow depths and determine the depth of overburden to bedrock. Electrical surveys have also been used successfully to locate the groundwater table.
Gravimetric surveys	Measures variations in the gravitational field caused by density variations in the subsurface. Has been used successfully to map geological structures such as faults, anticlines and salt domes that are often associated with oil-bearing formations. High-density minerals such as iron ore, pyrite and Pb–Zn mineralisation can also be mapped using gravimetric methods.
Radiometric surveys	Often used to map rock formations that contain elevated background concentrations of radionuclides such as uranium and thorium.
Seismic surveys	Records wave traversal through rocks and can detect changes in their physical properties. Often used to delineate subsurface layers, oil-bearing reservoirs, detect geological structures and mineral deposits. In-tunnel seismic imaging can be used for more detailed imaging. Reflection seismic surveys can be either 2D or 3D. Passive seismic can monitor ambient seismicity and image changes in surrounding rocks.

Common mining methods - Surface versus underground

Once it is established that an exploitable ore deposit exists, it is imperative that a process be undertaken known as life of mine (LOM) planning, which is a strategic approach to the consideration of many factors that ensure economically viable but also environmentally sustainable operations over the entire lifespan of the mine. The LOM planning begins before any ore is extracted and tries to foresee decisions that will ensure optimal performance during operations but also already makes plans for the eventual mine closure. Such issues as assessing if a deposit is likely to support a long term project, estimating reserves, determining appropriate mining methods, assessing infrastructure available to support such a project (prefeasibility stage), defining a mine extraction methods, establishing legal requirements, estimating capital and operating costs (feasibility stage), and waste management (NZPAM 2017).

An important decision in the LOM planning stage is the method at which the ore will be extracted. The mining method selection is choosing the most suitable mining technique for a particular deposit and geology, and evaluating factors to determine the most efficient, safe and cost-effective method to extract minerals. To a large extent the type of rock, its properties and structure and depth of the deposit overwhelmingly influence the mining method. The rock and deposits qualities such as friability, extent of metamorphism, shape of the overall deposit, in-situ stress and plasticity are all major factors in determining how the ore will be exploited, mainly due to the extent to which the ore body and the mine will need to be supported for safe working conditions (Atlas Copco 2007).

Surface Mining

Surface mining is the most commonly utilized. A production technique that is generally less risky operationally and financially more cost effective than the more complex and expensive underground mining. Furthermore, with the depletion of high grade resources and modern advances in extraction methods, surface mining can successfully extract lower ore grades, where the higher cost underground methods, the low grade ore would not be economically viable (Atlas Copco 2007). Additional advantages of surface mining are the following:

- More suitable for **near surface** deposits
- Can **successfully exploit** unstable, weathered, poor quality rock or disseminated deposit
- Generally considered **less complicated**, as it eliminates: the need for underground infrastructure like safe ventilation systems, power supply, and ore transport infrastructure to the surface, and avoids the need for slow working in confined tunnels and shafts,
- **Higher productivity and production capacity** due to higher mechanisation of the operations
- General better working conditions

Surface mining is not without its disadvantages. Surface open pits have a significant impact on the local environment and causes environmental degradation such as habitat destruction and modification of the local ecosystems. In addition, the large scar surface mining leaves on the landscape can lead to resistance within the local communities, potentially leading to mistrust and the development of their “not in my backyard” opposition. Thus, a company planning surface operations may encounter the need to obtain the so called “social license to operate” (Constantinides 2023). Further disadvantages to surface mining are the following (Gordon 2023):

- **Waste management challenges**, due to the removal of large quantities of overburden materials (rock, soil, and vegetation).
- **High waste to ore ratio**.
- Mine walls needs to be monitored for **stability**.
- Safe pit construction often requires wide pits to be constructed, thus the large quantities of waste or country rock removed require **tailings storage facility construction (TSF)**.
- **Long term safety monitoring** of a TSF, even years after mine closure.
- Surface mining can cause additional **environmental impacts**. They often impact the quality of the air (dust and particulate matter production), cause noise disturbances, and can risk water

pollution from poorly managed rain runoff, or acid mine drainage from any now surface exposed sulphide minerals present in the ore or country rock.

Figure 24 shows two similar types of surface mining techniques, the open pit and the high wall open pit. Both are common methods for mineral extraction, especially in copper, aluminium and iron ore mining (Gordon 2023).

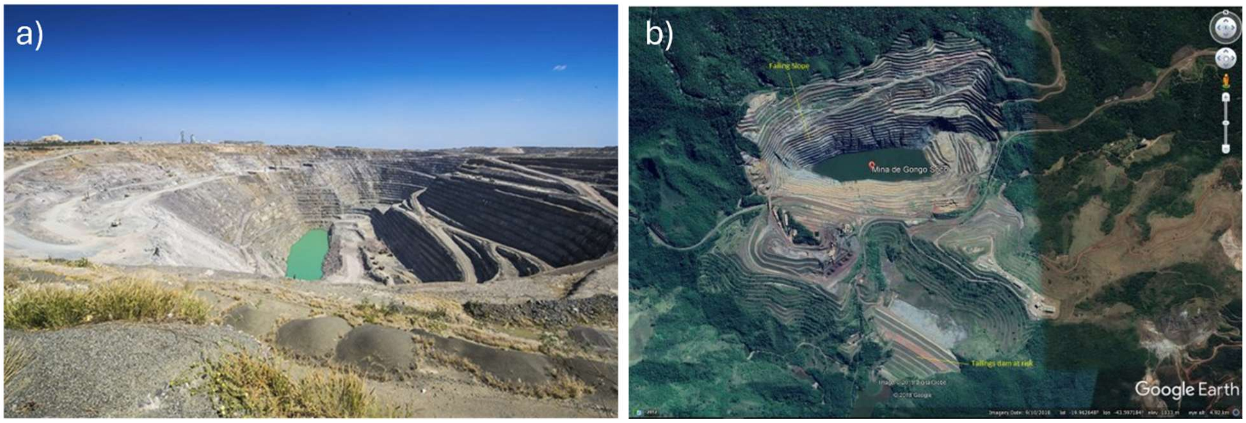


Figure 24. Photos of different surface mining techniques, a) open pit and b) high wall pit. Source: (Gordon 2023)

Underground Mining

The underground mining method is an ore extraction technique that attempts to maximize ore extraction while **minimizing** the amount of waste produced. Underground mining techniques are commonly more costly given the associated logistical and safety challenges; thus, it is commonly used with higher grade ores, where the extraction is economically viable (Ghorbani et al. 2023). Some advantages of underground mining are the following (Atlas Copco 2007):

- Gives access to **deep ore deposits**, that would not be accessible from the surface. Thus, a more precise targeting of higher grade ore bodies can be achieved. This potentially also can extend the life of the mine.
- **Preservation of ecosystems and landscapes** from the minimization of surface land use.
- **Fewer weather related interruptions**, which could ensure consistent production.

As with surface mining, there are also numerous disadvantages to underground extraction methods that need to be overcome should this technique be considered economically viable. Some disadvantages to underground mining are the following:

- Cooling – higher temperatures and humidities make for **challenging work conditions**.
- Ventilation – **air quality**, supplying workers with enough breathable air, while also venting any gases produced from underground equipment and rock blasting.
- **Safety** – prevention of rockfalls and cave-ins, avoiding potentially trapping miners. Changes to *in-situ* stresses of surrounding rock after operations begin, can cause instabilities over time.

Just cooling and ventilation are estimated to be between 30-40% of the total electricity costs of an underground mine (Ghorbani et al. 2023). Often, mines that start as surface operations then switch to underground when shallow ore deposits have been exhausted. Thus, many mines end up being mixed pit designs (Figure 25).

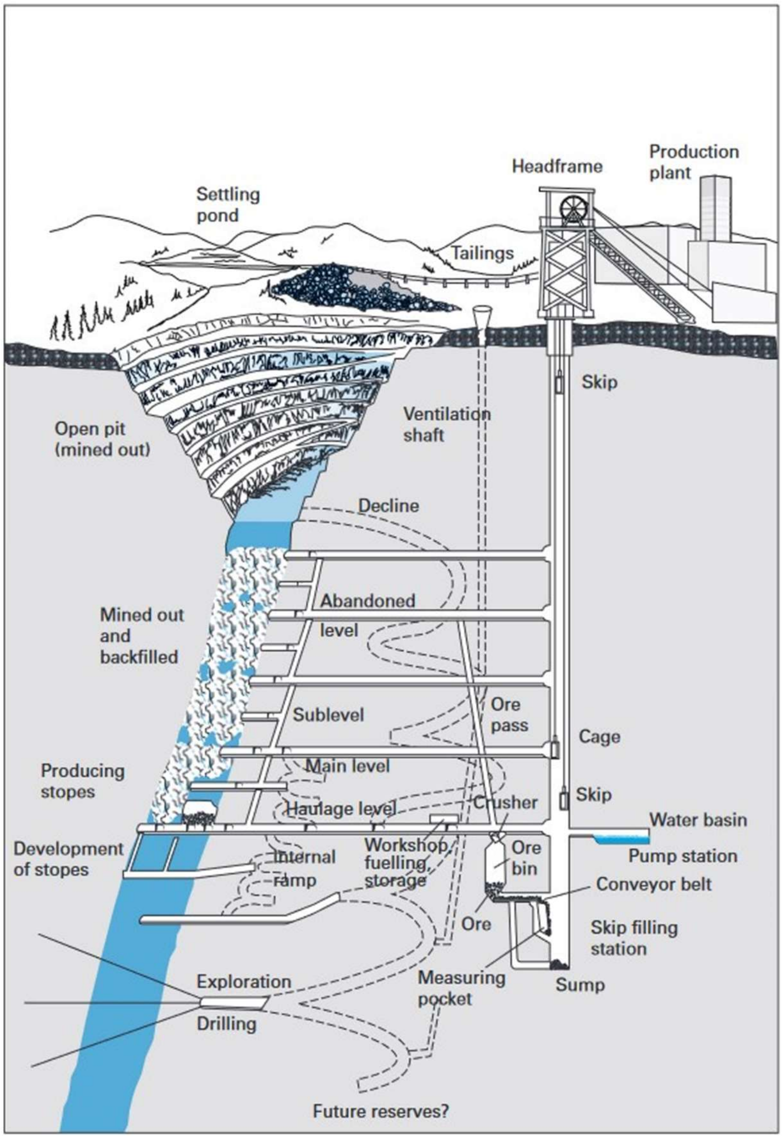


Figure 25. Conceptual diagram of the infrastructure required for safe and cost effective underground mining. Source: (Atlas Copco 2007)

Case Studies - Zimbabwe

A medium- to large-scale pit mine is located about 80 km east-northeast of the town of Bulawayo, Zimbabwe. Here the primary commodities mined are lithium and tantalum hosted in one of the region's many LCT pegmatites, found intruded into a local greenstone belt. The primary lithium ores mined are spodumene, petalite and lepidolite while the tantalum ore mineral is tantalite. The project owners utilize open pit mining techniques and include surface blasting for ore extraction. Ore processing is done on site, with sophisticated operations that include crushing and sorting, and floatation separation facilities (Premier African Minerals 2024; Premier African Minerals Ltd 2024).

Figure 26. Photo of active open pit operations mining lithium from a pegmatite found in Zimbabwe. Source: Robin Gilli

Case Studies - Madagascar

A small-scale underground mine is located near the town of Antsirabe, Madagascar. As in Zimbabwe, here the primary commodities mined are lithium, niobium and tantalum hosted in one of the region's many LCT pegmatites. The primary lithium ores mined are spodumene and lepidolite while the niobium and tantalum ore minerals are columbite and tantalite, also known as coltan.

Figure 27. Small-scale underground mine showing a) exposed lithium bearing pegmatite surface and b) a miner examining the lithium bearing mineralogy. Source: Robin Gilli

Case Studies - Zambia

A small-scale mine pit mine is located in the Luapula Region of Zambia, near the town of Mansa. Here the primary commodity mined is manganese, which is hosted in the sedimentary deposits of the Katanga Supergroup. Due to the loose nature of the deposit, the miners are able to utilize simple hand tools and heavy machinery, such as excavators, to extract the ore. The open pits are designed with benches and steps to ensure safe entry and exit of the workers. Small-scale miners can take crude ore to a facility in Mansa for further processing.

Figure 28. Small-scale open pit benched mine excavating manganese ore. Note the structural ramps designed for entry and exit. Source: Robin Gilli

Unit 3 – Processing and beneficiation

Beneficiation

Ore processing is a term for the multiple steps of separating the economically valuable components out of the ore materials excavated directly from the mine. Beneficiation is a term used to describe adding value to the target material through multiple purification steps. Thus, processing and beneficiation are steps to concentrate and purify the valuable material of interest from the material of little to no value. There are normally numerous beneficiation steps that must be taken to get the raw or to an economically viable concentrate. Common general steps of ore beneficiation are displayed in Figure 29.

When the ore comes out of the mine it is composed of the target mineral of interest as well as gangue minerals (not of economic interest) and any host rock (waste materials). The steps of processing and beneficiation generally start with numerous physical separation and purification techniques until a target intermediate product is obtained, where it is then further purified utilizing steps involving chemicals and other more complex procedures. Such physical separation steps include crushing, milling and sieving, followed by steps including magnetic and gravity separation. Steps that begin to involve chemical reagents include froth flotation and chemical leaching. The nature of the exact processing procedures depends on the properties of the ore and its host rock, such as hardness and texture, and location and size of ore (SGU 2024). Important physical and chemical processing steps are described below.

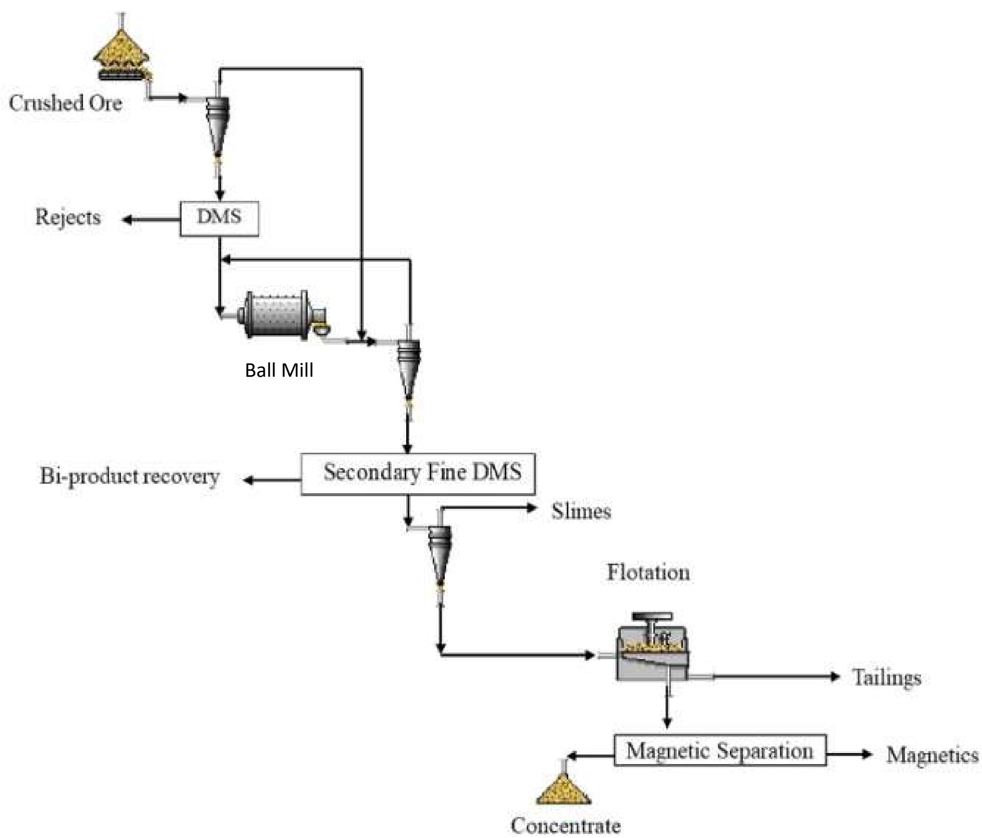


Figure 29. Common steps to ore beneficiation from raw ore to concentrate. Source: (Tadesse et al. 2019)

Physical Processing

Crushing and milling

The first step in ore beneficiation usually always begins with the crushing and milling in a process called comminution. The objective of this step is to begin to free the ore from the host rock and to obtain a specific sized material (SGU 2024; Tadesse et al. 2019). The raw ore is first put into a type of crusher and is then crushed into smaller, gravel sized fragments. This material is then passed through a mill, often through what is called a ball mill, where it is ground into sand or smaller sized fragments. This material is now ready for further separation steps (SGU 2024).

Gravity and dense material separation

Dense material separation (DMS) is a beneficiation process commonly used to separate out gangue minerals from ore and can be utilized in lithium ore mineral concentrating. It involves utilizing the difference in the specific gravity (SG) between the target mineral of interest and those not of economic value in a dense media (Gibson et al. 2021; Tadesse et al. 2019). In the case of lithium mineral beneficiation from pegmatite, this usually involves separation of the spodumene (SG 3.1-3.2) from minerals such as quartz (~2.65), feldspar (~2.60), and mica (~2.8), which all have significant differences in specific gravities as compared to the lithium ore (Tadesse et al. 2019). Thus, in the dense media, the spodumene will sink while the gangue minerals float in a dense media chosen for this process. Commonly used dense media for spodumene separation is a medium with a specific gravity lower than spodumene but higher than that of the gangue minerals, a medium mixture often with a range of SG between 2.6 and 3.1 (Gibson et al. 2021). The separated gangue minerals are then discarded as tailings or undergo further separation of any accessory minerals that could be of lesser value (Tadesse et al. 2019).

Magnetic separation

An important ore concentration step is called magnetic separation. Many ores and bodies hosting ores often contain iron-bearing trace minerals, as is especially the case in manganese ores, as the paramagnetic properties of Mn-Oxides are caused by trace iron minerals present. Pegmatites can also contain iron-bearing minerals. This procedure separates the non-magnetic ores with the magnetic gangue minerals that are not already separated during the gravity or DMS procedure. This procedure can also be conducted before the gravity or DMS step, depending on the conditions and mineralization of the ore body (Tadesse et al. 2019). Or in the case where the magnetic minerals are the ore minerals of interest, this separates out the gangue non-magnetic minerals, for example, this has been shown to be effective at separating the magnetic lithium mineral zinnwaldite ($KLiFeAl(AlSi_3)O_{10}(OH,F)_2$, with up to 11% FeO) from tin-tungsten bearing tailings (Botula, Rucky, and Repka 2005; Tadesse et al. 2019). The separated residues are then generally considered waste materials.

Chemical Processing

Flotation

Flotation is a common beneficiation step that utilizes the surface characteristics of minerals when the size difference between the target ore and the gangue mineral is too small for gravity separation or when the ore grade is low. This procedure is common for both lithium and manganese ore beneficiation (Andrade et al. 2012; Tadesse et al. 2019). The process consists of separating out hydrophobic and hydrophilic (repelled by- or attracted to- water, respectively) from one another (SGU 2024). For example this process can use chemical reagents and surfactants in addition to water, such as oleic acid and sodium oleate for manganese ores or reagents like anionic sulfonates and sulfates for lithium ores (Andrade et al. 2012; Tadesse et al. 2019). The separated residues are generally then also considered waste materials.

Refining - Chemical leaching

Refining is a general purification term and refers commonly the process to free the target metal from any last remaining, unwanted impurities. Ore can be further treated and refined with chemical leaching. A common concentrating and ore beneficiation process and is considered hydrometallurgy (Figure 30), leaching is one of the last steps in separating out the target metal (such as lithium or manganese) from certain types of ore and preparing them for final production. Commonly used to concentrate gold, chemical leaching consist of using chemicals like solvents or acids, to dissolve out the element of interest. It is often being used in the extraction of lithium from spodumene in low grade ores. Common, spodumene is leached using strong acids, such as a sulfuric acid, or alkaline solutions, such as sodium hydroxide. The product of the chemical leaching process is an intermediate product such as a lithium-sulfate or -hydroxide that can be further refined (Yelatontsev and Mukhachev 2021). Chemical leaching process can produce waste materials that could require special handling, given they contain acid or alkaline solution residues.

Refining - Roasting and Smelting

Once all the beneficiation steps are completed, generally the last purification steps of certain types of ore are roasting and smelting. These steps extract the pure metal from any intermediate product produced during beneficiation. Ore roasting and smelting are considered pyrometallurgy. Roasting is an intermediate step that uses a furnace to heat ore to a high temperature in the presence of air and is common procedure for ore containing sulphide (S^{2-}) impurities (Lottermoser 2010). If not done properly, roasting ore can be a source of air pollution. Smelting is generally the process by which heat is used to extract the metals as a melt, which is then separated from any other melted matter of no economic value. Once cooled, this waste material is then called slag (SGU 2024). Material can be added during the smelting that influences the process temperature or the composition of the waste materials (slag, see section 0), such as lime rock (CaO) or ironstone (Lottermoser 2010).

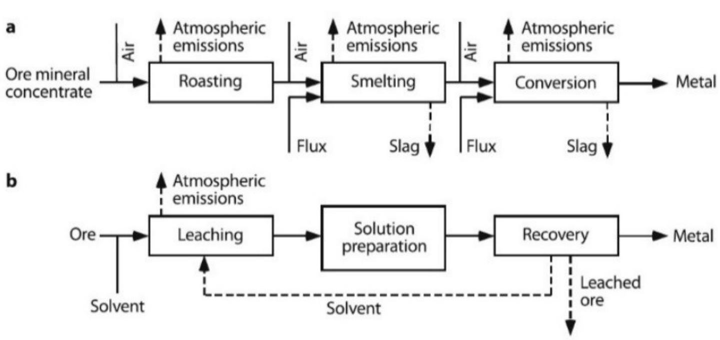


Figure 30. A simplified diagram of a) pyro- and b) hydro-metallurgical refining (Lottermoser 2010).

Unit 4 – Waste disposal and tailings storage

There are many types of wastes that are produced during the process of mining ore material to refining the ore to a metal, including waste from the ore body host rock that has no economic value to waste that is generated with the extraction of the target ore mineral and processing it to the end stage product. Figure 31 displays a generalization of the various wastes and where in the mine life cycle they are generated (Taha and Benzaazoua 2020). This material varies from waste rocks, tailings, and metallurgical wastes like slags, and their disposal and management can present many challenges in both the short and long term of mine operations.

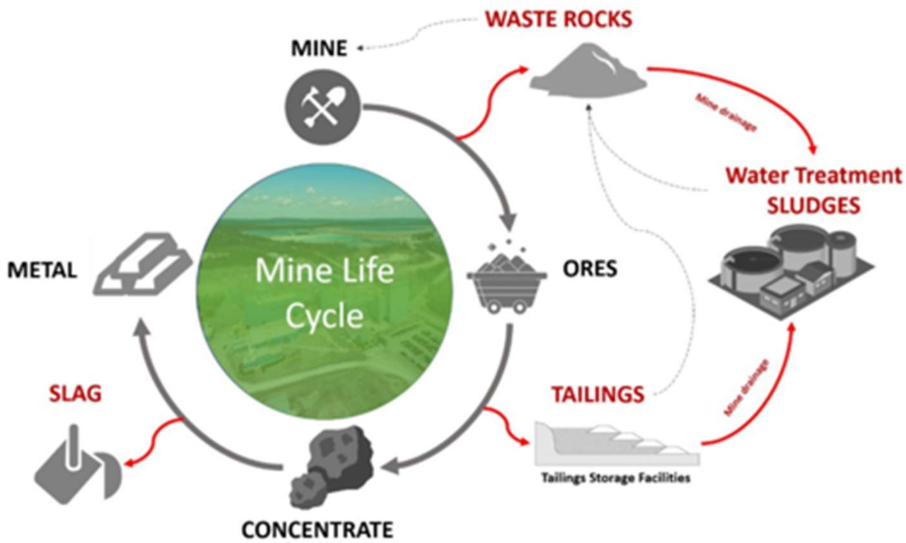


Figure 31. A generalization of the various types of wastes generated during the typical life cycle of a mine, including waste rocks, slags and tailings. Source: (Taha and Benzaazoua 2020)

Waste Rocks

Whether mining occurs from surface or underground operations, a large volume of material has to be removed in order to access the ore deposit of interest. In open pit mining, often the overburden material consists of any soil and subsequent unconsolidated overburden material layers that exist directly on the surface. When a LOM process has been thoroughly conducted, any soil existing can be stockpiled for later use during land reclamation and remediation once operations have ceased. Other unconsolidated materials such as loose sand and gravel deposits are considered waste and must be managed. Other materials considered waste rock are any country rock or wall rock that is hosting the ore body. Such material either contains no ore or has such a low concentration of ore it is not economically viable to process. The **ore grade** is the proportion of valuable minerals in the ore rock. The lower concentration limit of ore material, in which a rock is of value to the mining operations, is called the ***cut-off grade***. Waste rock are generally very heterogeneous materials and can vary in size from silt and clay to large boulders, which can often cause challenges for their disposal (Lottermoser 2010).

Processing waste and tailings

The next type of production wastes is called tailings. This is a general term given to waste materials that are produced during the physical beneficiation processing. These wastes can vary from colloidal clay sized, to coarse gravel sized materials and are determined to contain little to know ore minerals of value. Sludge or wastewater from processing water can also be considered processing waste. It is possible that some of this material could be used again for mine reclamation or remediation but most of this material ends up being stockpiled in what is known as a tailings storage facility (TSF), which are often constructed near the mine itself (Lottermoser 2010).

Metallurgical Wastes

Once the physical processing and beneficiation steps are completed, wastes are also produced during the various metallurgical beneficiation steps. These metallurgical wastes can be quite different from tailings. These wastes are produced from hydro or pyrometallurgical refining process, which involves the use of chemical solutions, solvents, or flux materials that then end up in the waste materials once the metal of interest has been extracted and thus produce a wide range of waste products. Metallurgical wastes can be anything from fine dust, slag material, wastewater or the remnants after leaching and can often cause issue for their long term storage. Often metallurgical wastes are dispose of in TSFs (Lottermoser 2010).

Acid Mine Drainage

An important part of mine waste management is developing a plan to manage run off waters. Acid mine drainage (AMD) is a common problem at mines where sulphide minerals are present. Frequently run off at these mines can react with and oxidize any iron (FeS_2) or other sulphide minerals found in the ore and country rock and produce sulphuric acid and dissolved iron. This iron can then precipitate to form a fine grained, ferrous hydroxide nanomaterial that can be suspended in the water as colloids or settle out in the mud and sediments of the streams in the mine's drainage basin. AMD thus creates water that subsequently has a low pH value and the iron precipitate can stain the surrounding region with a bright orange colour. Such water can cause environmental damage to the surrounding ecosystem by leaching out metals and metalloids from the area, yielding water that is toxic to aquatic organisms. In addition, the ferrous hydroxide precipitation is very reactive and can influence the ecosystems in numerous ways. While the iron precipitation is common result of AMD, not all AMD produces this by-product (Simate and Ndlovu 2014).

There are numerous strategies employed at mines to handle water runoff and prevent AMD. In the early stages of LOM planning, the potential for AMD can often be predicted and engineering controls of water management can be developed for before the mine begins any ore excavations. One common methods of prevention or controlling AMD is to separate **sulphide containing**- from **non-sulphide containing** waste rock. These materials can then be covered with a soil layer or some other material to hinder oxygen availability inside the waste heaps (SGU 2024). A buffering rock, such as limestone ($CaCO_3$) can be subsequently mixed with or layered between sulphide containing waste rock. The limestone will readily dissolve in the presence of any AMD and neutralize any acidity and reduce the solubility of heavy metals in the waste rock (Skousen, Ziemkiewicz, and McDonald 2019). A common method for AMD prevention that can be used at underground operations is to backfill or flood abandoned shafts to hinder air from contacting and reacting with the sulphides (SGU 2024; Skousen, Ziemkiewicz, and McDonald 2019).

Figure 32. Example of the confluence of an acid mine drainage (AMD) and yet unimpacted creek upstream from a sulphide mine. Note the orange iron-hydroxide precipitation. Source: Robin Gilli

Tailings Storage Facility

As previously mentioned, tailings are the residual material produced during the ore beneficiation process. Depending on the cut-off grade of ore, a large volume of tailings can be generated, requiring the construction of a tailings storage facility (TSF) for long term tailings disposal. The TSFs are generally designed specifically to the surrounding environment with a variety of construction techniques. Figure 33a shows generalized construction. The TSFs generally consist of a high embankment acting as a dam and can be constructed of non-sulphide containing waste rocks, with varying degrees of liners barriers and/or geomembranes for long-term stability and low permeability. They can be constructed in an upstream, downstream or centreline manner (Figure 33b) depending on the direction in which the embankment crest is in relation to the base of the embankment wall (Oberle, Brereton, and Mihaylova 2020). Fine- to coarse grained tailings are then discharged behind the dam embankment and often contain some amount of water, which can assist in preventing any AMD should sulphides be present in the tailings. This concept is generally called a conventional impoundment storage (SGU 2024).

It is imperative that TSF be monitored for their proper design, construction and long term stability. Depending on the size and the duration of mining operations, TSF can become enormous man-made structures in the landscape. Depending on the location of their construction, failure of an unstable TSF can have devastating consequences to the surrounding communities. Numerous failure of TSF have occurred in the past; however, a recent and particularly disastrous TSF failure occurred at Brumadinho, Brazil in 2019 (Figure 33c), when 248 people lost their lives and 22 people went missing. The dam failure spilt about 12 million cubic meters of mud, sludge and tailings, downstream of the TSF, polluted the flood plain and devastated the regions ecosystem (Cheng et al. 2021). It was after this disaster that the International Council on Mining and Metals (ICMM), the United Nations Environment Programme (UNEP) and the Principles for Responsible Investment (PRI) came together to co-convene a process to establish an international standard for safe management of TSFs, called the Global Industry Standard on Tailings Management (GIST).

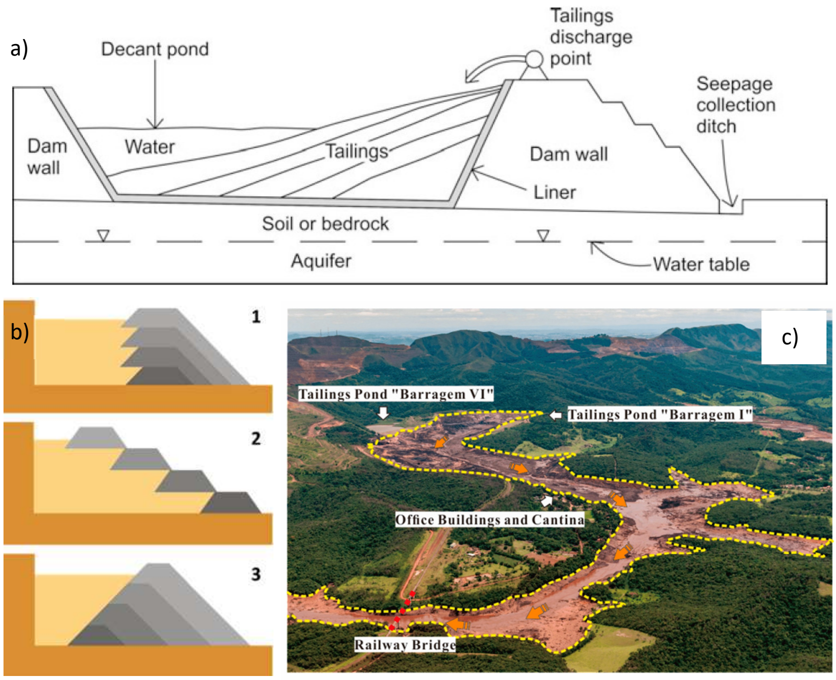


Figure 33. a) Simplified cross section of a tailings storage facility (TSF) for tailings waste, b) three common methods for TSF construction, and c) an example of a potential consequence of a TSF failure, Brumadinho, Brazil in 2019. Sources: (Cheng et al. 2021; Lottermoser 2010; Oberle, Brereton, and Mihaylova 2020; SGU 2024)

Group work or exercise

Training Worksheet – Rock & Mineral Identification Sheet

Training Exercise - Rock & Mineral Identification Laboratory

Rock & Mineral Identification Sheet

Rock Forming Minerals

Quartz

Color and Luster: White (*milky quartz*), colorless and transparent, and in various shades, purple – *Amethyst*; pink – *rose quartz*; clear-yellow – *Citrine*; pale brown to black – *smoky quartz*

Crystal shape and breakage: Forms hexagonal crystals terminated with a pyramid when perfect, otherwise forms masses; breaks into circular “conchoidal” fractures with sharp edges.

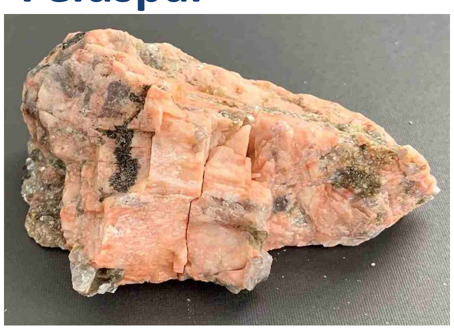
Mica

Image source: Wikipedia

Color and Luster: White or colorless, and in various shades pearly brown – *muscovite*; dark brown to black – *biotite*; pink to purple – *lepidolite*; all can appear to “sparkle” in the light.

Crystal shape and breakage: flat and commonly tabular, when viewed to the side looks like pages of a book; can be large to very small in size; breaks into flakes.

Feldspar



Color and Luster: Clear, white, pink, brown, gray, blue-green, rainbow; forms a series of minerals with different elemental components; white – *albite* or *anorthite*; pink – *orthoclase*; blue-green – *microcline* also called *amazonite*; rainbow – *labradorite*.

Crystal shape and breakage: forms rectangular or square blocks, otherwise forms masses; breaks with 2 directions forming a 90° angle.

Rock Forming Minerals

Amphibole

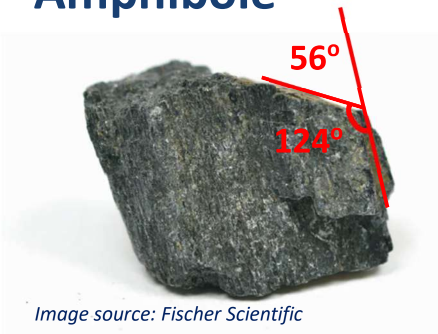


Image source: Fischer Scientific

Color and Luster: Most commonly gray, black or dark brown – *Hornblende*, green – *actinolite*; dark blue-gray – *glaucophane*.

Crystal shape and breakage: Forms in magmas cooling above or below ground and metamorphic rocks; form usually in long column shaped crystals that have a splintery, fibrous-like appearance, otherwise forms masses; breaks in 2 directions forming 56° / 124° angles.

Pyroxene


Image source: Eisco Labs

Image source: Eisco Labs

Color and Luster: Most commonly black to dark green, grayish green – *Augite or Hedenbergite*; apple green – *Jadeite*; white to gray or yellow - *Spodumene*.

Crystal shape and breakage: Forms most commonly in magmas cooling above or below ground; forms usually short, stubby mineral shapes; breaks in 2 directions forming 90° angles.

Lithium Ores

Spodumene

Image source: Turnstone Geological Services Ltd.

Color and Luster: Most commonly in rock as white or pink and appears cloudy or glassy; gem varieties: clear with pink hue – *kunzite*; green – *hiddenite*; it can look similar to feldspar.

Crystal shape and breakage: forms needle to table or rectangular shaped crystals, appears with light lines on surface; otherwise also forms masses; breaks in 2 directions forming a 90° angle. Is a member of the pyroxene family.

Lepidolite

Color and Luster: Found in pegmatites; commonly pink to light purple, can also be white; pearly and appears to "sparkle" in the light.

Crystal shape and breakage: Most commonly forms aggregate masses of very small crystals that give the appearance of "scales", rarely forms large,flat and tabular flakes, when viewed to the side looks like pages of a book. Is a member of the mica family

Petalite

Image source: mindat.org

Color and Luster: Found in pegmatites, commonly found at Zulu and Bikita mine; commonly colorless to white or is often light pink; can milky to semi-glassy.

Crystal shape and breakage: Most commonly forms blocky to long crystals, often tabular shaped. Can often break into circular "conchoidal" fractures with dull to semi-sharp edges

Common Rocks

Granite

Image source: nagra.ch

Image source: geologyscience.com

Texture and color: Magma that cooled underground, crystals are usually visible with the eye; colors can vary from white, black, pink, brown; some crystals appear milky, glassy and/or pearly.

Minerals present: Common minerals are white and pink feldspars, dark grey to black amphiboles and pyroxene, clear to white, glassy quartz, pearly brown to black micas (common with both *muscovite* and *biotite*).

Common Rocks

Pegmatite

Image source: US National Parks Service

Texture and color: Magma that cooled *very* slowly underground, crystals are *extremely* large and visible with the eye; colors can vary from white, black, pink, brown; some crystals appear milky, glassy and/or pearly. Similar to granite.

Minerals present: Common minerals are white and pink feldspars, dark grey to black amphiboles and pyroxene, clear to white, glassy quartz, pearly brown to black micas (common with both *muscovite* and *biotite*). Commonly occurs with valuable trace minerals like *tourmaline* (often black), *spodumene, petalite, cassiterite, aquamarine, coltan, zircon*

Basalt

Texture and color: Magma that cooled *above ground*; is typically dark gray to black, can age to brown; crystals are usually small and difficult to see with the eye, when viewed with the magnifying glass, the crystals are black, white, and sometimes glassy green; can often appear to have vesicles or "holes".

Minerals present: Common minerals are white feldspars, dark grey to black amphiboles and pyroxene, clear to white, glassy green (*olivine*).

Sandstone

Image source: geologyscience.com

Image source: nagra.ch

Texture and color: Sedimentary rock consisting of smaller sand sized particles, that is difficult to see with the eye, but easy to see with a hand magnifying glass. Particles often look glassy and rounded; can contain fossils; rock can often appear "layered" or "banded"; rough and gritty to the touch.

Minerals present: Common minerals are glassy to white quartz, white feldspars.

Common Rocks

Gneiss

Image source: nagra.ch

Image source: sciencephoto.com

Texture and color: Common metamorphic rock formed from high temperatures and pressures; almost always has a "banded" appearance with alternating dark and light colored bands; crystals often visible to the eye and are usually white and black, sometimes pink and black.

Minerals present: Common minerals are glassy to white *quartz*, white feldspars alternating with black mica (*biotite*) and amphibole

Schist

Texture and color: Common metamorphic rock of medium size crystals that can easily be seen with a hand magnifying glass; has the appearance of having flattened "layers" that are often folded; rock is often smooth to the touch.

Minerals present: Common minerals are abundant shiny, flat mica minerals (black – *biotite*, brown pearly – *muscovite*), black to green minerals of amphibole (*hornblende* or *actinolite*), Commonly occurs with valuable trace minerals like *garnets*, *emeralds*.

Greenstone

Image source: Wikipedia

Texture and color: Common metamorphic rock consists of crystals that are small to medium in size and can be easily seen with a hand magnifying glass but often more difficult to see with the eye; crystals are typically dull and are dark green to black. Looks similar to basalt.

Minerals present: Common minerals are abundant green or black amphibole minerals (*actinolite or hornblende*), feldspars (*albite*), and small mica minerals (*chlorite*).

Rock and Mineral Identification Lab

Identify the following common minerals

Quartz – Common rock forming mineral, can be colorless, white (milky quartz), **pink** (rose quartz), **purple** (amethyst), **yellow brown** (citrine quartz) or **gray black** (smokey quartz), commonly found in granite, gneiss, and sandstone. Appears glassy, and when broken, can have sharp edges with circular patterns at the point where it broke. Uses – makes glass, colored varieties can make gemstones.

Feldspar – Common rock forming mineral, can be white or **pink**. Forms **blocky** crystals shaped like a table and appears like it has **light lines** on the mineral surface. On the broken edges it appears with right angles. Commonly found in granite and gneiss. Uses – makes ceramics, glass, construction tiles, insulation for buildings.

Mica – Common rock forming mineral, can be clear, **brown**, or **black**. Forms broad, flat flakes that are stacked on top of each other. When viewed from the side it appears like the pages of a book. Often looks shiny in the light. Commonly found in granite, gneiss and schist. Uses – makes computer chips and electrical parts, insulation, construction dry wall, a component in paint and cosmetics.

Spodumene – Mineral found in pegmatites. Forms needle to table shaped crystals that can grow to very large in size (up to 12 meters!) and often appears like it has **light lines** on the mineral surface. On the broken edges it appears with right angles. It is commonly white but can also be **light pink** and it is normally cloudy. However, when it is glassy to semi-glassy and clear to pink in color it is called Kuznite, when it is glassy to semi-glassy and **green** in color it is called Hiddenite. Can look similar to feldspar. It is the most sought-after ore for **lithium**. Uses – batteries, ceramics, glass.

Lepidolite – Mineral found in pegmatites. Forms aggregate masses of small flat crystals that give the appearance of "scales", which can often appear to "sparkle" in the light. It is often **rose** or **light purple** colored, but can also be white. It is an ore of **lithium**. Uses – makes ceramics, glass, and can be used for batteries.

Funded by
the European Union

Petalite – Mineral found in pegmatites. Forms a long crystal that can also be shaped like a table. It is glassy to milky and can be white or **pale pink** in color. It is an ore of **lithium**. Uses – makes ceramics, glass and can be used in batteries.

Identify the following common rocks

Granite – Is magma that was ***not*** erupted out of a volcano instead cooled below ground. **Large crystals** visible to the eye, with crystals colors of white, **pink**, clear glassy, and black and they are different shapes. Some crystals may shine in the light. Rock is very hard to the touch.

Pegmatite – Is magma that was ***not*** erupted out of a volcano instead cooled below ground, very slowly. Similar to granite, this rock has **extremely** large crystals, visible to the eye. Crystal colors are white, **pink**, clear glassy, and black and the minerals are different shapes. Rock is very hard to the touch.

Basalt – Is magma that erupted out of a volcano and cooled **above ground**, is dark gray to black in color. Crystals are **small** and difficult to see with the eye. When viewed with a hand magnifying glass, the crystals are black, white and sometimes glassy green. Can often appear to have vesicles or “holes”.

Sandstone – Common sedimentary rock consisting of smaller sized, **sand** “particles” that can be easily seen with a hand magnifying glass. Particles often look “glassy”. Can often contain fossils. Rock can sometimes have a “layered” or “banded” appearance and is often rough and gritty to the touch.

Gneiss – Common metamorphic rock formed by high temperatures and high pressure almost always has a “banded” appearance of **alternating** dark and light colored bands. Crystals are often visible to the eye and are usually white and black. Rock is very hard to the touch.

Schist – Common metamorphic rock of medium size crystals that can be easily seen with a hand magnifying glass, has an appearance of having **flattened** “layers” that often are folded, contains abundant **shiny, flat** (*mica – biotite and muscovite*) minerals, sometimes also contains large crystals (ex., garnets, emerald). Rock is often smooth to the touch.

Greenstone – Common metamorphic rock, consisting of **dark green** to **black** crystals that are small to medium in size and can be easily seen with a hand magnifying glass. Rock is very hard to the touch and looks similar to basalt.

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Instructions

You have 6 randomly ordered **minerals**. Please identify the minerals and write the name of the mineral in the table below. Use the mineral descriptions provided above.

Minerals Identification Table

Mineral Number	Mineral Name	Notes
1		
2		
3		
4		
5		
6		

Notes

You have 6 randomly ordered **rocks**. Please identify the rocks and write the name of the rock in the table below. Use the rock descriptions provided above.

Rock Identification Table

Rock Number	Rock Name	Notes
1		
2		
3		
4		
5		
6		
7		

Notes

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2.4. Module 4: Management of Environmental, Health, Safety and Social Issues

Module Title	**Management of environmental, health, safety and social issues**
Module Aims	This module aims to provide participants with knowledge on the management of environmental, social, safety and health issues commonly found at the artisanal and small-scale mining sites.
Specific Learning Outcomes	Upon completing the module participants will, through assessment activities, show evidence of their ability to: • Understanding the basic environmental issues associated with ASM activities • Understand the fundamentals of the mercury cycle and acid mine drainage and their contamination in the environment • Understand the fundamentals of diverse social issues common to ASM • Become familiar with the diverse health and safety issues common to ASM and how to manage them, including a health and safety management plan.
Comprehensive Learning Outcome	The course ultimately aims to build capacity among ASM workers on recognition and management of diverse environmental, social, safety and health issues.
Module Content	• Environmental issues and Environmental management plan • Management of social issues • Management of occupational health and safety issues
Methods of Facilitating Learning	This Module will be facilitated through modular lecturing, group discussions, group exercises, and presentations.
Reflection on learning outcomes	Group presentations and feedback from the trainees on ranking the relevancy of themes presented, soliciting responses on if they expect the content presented and lessons learned to impactful.
Student Support & Learning Resources	Group Exercise - Identifying & Addressing Environmental Impacts in Operations Group Exercise - World Café - Environmental and Social Issues Course materials in form of PPT slides and additional information on relevant publications, internet resources and other reading material will be provided.

Introduction

With the ever increasing push for critical raw materials needed to drive the energy transition, there has been an ever increasing growth of the artisanal and small scale mining (ASM) sector. Some recent estimates have 40.5 million people being directly involved in the sector (, emphasizing just how immense this sector is globally and it is growing (IGF 2017). The majority of the sector is involved in the production of gold; however, there has been growth in ASM mining CRMs, like lithium and manganese as well. The ASM sector is often associated with a significant negative impact on the environment around the mines where the miners are working. Many of these environmental issues are also common to large scale mining (LSM) as well. The following sections will introduce the environmental issues primarily associated with the ASM sector with overlapping discussion on impacts caused also by LSM operations and mining in general.

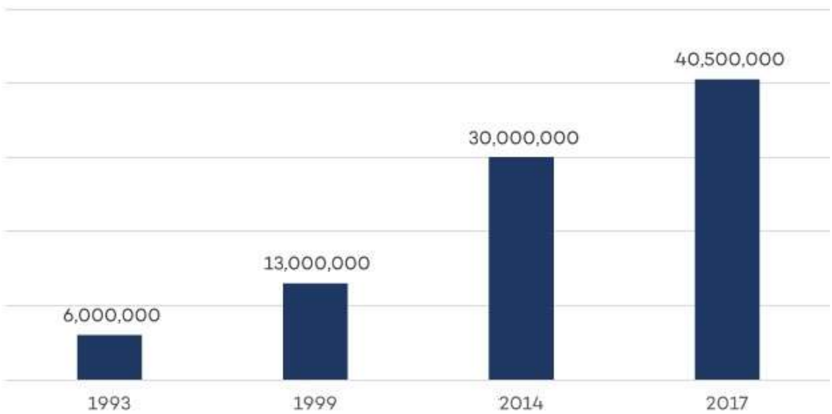

Figure 34. Bar graph showing the increase of ASM operations worldwide between 1993 and 2017. Source: (IGF 2017).

Unit 1. Management of environmental issues

Deforestation

The importance of healthy forests to the environment are generally well known. They provide a source of clean fresh air, naturally sequester CO_2 and provide habitat and food for a number of species, humans included. Unfortunately, mining, ranging from the large to artisanal scale, is associated with extensive deforestation and land degradation with recent estimates showing that 63% of deforestation happening after 2010 was a result of the expansion of mining activities, specifically in the tropical and subtropical forests, whether this be directly cause by clearing land for mineral extraction or indirectly through support activities the building of mining related infrastructure (Kramer et al. 2023). Deforestation is also directly related to an increase in CO_2 emissions (Figure 35) with Indonesia and Brazil showing the largest tree cover loss and subsequent CO_2 emissions (Stanimirova et al. 2024). While much of this loss is related to the mining of coal and gold, it is expected that with the increasing demand for critical raw materials to drive the energy transition, deforestation will continue to rise (Kramer et al. 2023).

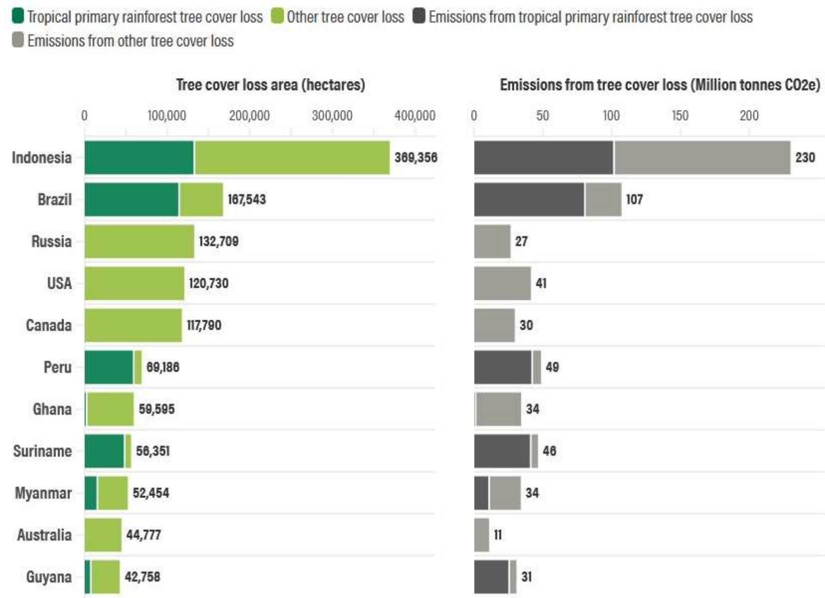

Figure 35. The countries leading in tree cover loss and associated emissions related to mining activities between 2001 and 2020. Source: (Stanimirova et al. 2024)

There are some significant differences in deforestation from LSM and ASM activities. Given the large industrial scale of LSM activities, it is often that LSM is often subjected to regulatory oversight and compliance with environmental regulations. ASM activities, however, are generally unregulated and informal, often with little to no oversight, especially of their ore extraction methods, which in the case of gold can often involve the use of the toxic mercury. Consequently, ASM is often not subject to any surface or landscape remediation or rehabilitation of their operations (Kramer et al. 2023). An example of ongoing deforestation is found in the gold- and bauxite (aluminium ore) rich country of Ghana (Figure 36). Its land is predominantly covered by a mix of grass-, shrublands and forests. A recent study found that about a third of the deforestation of the country (approximately 62.7 km^2) in regions with high ASM activities, was caused by the expansion of ASM gold mining (Kramer et al. 2023).

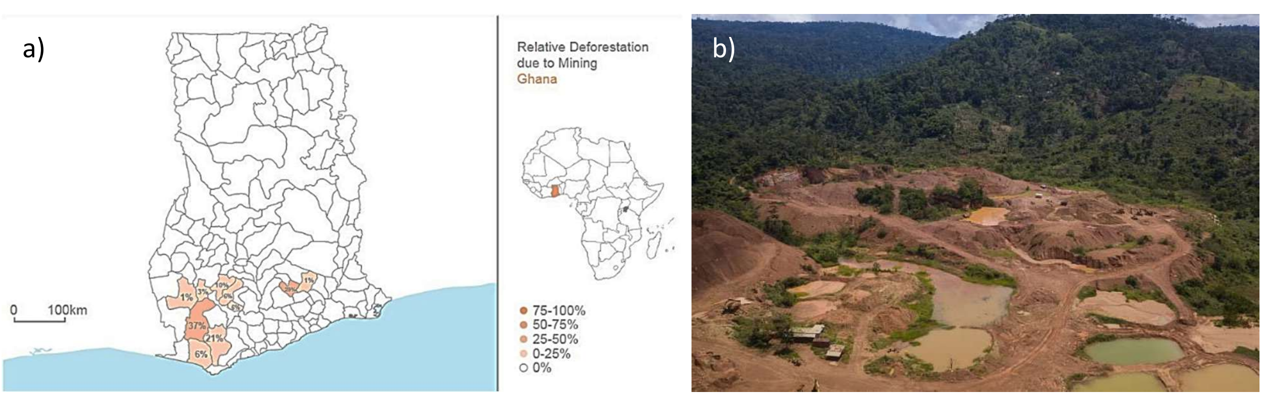

Figure 36. Shows a) map of relative deforestation of Ghana related to mining and b) an image of ASM gold operations in the country. Sources: (Damptey 2023; Kramer et al. 2023).

Soil Degradation

Deforestation can have a significant impact on the degradation of the land and subsequent erosion of the soil. This can lead to a number of consequences that can have lasting effects on the surrounding ecosystems and the communities which rely on healthy soil. Overall, soils in sub-Saharan Africa are significantly degraded (Figure 37a), caused by numerous factors including the expansion of agricultural activities to feed a growing population (Tully et al. 2015). Deforestation caused by mining further exacerbates the soil conditions, as streams draining mining areas are often carry high sedimentation loads from easily eroded deforested areas. This increase in soil erosion can have significant impacts to riverine environments. The high turbidity can negatively impact the aquatic organisms not adapted to these conditions (Wantzen and Mol 2013). In addition, channels can be severely impacted by sedimentation, shallowing the river bed, making navigation difficult and increasing the risk of flooding (Muzamwese 2020).

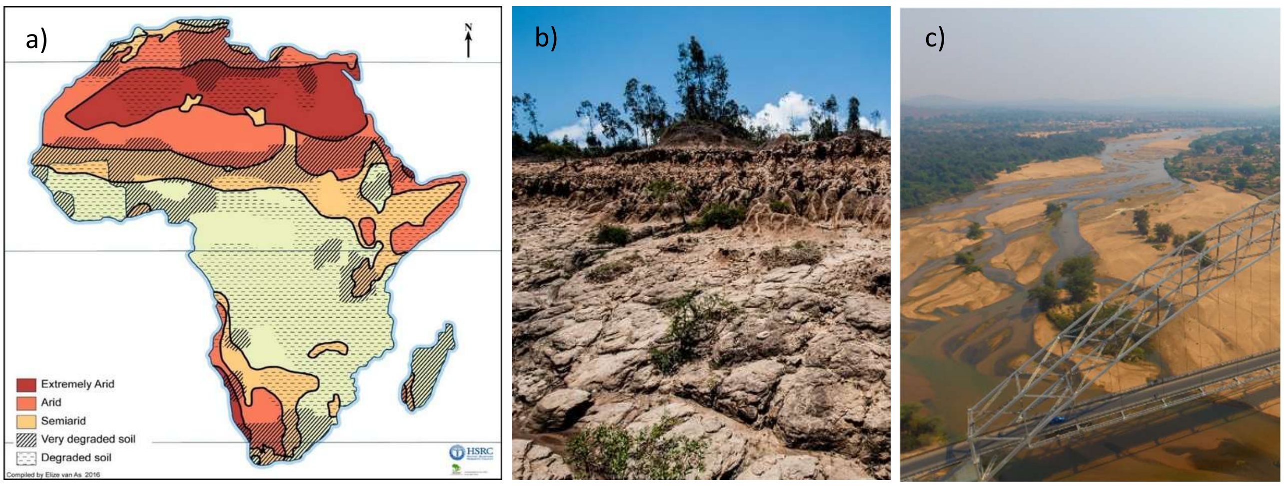

Figure 37. a) Map showing the degrees of soil degradation across Africa; b) image of an extensively degraded soil in Ethiopia; c) an example of soil erosion due to unsustainable mining activity causing chocking of the Save River, Zimbabwe. Sources: (Cavallito 2021; Managa and Nkobole-Mhlongo 2016; Muzamwese 2020).

Soil contamination

Soil contamination is very common in the areas around mine sites. There are many ways the soils can be negatively impacted, from emissions of dust generated by or chemicals used during extraction activities, improper tailings and processing waste disposal, to acid mine drainage.

Dust produced from extraction and processing activities are one of the primary sources of contamination to the soil in the vicinity around a mine. Such activities producing dust include drilling and blasting, transportation, and some beneficiation that may occur at the mine, including crushing, milling and sieving and screening (Noble et al. 2017). Often, dust contains high concentrations of metals and metalloids, often reflective of the ore minerals being mined, which can be toxic if inhaled or digested by humans or other organisms. Dust can be a range of particle sizes, from micro- to nanometre in scale; thus, their dispersion can range from the immediate vicinity to even long- range transport (Csavina et al. 2012).

While not utilized for CRM extraction, mercury (Hg) is still commonly used for fine placer gold recovery from sediments by the ASM sector. **All forms** of Hg are **toxic** and it represents a major health and environmental concern, especially for the regions where ASM is active. Mercury has been used for centuries to capture gold and is still very much used today. Liquid mercury is added either during the ore grinding process or directly during the gold panning of placer deposits at or near the water's edge. Mercury dissolves the gold into the liquid metal droplet forming an amalgam, or an alloy of Hg and gold. Given that Hg readily evaporates, the process to recover the gold from the amalgam involves the burning and release of the Hg to the atmosphere, leaving the concentrated gold behind. Figure 38 displays the stepwise process of extracting gold from placer deposits (represented in the figure by sand).

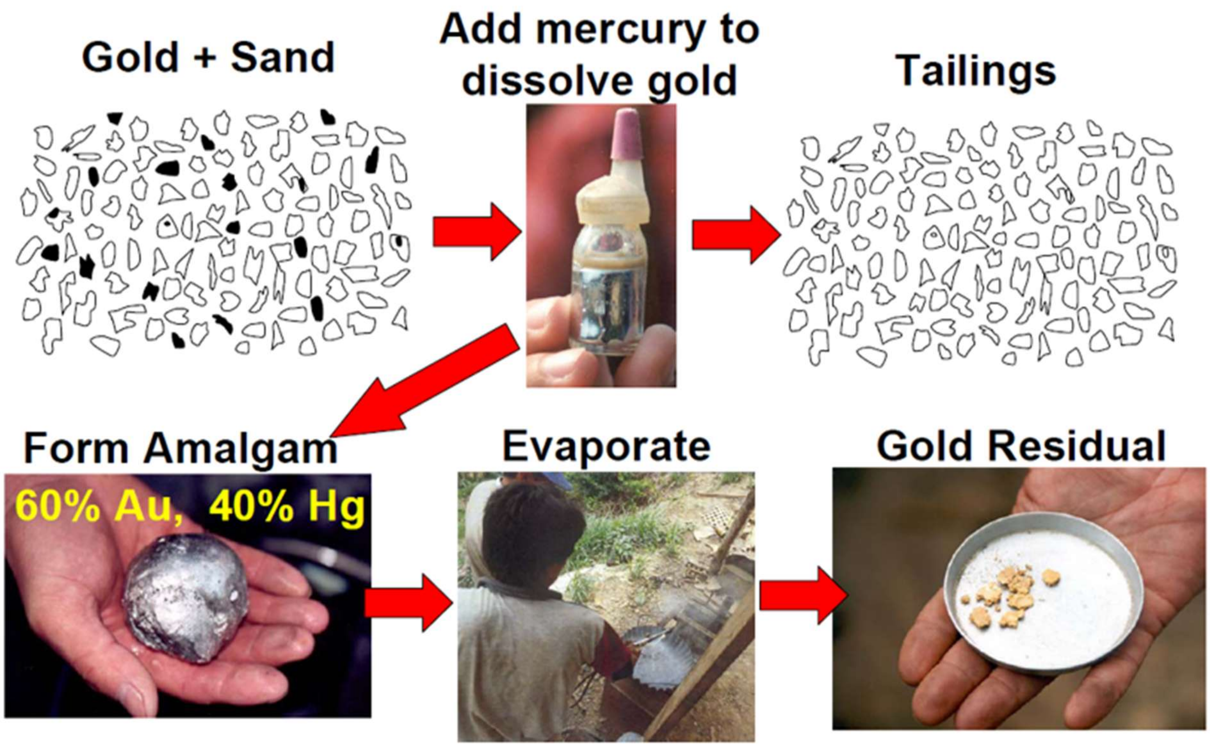

Figure 38. The stepwise procedure of using mercury (Hg) for gold recovery from placer deposits. Image source: (Telmer 2010)

In one study looking at heavy metal concentrations in the soils around a gold mining region in Senegal (Figure 39a), the researchers determined that the highest levels of Hg (Figure 39b) are found in villages linked to a large number of ASM activities, where gold is known to be recovered using Hg (Thiombane et al. 2023). Overall, there is a significant correlation between areas where there are ASM and LSM activities and higher concentrations of Hg in the soil. The study also revealed high concentrations of other toxic heavy metals in the soils in and around regions with mining activities (Thiombane et al. 2023).

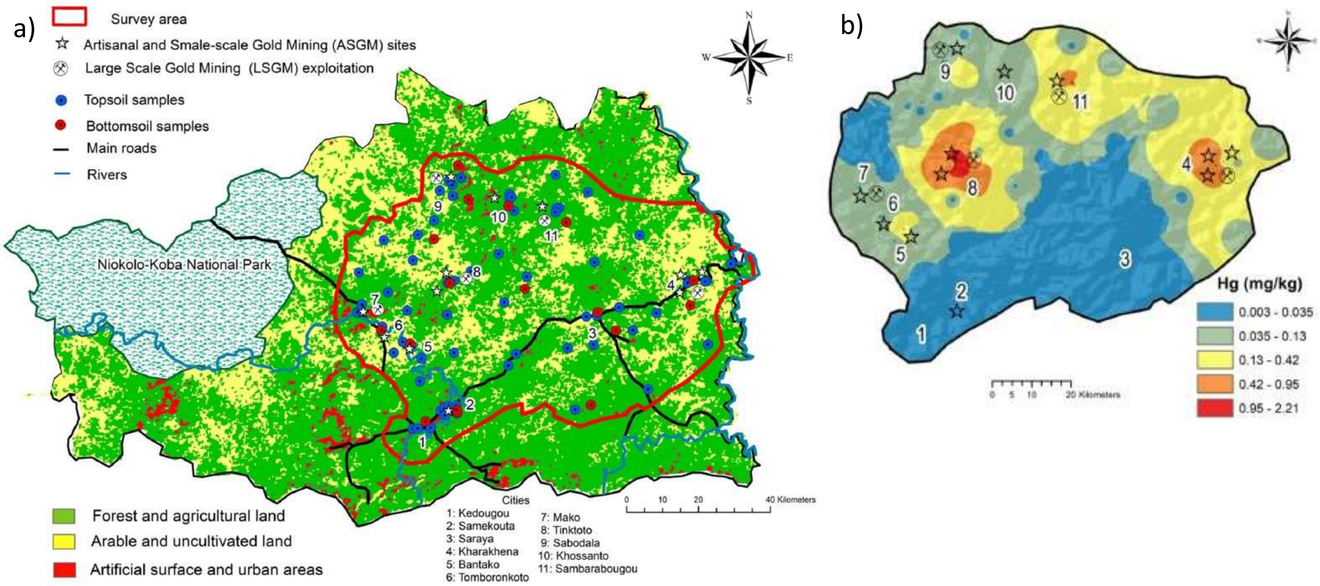

Figure 39. a) An example a study showing the sampling plan of a region in Senegal where both ASM and LSM are mining gold and b) the concentrations of Hg in the soil. Source: (Thiombane et al. 2023)

Mercury is released into the environment by anthropogenic as well as natural sources and is considered a global pollutant. It has a global cycle, as displayed in Figure 40. This is due to the ease at which Hg evaporates into its gaseous form (Hg^0). Once mercury is released into the atmosphere it can be transported around the globe, with an average atmospheric residence time of 1.5 years. Eventually Hg will oxidize (Hg^{2+}) allowing for deposition again onto the earth into surface waters, soils and plants.

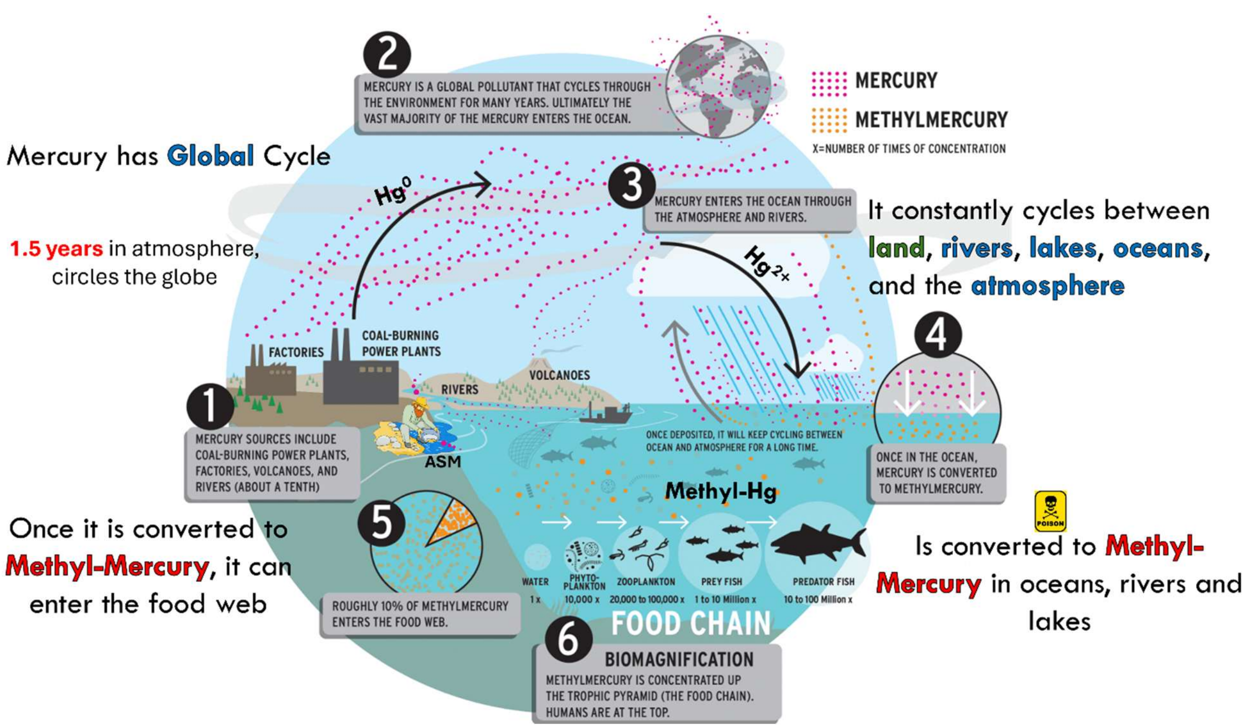

Figure 40. The global Hg cycle includes continuous cycling between the atmosphere, water bodies, and aquatic organisms. Modified after source: (Humphries 2018)

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Once Hg is back on the earth, it can again volatize to the atmosphere, be transported by water, or be taken into the food web, where often it has been converted to the **most toxic** form called **methylmercury**. This form is most concerning as **biomagnifies** and **bioaccumulates** in the food web, specifically in aquatic systems. This means that the uptake and storage of Hg in the organism is faster than the organism can excrete it out of its body. Thus, in a predator-prey food chain, such as in fish to humans, it is often that the higher the trophic level of the organism, the higher concentrations (i.e., biomagnification) of Hg in its body (UN Environment 2019).

Country signatories to the 2013 international treaty called the Minamata Convention, have agreed to prohibit the use of mercury in products previously containing it. Subsequentially, there has been a steep reduction in the use of Hg in products on the market due to this phase out. However, there has been a continued use of Hg by the ASM for gold recovery such that the sector is now the largest emitter of Hg to the environment. As can be seen by Figure 41, the two largest sources of Hg to the environment are ASM gold mining and the burning of coal (UN Environment 2019).

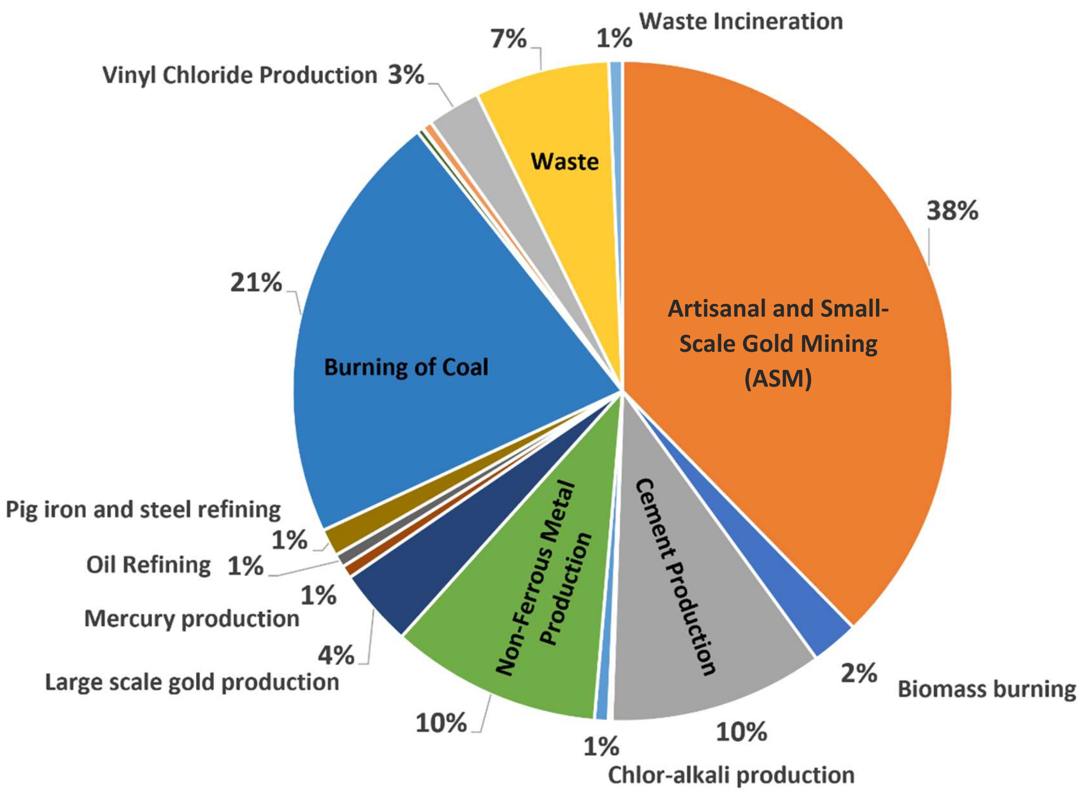

Figure 41. Major sources of mercury to the environment, note the majority comes from the ASM sector and its use for gold recovery. Source: (UN Environment 2019)

Water scarcity

With the need to combat climate change with lithium, cobalt and copper containing green energy technologies, the mining industry will only continue to boom. New areas will be explored for undiscovered critical raw material deposits. Mining utilizes a large volume of water and any increase in activities, might have unintended consequences on the availability of fresh water, especially in areas with existing water availability issues. A recent study determined that 16% of the existing terrestrial mines and deposits are in areas of high water stress (Figure 42a) risking an increase in an already vulnerable situation (Lakshman 2024). Furthermore, around 40% of the available fresh water is already used in other areas, such as agriculture and domestic use, meaning an increase in competition for water resources (Lakshman 2024). Some of the most productive CRM mining areas in Africa are also located in regions with acute water scarcity (Figure 42b), an area also prone to droughts (Matchaya et al. 2019).

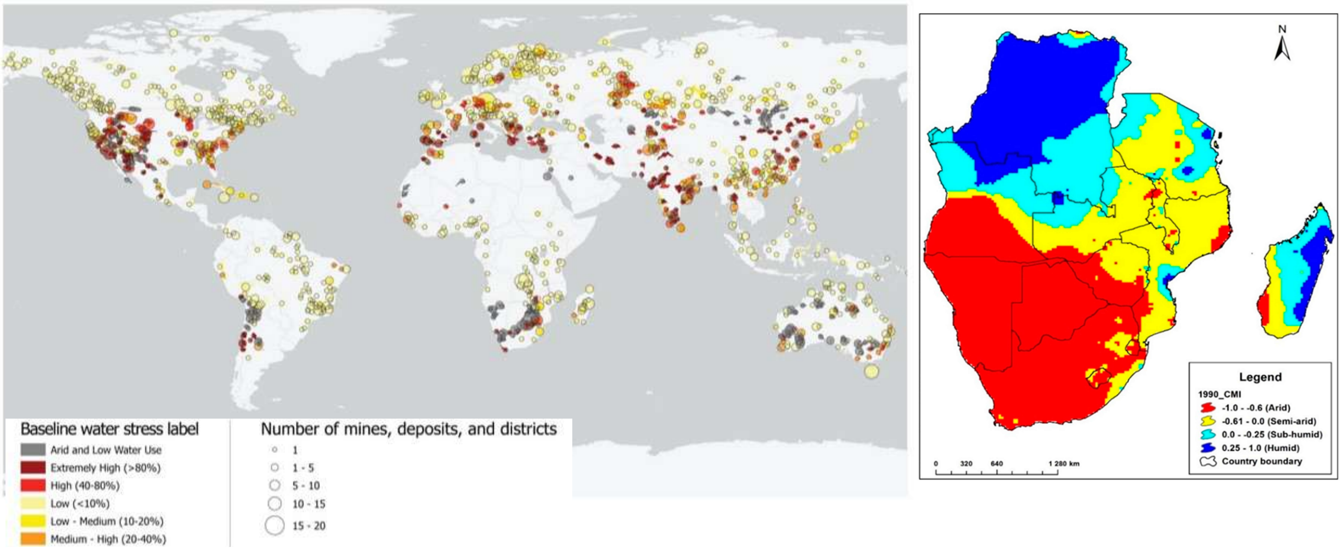

Figure 42. a) Baseline water stress levels in areas with known CRM mines and deposits; b) map showing the water scarcity and aridity levels of the Southern Africa region. Sources: (Lakshman 2024; Matchaya et al. 2019)

Water pollution

Given there are a number of chemicals used to extract ore from the rock, mining site are particularly susceptible to pollution of water. Generally, water contamination from mining activities are a result of toxic chemicals such as acids, cyanide or mercury, that are used and then discharged to surface water bodies or directly into the ground water. This pollution can have a number of consequences for the aquatic environment as well as pose a considerable danger to any nearby community who may depend on this water for domestic use. Thus, it is essential for the human health and that of the surrounding ecosystems that water pollution be avoided.

Such ramifications of water pollution may include acid mine drainage (AMD), that usually triggers a change in water pH levels and can cause the dissolution leaching of toxic heavy metals from the ore or the host rock. As mentioned in Unit 3, AMD generally occurs whenever sulphide minerals are excavated and subsequently exposed to atmospheric oxygen (Blowes et al. 2005). This causes the generation of sulphuric acid, causing the higher water pH levels and the mobility of the toxic heavy metals in the water (Figure 43). If iron sulphide minerals are present in the host rock, the reaction will dissolve the iron, which will precipitate out as iron hydroxide mineral, staining the water body bright orange. This mineral is also highly reactive and may subsequently interact with the surrounding ecosystem, including sorption of dissolved toxic metals, increasing their mobility and longevity in ground and surface waters (Blowes et al. 2005; Webster, Swedlund, and Webster 1998).

Cyanide (CN) is similarly used in mining to leach gold from low grade placer deposits in heaps. In a hydrometallurgical process known as gold cyanidation and heap leaching, an alkaline solution of sodium cyanide (pH > 10.5) is irrigated over the low grade ore, selectively dissolving gold to form a soluble gold-cyanide complex. The liquid is then collected and the gold is recovered. This leaching process is typically done in a closed system with a geomembrane or textile lining the bottom of the heap. However, if not done properly, the cyanide containing solution can seep into the groundwater from the heap leaching operations, where it is very mobile and highly toxic.

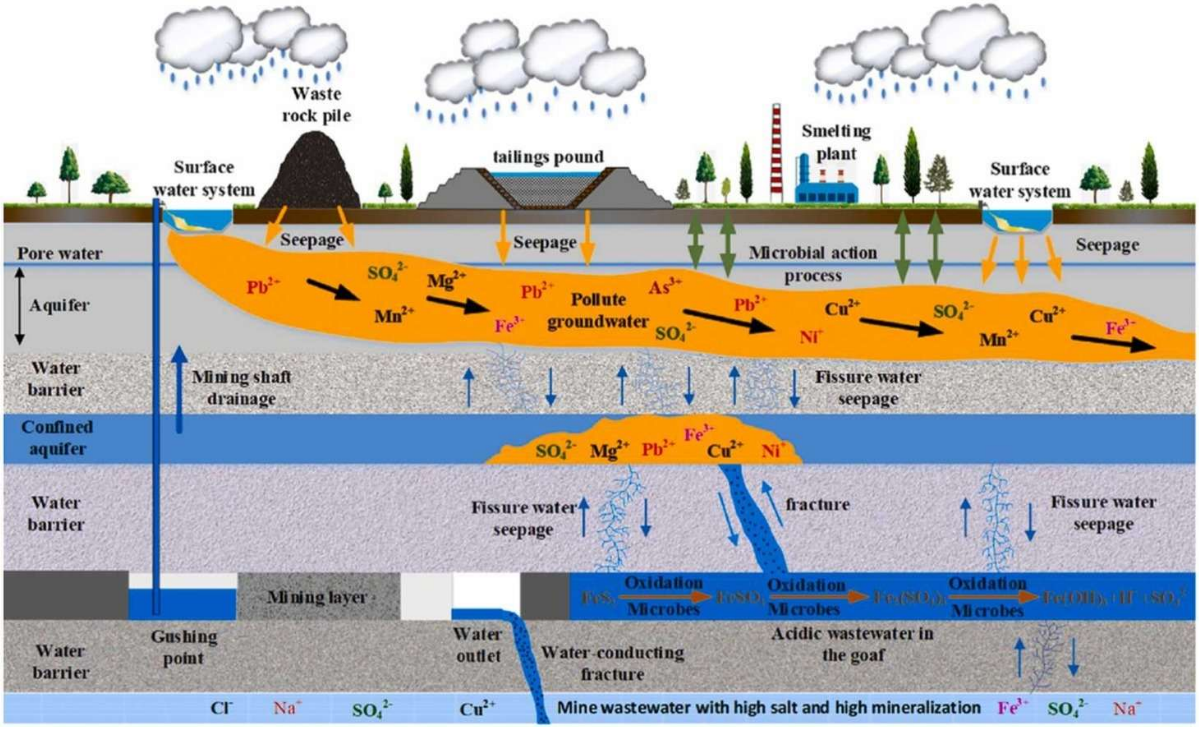

Figure 43: A generalized sketch showing the various heavy metals that can be leached and mobilized underground in acid mine drainage systems. Source: (Jiao et al. 2023)

Environmental Management Plan

Most mines need to have what is called an Environmental Management Plan (EMP) in order to get approval to operate. An EMP is a set of management and institutional measures that include monitoring of water, waste, mine stability and other aspects of the operations that may impact the surrounding environment and then have a plan for any mitigation to be implemented during the LOM operations. It is essentially a set of measures to minimize and manage the impact of operations on the environment (Handley 2022). It typically consists of the following components (Handley 2022; Newmont 2008):

- **Environmental Management Structure** – that defines the responsibilities for environmental management within the company.
- **Environmental Policies and Objectives** – including company commitments and specific goals, and policies on the environment and health and safety.

- **Project Outline** – includes descriptions of the mining method, the plans and strategies for waste rock disposal and any TSF, mine processing, water storage and management, and sediment control measures.
- **Legal and regulatory framework** – including identification of local, regional and state environmental laws and regulations
- **Environmental Impact Assessment (EIA)** – including a baseline study and impact analysis to evaluate pre mining environmental conditions and possible impacts from mining operations on the biological and physical environment surrounding the mine.
- **Mitigation measures** – plans and strategies to avoid or minimize environmental impacts or plans to remediate any effects.
- **Monitoring and reporting** – including regular assessment and documentation of various environmental conditions to ensure compliance with environmental regulations and the effectiveness of mitigation measures.
- **Emergency response plan** – including strategies for incidents effecting the environment, e.g., spills or releases.
- **Rehabilitation and mine closure plan**
- **Stakeholder engagement** and/or plans regional for **socio-economic development** – plan that defines how stakeholders, local communities and indigenous groups are informed of and involved in the environmental management of the mine
- **Review Plans** – including mechanisms for regular evaluation of mine management of the environmental impacts.

Mine closure and environmental remediation

Mineral resources are finite and thus it is imperative that a mining company have plans for **mine closure**, well in advance of the exhaustion of the reserves. Still mine closure remains one of the biggest challenges facing a mining company. Ideally, mine closure needs to be considered in the early stages, before the mine is even in operation, during the initial LOM planning, including to have a vision for the closure and engage with relevant stakeholders including authorities, regularly consult internal and external stakeholders and include the financial aspects of closure (ICMM 2019). If a mine is not adequately closed and the land reclaimed, the company risks generating long-term liabilities (IGF 2021). It was famously written: “the excitement and fanfare that surrounds the opening of a new mine is never present when it finally closes” and as such a well-developed mine closure plan allows for all parties involved, including the surrounding community, to ensure a maximum benefit (Laurence 2006).

There are many aspects to a mine closure plan that include not only decommission of the mine but also mitigating the financial impacts to the local communities who have relied on the mine, as well as undertaking environmental rehabilitation and remediation and eventually the relinquish of the lease back to the community. Thus, there are physical, environmental and social aspects (Figure 44) that need to be considered during mine closure (Sustainable Minerals Institute 2022).

Figure 44. The various aspects of mine closure, including both physical and environmental as well as social. Source: (Sustainable Minerals Institute 2022)

There is now recognition that mine closure can begin before the last ore has been extracted. This is what has been called progressive mine closure (see spotlight box below).

Progressive Closure - *The term ‘progressive closure’ encompasses ongoing efforts to advance closure activities during construction and operation of a mine. Progressive closure is the implementation of closure activities during the operating life of a mine.*

Some of the most common progressive closure works include:

- *Soil management (e.g., stripping, stockpiling, placement).*
- *Strategic placement of uneconomic materials.*
- *Diversion of unimpacted waters.*
- *Revegetation.*
- *Stabilisation works.*
- *Cover placement.*
- *Demolition of unneeded infrastructure.*
- *Improvements to water management infrastructure.*
- *In-pit dumping of waste rock material.*
- *Capping or encapsulation of tailings waste rock material.*

- ICMM, 2019

Progressive closure can demonstrate to authorities and the community the company's commitment to responsible mine closure, can give a company time to evaluate its closure activity strategies and adjust as needed, which can thereby reduce the company's liability (ICMM 2019). As seen in Figure 45, the process is an iterative process that can be defined and redefined during the LoM, with closure beginning already during the main extractive and operations phase of the mine (ICMM 2019).

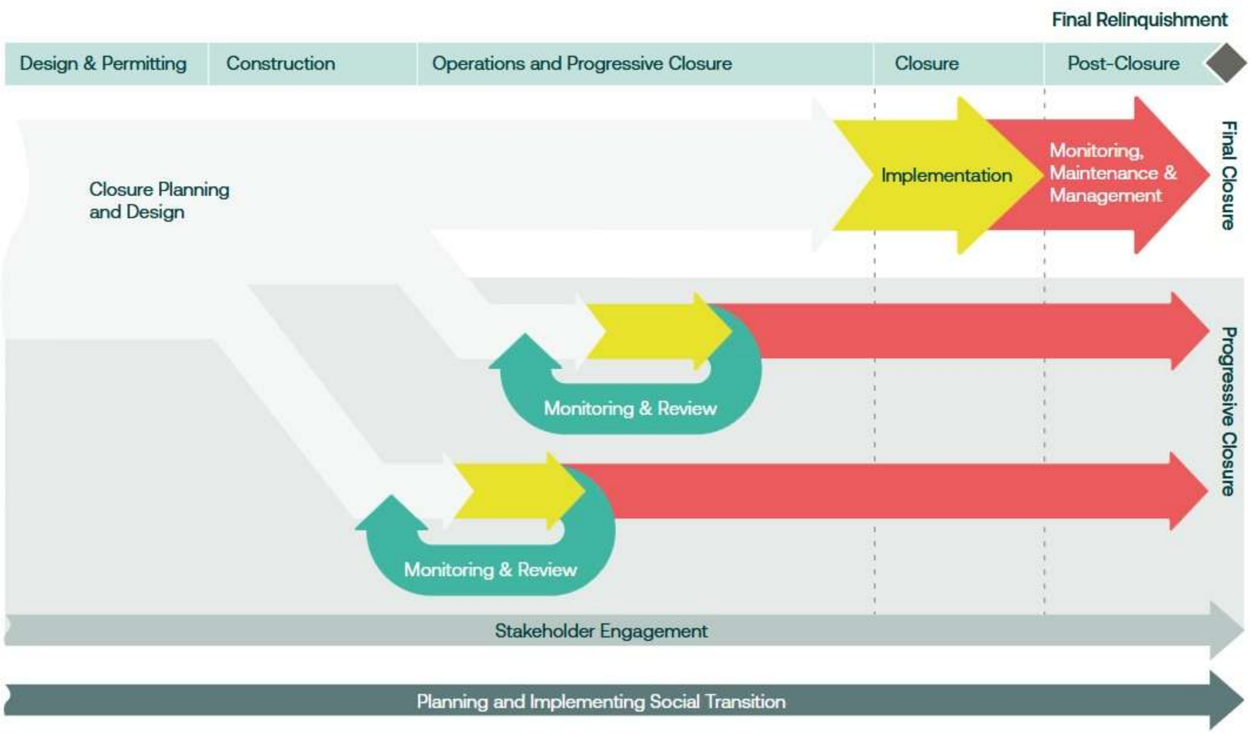

Figure 45. The Mine Closure Framework shows the steps for progressive closure and during the life of the mine, when these steps are implemented. Source (ICMM 2019)

Unit 2 – Management of social issues

There are many social issues and challenges that are unique to the ASM sector that are not necessarily common in LSM (Figure 46). Given that the sector is often working outside or on the fringes of legal frameworks, governmental oversight or regulation and is in general a subsistence activity, it is often associated with mining under dangerous conditions with numerous health and safety risks and is linked to human rights abuses and incidents of child labour, gender inequalities and in some regions are associated with conflict-affected and high-risk areas (CAHRA). The ASM sector has traditionally been active in gold mining, providing up to 20% the world's supply, but in recent years has been branching out into extraction of commodities like cobalt, tantalum and tin, producing an estimated 20-, 26-, and 25% of the world supply, respectively (IGF 2017). The following sections will detail some of the common social issues associated with the ASM sector and what some possible solutions.

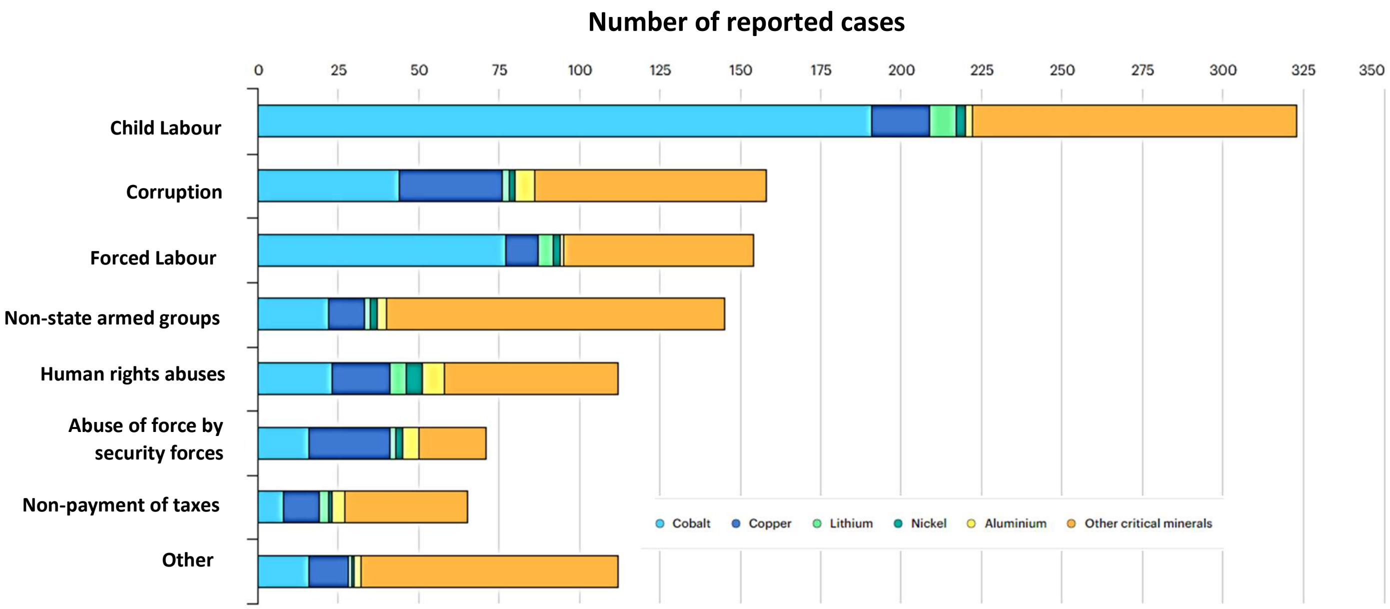

Figure 46. The number of reported cases of various social issues in specific critical commodity sectors. Source: (IEA 2022).

Child labour

Arguably one of the most important and persistent social issue associated with the ASM sector is that of child labour. It is a complex problem with multiple factors contributing to the issue. In general, it is common that parents bring their children to the mine sites because they cannot afford the fees to send them to school. This is thought to result in children assisting their parents in order to supplement the family income, but researchers also find children who have become displace or lack family support and thus are mining for their own subsistence. In some cases, children are in forced labour situations, whether they are brought in by traffickers or the family is in a debt bondage (Schipper, de Haan, and van Dorp 2015). Figure 47 shows an estimate of the problem globally.

Children in the ASM sector are particularly vulnerable to a number of hazards including working under physically dangerous conditions. Often ASM mines are unstable underground shafts, children are found digging, cleaning, hauling heavy loads of rock and ore, or using toxic chemicals, such as mercury, to separate ore (ILO 2019; ILO and UNICEF 2020; Schipper, de Haan, and van Dorp 2015). According to the ILO, this isolated nature of the work of children on ASM mine sites can put them at risk for physical, verbal and sexual abuse ore being drawn into illicit activities (ILO and UNICEF 2020).

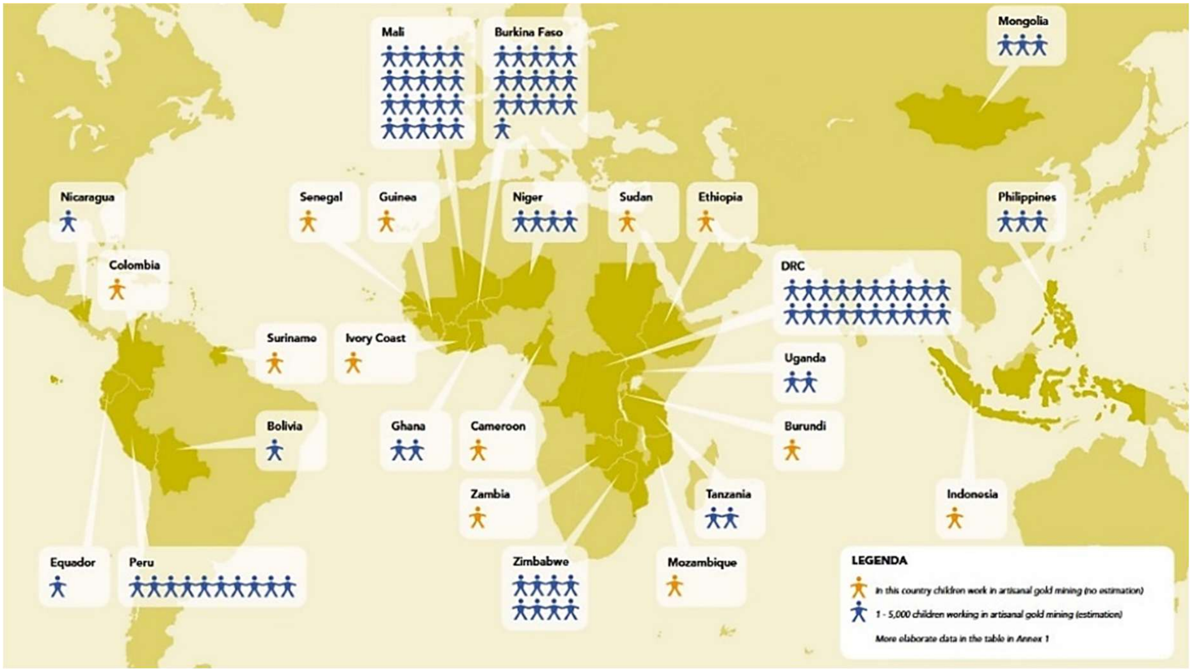

Figure 47. A compilation of estimates of the extent of child labour in ASM gold mining worldwide. Source: (Schipper, de Haan, and van Dorp 2015)

Health and Safety risks

There are a number of health and safety risks that are common to ASM sites that detrimentally effect the lives of the individual miners. These issues include accidents and physical injuries caused by collapse of poorly constructed mine shafts, pits and tunnels, lack of personal protective equipment (PPE), poor mine ventilation, exposure to dust leading to respiratory diseases, harsh working conditions caused by excessive heat, nose, leading to heat stroke, exhaustion or worsening of preexisting conditions, and sanitation and hygiene issues, especially for women workers (MME 2021). See **Unit 3** for a more detailed description of the management of health and safety issues at ASM sites.

Gener inequality

Women make up a large percentage of ASM workers in Sub-Saharan Africa. It is estimated that women ASM miners generally range anywhere from 30-50%, but can be as high as 70% in certain countries where ASM is particularly active, like in Guinea or Uganda (Tekinbas 2022). Women hold a number of roles in the sector by commonly being involved in support services such as sale of equipment, transportation of ores, food and drink sales, cleaning and laundry services or in the entertainment or the sex industry. Perhaps less commonly are women directly involved in the ore extraction process in roles like ore crushing,

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sluicing, washing, sieving, panning, gold amalgamation with Hg or gold-recovery from the amalgam. It is often that women are prevented either culturally or institutionally, from being involved in the higher value activities, making the full and fair participation of women in ASM a key challenge (IGF 2018). The discrepancies between male and female and their roles at ASM site are displayed in Table 7.

Table 7. Activities at mine site by gender (in %; sample size given). Source: (Buss et al. 2019).

	Male	Female
Head of mining team/chef d'equipe/head of mill	11.04	1.97
Digger	63.91	14.25
Washing the ore	4.67	14.50
Grinding the ore	1.70	20.39
Sluicing	9.98	0.74
Panning	25.69	19.66
Carrier of ore	9.77	27.52
Carrier of water or firewood	6.37	18.67
Administrative work	1.06	1.47
Trading in the mineral/product	7.43	7.86
Selling food/water for personal consumption	1.49	23.59
Selling other provisions for either personal consumption/ production	1.49	8.85
Selling services (including sex)	2.34	4.42
Open cast mining	0.42	3.93
Other	3.40	2.70
Sample size	471	407

Conflict Affected and High-Risk Areas

ASM activities are common in conflict affected and high-risk areas (CAHRAs) and presents significant challenges for the sector, including being associated with human rights abuses and financing armed conflicts. This is common in areas of weak governance, where the safety of the ASM workers cannot be guaranteed because there is a lack of security control or the miners may be operating informally (Crawford and Ledwell 2017). In these regions, the conflict then disrupts the activities of miners trying to earn a living from small-scale or artisanal mining. Such CAHRAs are generally associated with specific commodities such as diamonds, gold, or the '3T' minerals, or the minerals containing tungsten, tin, and tantalum.

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Solutions

Formalization

Support for ASM formalization is generally thought to be one way to improve working conditions and integrate miners into the formal economy. Formalization has been discussed for many years as a means of improving the circumstances of the sector as a whole. Given the extent to which the ASM sector contributes to not only the global supply of these commodities, but also their activities support the local economies, host governments need to recognize the benefits of a formalized ASM sector. Formalization would occur via a change in legal, regulatory and policy frameworks of each ASM host country (IGF 2017). Some researchers argue that if properly supported into formalization, the sector can contribute to the sub-Saharan African governments' fulfilling their sustainable development goals (SDGs) in a number of different ways (Hilson and Maconachie 2020). The researchers argue, that a formalized ASM contributes to a county's mineral production and revenue (SDG 8), to population employment and wealth creation (SDG 1) as well as its connection with agriculture (SDG 2 and 5) by being a supplementary income during periods of hardship (Hilson and Maconachie 2020). Figure 48 shows various ways ASM formalization could contribute to countries' SDG targets.

Figure 48. How the formalization of ASM could contribute the SDGs for sub-Saharan African countries. Source: (Hilson and Maconachie 2020).

There are a number of barriers to be addressed to formalize the ASM sector and there are some key avenues this can be overcome (IGF 2017). Formalization begins with developing comprehensive legal frameworks. Legislation should be developed that could account for the diversity and dynamic nature of the sector. Such legislation needs to be specific for the ASM, instead of the ‘scaling down’ of the regulation that govern LSM in African countries (Mutemeri et al. 2016). Some considerations to new regulatory frameworks should include: no restrictions on mining depths, no prohibition of mechanisation, ensuring access to land, environmental, safety and labour standards and gender equality (IGF 2017; IISD 2018; Mutemeri et al. 2016).

Another important aspect to formalization needs to account for providing access to deposit specific and other geologic data as well as an access to equipment to assist in efficient recovery of those deposits. Miners often work in a trial and error way, as they do not have access to knowledge of the occurrence of minerals or a map of potential reserves. This can lead to low yields, loss of investment, and their work entering environmentally sensitive areas, leading to degradation (IISD 2018). Access to geologic data would help improve profitability, efficiency and longevity at a site. In conjunction with this, accessing finance is crucial for ASM and having geological data would allow the miner to prove to the bank, the size of deposit and longevity of expected activities, thereby allowing it easier to request bank loans. Other forms of finance should be made available to ASM during formalization such as microfinance credit, or government grants or loans (IISD 2018).

Finally, any formalization efforts of the ASM needs to include capacity building and a continued dialogue between the ASM and other stakeholders. Capacity building not only promotes best practices, it also can support the technical development of the sector. This can improve productivity and also support the sector towards more responsible mining. Finally, a continued professional development can create a platform for positive dialogue between the ASM and other stakeholders such as local and regional governments, forming long-term partnerships (IISD 2018).

Child labour

For the complex issue of child labour, overall support for the ASM sector and the adult workers can begin to tackle the issue of children workers. Improvements in artisanal mining and labour and working conditions for adult workers is an integral part of eliminating child labour. This includes formalization efforts of the ASM sector in regions where it is often illegal or working on the fringes of legal frameworks. Furthermore, ensuring a fair compensation for the ore mined by ASM, can help contribute to the elimination of child labour, by ensuring families have enough to send children to school. Thus, promoting improvements in the governance of the ASM sector can begin to tackle the issue of child labour.

Community groups can collectively be engaged to address children working at ASM sites. Often women led organization at the mine can collaboratively devise ways to manage the children there. For example, given that women at the mine must also work to earn a living, agreements can be reached among the female workers for childcare, such as each day different caretaker for the children. Furthermore, supporting and developing programs to provide an alternative to youth can develop additional skills and livelihood options.

CAHRAs - Traceability and certification

Mineral supply chains can be monitored for ensuring a conflict free supply from the ASM. There are now a few well-known traceability and certification processes that have made efforts to break the link between natural resources and conflict. Probably the best and most well-known is that of the Kimberley Process, originally meant for the diamond sourcing, that promotes conflict-free production and trade. Such traceability schemes are also now employing tools such as blockchain for their mineral traceability and certification (Cartier and Ali 2019). The potential for blockchain in the Kimberley process is displayed in Figure 49. Additionally, a company can utilize the OECD guidelines for ensuring responsible sourcing of minerals from CAHRAs, which aim to prevent the financing of conflicts and promote transparent supply chains. Companies that support and facilitate participation in supply chain certification initiatives can promote conflict-free minerals, mined responsibly that supports human rights (Crawford and Ledwell 2017; OECD and UN 2023). See **modules 1** and **2** for more on the regional and international frameworks on responsible sourcing.

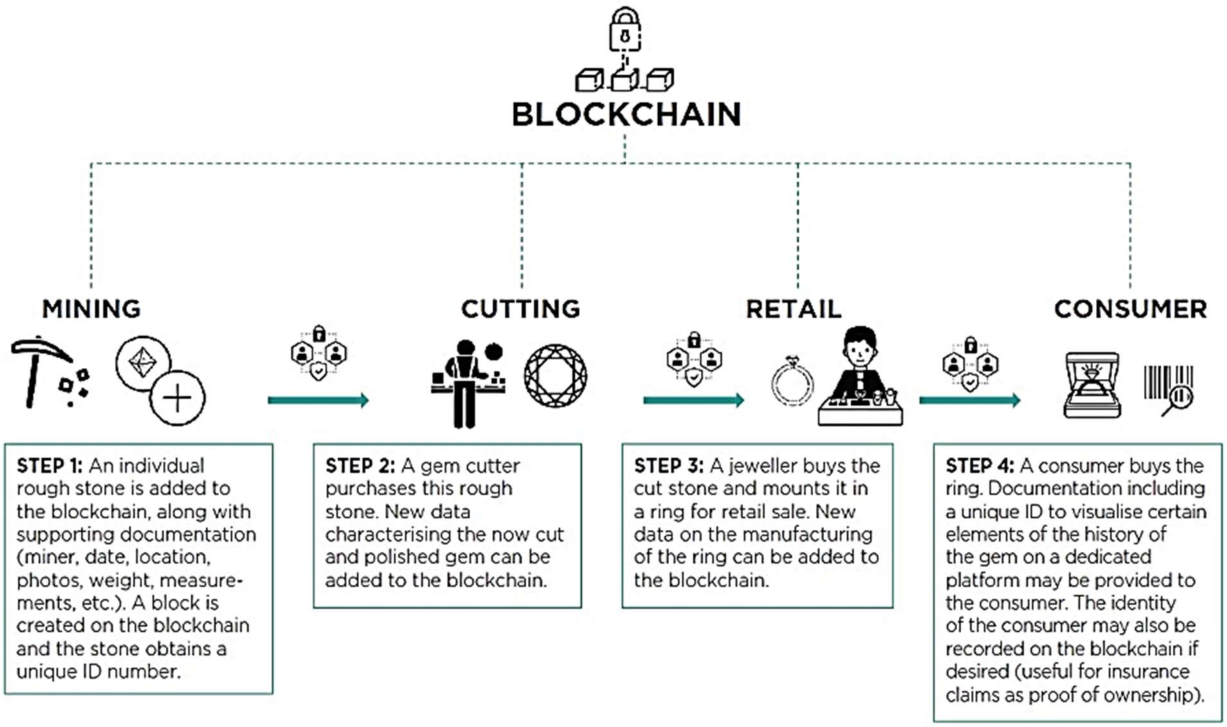

Figure 49. Schematic for a generalized Kimberley Process traceability scheme using blockchain technology. Source: (Cartier and Ali 2019).

Community involvement – Women in mining in the ASM sector

The involvement of the community as well as women in mining groups has been shown to advance the ASM sector as a whole. The Delve Exchange is a global online data platform for obtaining current information regarding various aspects of the ASM sector. Their annual report on the state of the ASM's advances towards fulfilling SDG 5, Achieve Gender Equality and Empower all Women and Girls, they show that communities and specifically the participation of women in ASM plays a pivotal role (World Bank 2023). Women make invaluable contributions through their participation, leadership and unique contributions. For example, the report states that women make up about 30% of the global ASM workforce in direct mining activities, ore processing and trade, in turn contributes to local economies, and improving household income stability, education and health services (World Bank 2023). Furthermore, women can advance environmental sustainability around the sector. As mentioned, often women are working in ore processing roles, such as gold recovery from Hg-amalgamation. With proper training and support, women can lead efforts towards responsible sourcing by advocating for better health and safety measures, for example via the reduction of the usage of hazardous chemicals in ore processing, introducing more efficient processing techniques and thus improving productivity and minimising environmental impact. This in turn can benefit the entire ASM community by advancing the sector's responsible mining practices (World Bank 2023). Moreover, the role of women in leadership and decision-making positions within the sector in cooperatives or associations, is generally thought to advance inclusivity, formalization and sustainability efforts and can lead to influencing mining laws and policy changes, leading to gender equality and a more equitable distribution of ASM benefits. Likewise, their active participation in various roles from mining to leadership positions, can further challenge cultural barriers that limit women's participation in mining and household income generation (World Bank 2023).

The Association of Women in Mining in Africa (AWIMA) is an umbrella organization of national women in mining groups across the continent. Figure 50 shows the 38 country members of women in mining organizations from the five regions of Africa. AWIMA plays a pivotal role in advancing women's participation in the extractive industry by advocating for their interest, promoting formalisation efforts, addressing challenges to women accessing financing and credit for mining projects, and developing capacity building programs (AWIMA 2024).

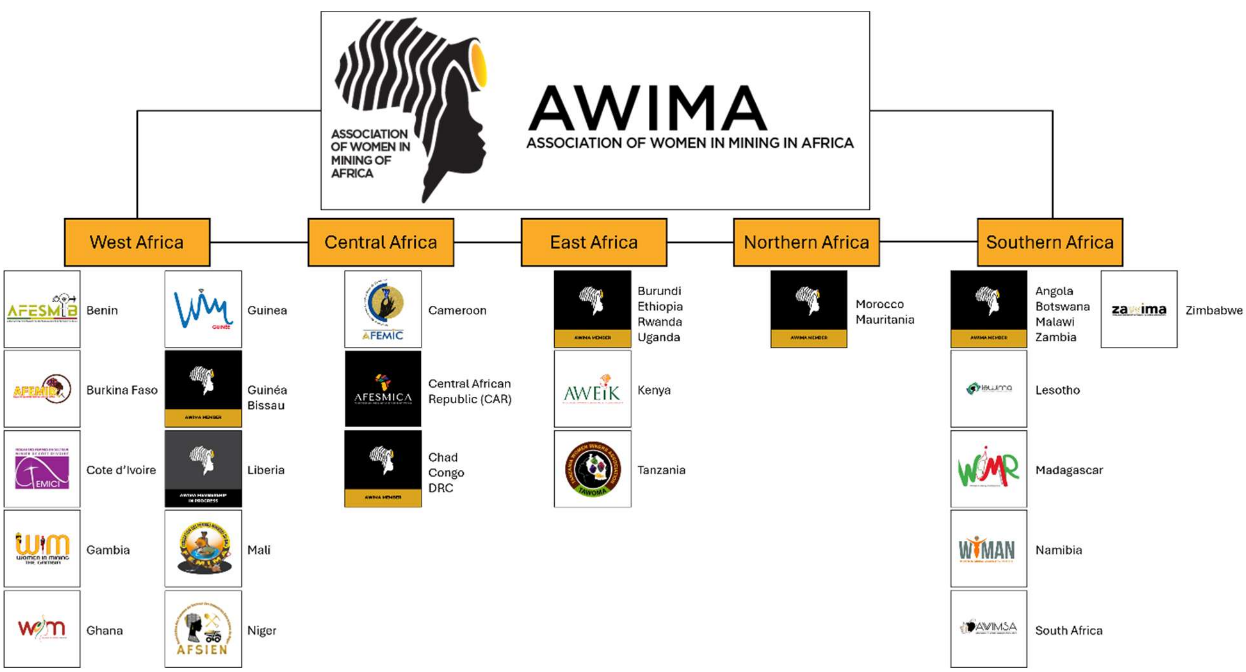

Figure 50. The AWIMA umbrella organization of various women in mining groups across Africa currently has 38 member countries. Source: (AWIMA 2024)

Unit 3 – Management of occupational health and safety issues

Occupational health and safety challenges

Issues of occupational health and safety (OHS) are common in the ASM sector. A common rallying cry heard from safety advocates when promoting safer ASM working sites is that the most important commodity to come out of an ASM mine is the miner. Indeed, ASM sector is negatively associated with unsafe working conditions leading to many tragedies every year. Thus, it is imperative that the sector improve its OHS performance if it is to be considered a source for responsibly mined minerals for sale on the international market. In this unit we present the most common challenges facing the sector and introduce some measures miners and mine owners can take to improve their OHS record and ultimately make their environment safer for those who work at the mines.

Structural integrity of ASM mines and pits

Safe working conditions begins with ensuring that there is a structural integrity of the mine where the workers are extracting the ore. There have been many accidents across sub-Saharan Africa in recent years related to both open pit and underground tunnel mine collapses where numerous miners lost their life. Many of these accidents are related to a lack of structural support of mine slopes and tunnel walls.

In open pit mining, the design of the excavation pit is critical to safe working conditions. Figure 51 displays various schematics associated with structural integrity of mine pits and tunnels (ITA 2021). Many accidents occur due to poor planning of the steepness of the pit walls (Figure 51a-b). Too steep side walls can lead to slope failure, landslides and rock falls. Knowing the approximate depth of the mineralized zone would allow for the proper pit design for safe ore excavation. For example, for deeper ore deposits, a wider pit with numerous benches with less steep sides can reduce the risk of slope failure and rock falls (Figure 51b). Furthermore, supporting overhead rock also reduces the risk of rock fall and collapse (Figure 51c). Additionally, the proper management of waste rock and tailings includes its storage more than 10 metres from the pit edges (Figure 51d). This will reduce the risk of pit wall collapse due to overloading the slopes (ITA 2021).

Underground tunnels present additional challenges to maintaining their structural integrity and keeping a safe working environment. Similar to open pits, it is imperative that the construction of the tunnel walls be done in a way that prevents wall collapse. For example, supporting the tunnels with strong and frequent timber supports reduces the risk of ceiling collapse (Figure 51e). In addition, planning of underground excavations can include leaving pillars or columns of natural material intact for tunnel support. Moreover, building a strong mine adit entrance is critical (ITA 2021). Supporting the adit with frequent timbers reduces the risk of entrance collapse and minimizes the risk of trapping any miners working inside the tunnels (Figure 51f). Furthermore, in underground mine design and planning phase, it is imperative that proper ventilation is considered. See spotlight box below for details on why proper ventilation is necessary. Such considerations must include at least two cross ventilation shafts with proper air pumps and both axial and centrifugal fans to ensure continuous flow of breathable air in the underground tunnels (Figure 52a). Proper ventilation shafts can also aid in mine temperature regulation and in providing more pleasant working conditions (Mungalaba 2016; Pact 2019).

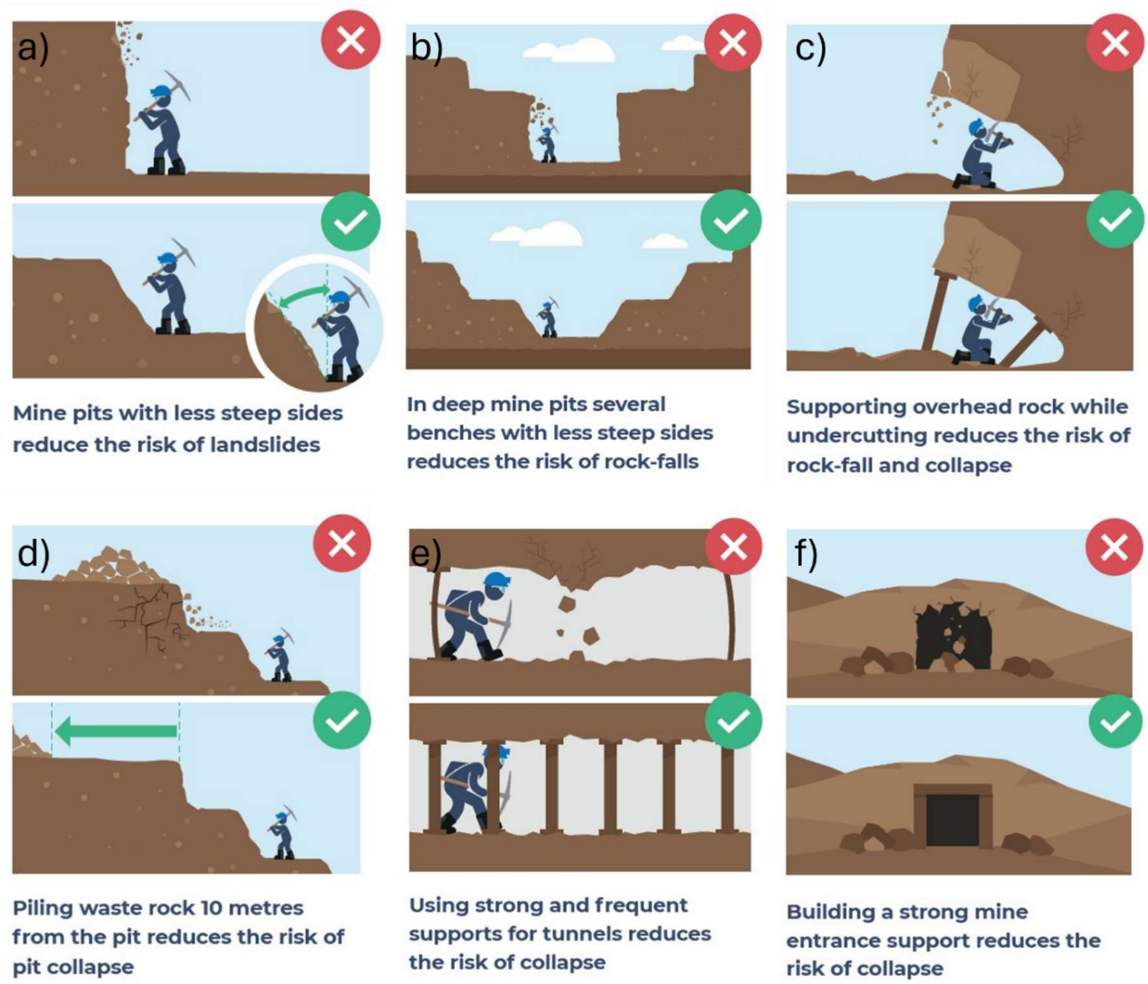

Figure 51. Schematics showing various issues associated with structural integrity of mine pits and tunnels. Source (ITA 2021).

Ventilation – Often overlooked in artisanal and small-scale underground mines is the need for proper mine ventilation. The ASM often lack the expertise to fully appreciate the health and safety risks resulting from poor ventilation, the build up of asphyxiating mine gases and increased temperatures in which the miners must work.

The ventilation of underground mines is essential for a number of reasons (PACT, 2019):

- *Supplying fresh air to miners.*
- *Expelling foul and stale air.*
- *Regulating temperature and humidity of the mine.*
- *Eliminating the build up noxious and poisonous gases such as exhaust from machinery and CO_2*
- *Controlling the levels of dust and other fine particulate matter.*
- *Promotes a more comfortable work environment.*

Many mines are accessed via vertical mine shafts. These present additional challenges to structural integrity and safe access to underground mine workings. As with horizontal adits, a vertical shaft mine entrances must be structurally sound so as to prevent from shaft wall failure and trapping miners working underground (Figure 52b). This can be done by timbering the shaft from the surface and can include the use of concrete if the ground at the surface is loose. Furthermore, water entry from surface runoff into vertical shafts must be controlled. Covering vertical mine shaft entrance, providing shade and protection from rain as well as constructing surface water diversion, directing it away from entrance can help reduce the risk of flooding of the mine (ITA 2021; Pact 2019).

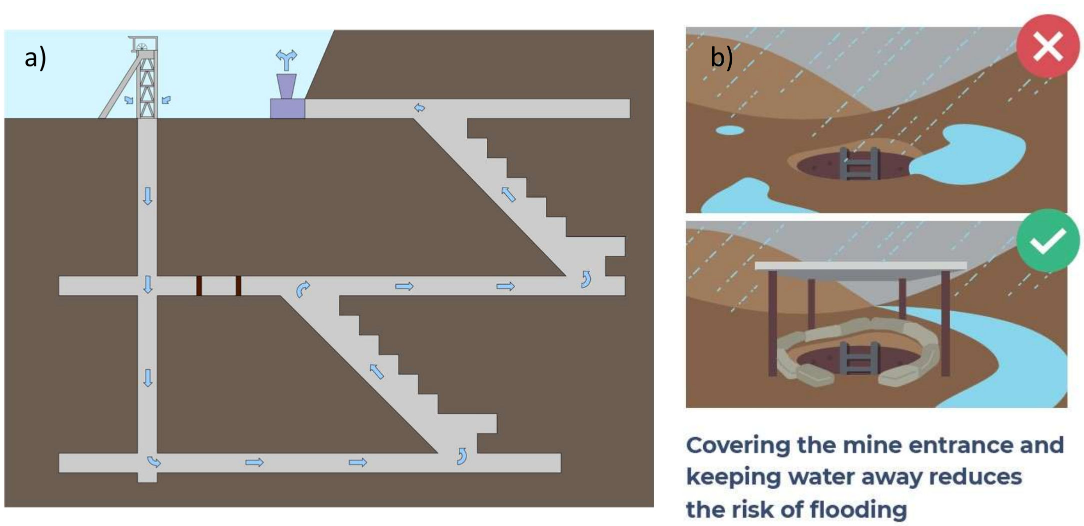

Figure 52. a) Example of a simplified underground mine ventilation system and b) example schematic on cover for a vertical shaft to prevent surface water intrusion and mine flooding. Source: (ITA 2021; Creative Commons 2009)

Harsh working conditions

It is generally well known that ASM activities are associated with a number of health risks due to the labour-intensive nature of the work. This means that care must be taken to ensure miners can work under the best possible conditions so as not to experience physical and mental exhaustion and burnout. For example, workers in an underground mine, especially one that has poor ventilation, often labour under extreme temperatures that can result in heat exhaustion if care is not taken by the workers to rest and stay hydrated. Furthermore, ASM tend to work long hours, which in turn can amplify extreme conditions.

An additional occupational health stress affecting the ASM sector is that of noise. Mining is a known source of noise and vibration from various equipment and machinery used to extract ore from host rock, especially that of workers in underground mines. Continuous exposure to high levels of noise can have severe negative consequences on the workers, from tinnitus and hearing loss to other stress-related health issues and even cardiovascular disease. Previous studies investigating the relationship between noise exposure and stress (as measured through cortisol stress hormone levels found in miners' saliva) in gold miners in Ghana revealed alarming associations between noise and increased stress of the workers. It showed that 95% of study participants had 24-hour noise levels above World Health Organization (WHO) guideline for hearing loss prevention, their cortisol levels showed they were experiencing chronic stress, even showing increased cortisol levels in the evening, which is indicative of lingering physiological stresses, and that noise variability was related to fluctuations their heart rate (Green et al. 2015).

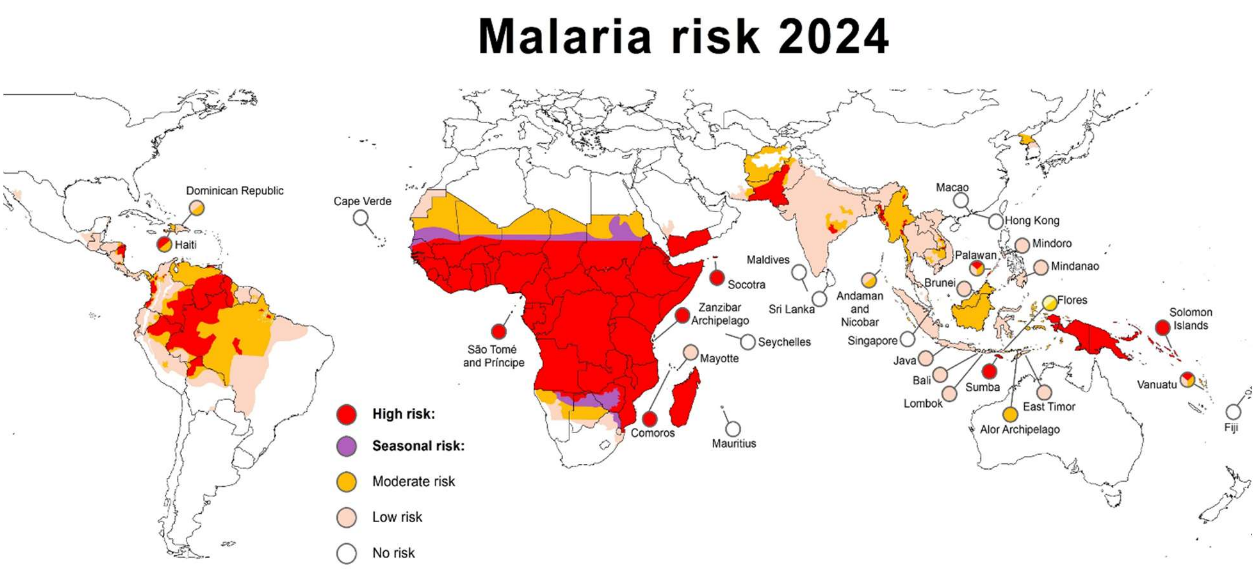

Figure 53. Global risk of Malaria in 2024. Source: (ECTM 2024)

Poor sanitation and hygiene conditions are also very common at artisanal and small-scale mines, given their often remote locations. This can leave the ASM workers suspectable to biological hazards such as waterborne or respiratory diseases, gastrointestinal issues, or easily transmitted infections. Access to clean water and sanitation infrastructure such as toilet facilities are often completely lacking or if a pit latrine is available, is commonly too shallow, cross contaminating other water sources and increasing the risk of outbreaks of diseases such as cholera (WHO 2016). Furthermore, stagnant water can promote a favourable environment for mosquitos-borne diseases such as malaria or dengue (Pommier de Santi et al.

2016; WHO 2016). Africa is particularly at risk, as incidence of these diseases are high, particularly for malaria (see Figure 53).

Respiratory diseases

The continuous overexposure of the miners to fine mineral dust particles can lead to numerous negative health impacts to ASM workers, including to respiratory diseases such as silicosis and tuberculosis (TB). Silicosis is a preventable but **incurable** disease of the lungs, caused by repeated exposure to respirable crystalline silica and usually presents itself decades after first exposure (Howlett et al. 2023). In addition, millions of people in the developing world die each year from TB, a preventable and usually **curable** disease. The ASM workers are especially at risk for silica dust-associated TB, in particular (Rees and Murray 2007). Caused by a bacterial infection in the lungs, it is spread by people who are sick when they expel bacteria into the air via coughing (WHO 2024). The estimated incidence of TB in Africa as a whole is high but is particularly elevated in regions where the ASM sector is active in sub-Saharan Africa (Figure 54). Respiratory diseases such as TB are exacerbated in individuals with human immunodeficiency virus (HIV). In Africa, HIV infections are prevalent in the ASM sector, meaning there is a heightened compounding risk (Howlett et al. 2023; Rees and Murray 2007; WHO 2024).

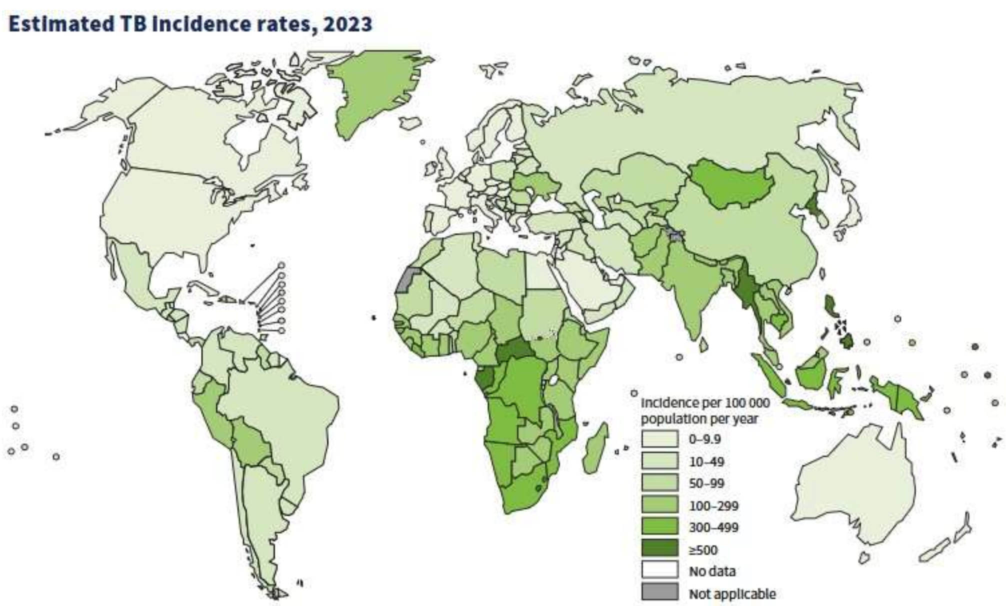

Figure 54. Global incidence rate of TB in 2023. Source: (WHO 2024).

Preventive measures

Managing hazards at the mine site

Fundamentally one of the major challenges to improved health and safety of the ASM sector is a lack of regulatory oversight or a control on operations compliance mechanisms. Given that the sector plays a key role in poverty reduction in these regions, governments are increasingly looking at reforms to improve the sector, including making efforts for formalization, a key strategy to improving the sector's sustainability and to understand the health and safety and environmental impact (Smith et al. 2016).

An ASM mine can improve its health and safety performance by developing and implementing an OHS management plan or system. Such a plan or system is a framework designed to help mine owners and workers assess and mitigate OHS risk associated with ASM operational activities, prevent injuries to workers and thereby prevent lost production time. See spotlight box below for details on the key components of a health and safety management plan for the ASM sector.

Health and Safety Management Plan – It is crucial for mine owners to design and implement a detailed health and safety management plan to protect workers and the surrounding community from any hazards of the ASM mining operations. A well designed plan contains the following key components:

- *Mine site risk assessment and hazard identification*
- *Workforce health and safety training and capacity building.*
- *Site conditions appropriate personal protective equipment (PPE) for all workers.*
- *Emergency management plan regularly reviewed and updated.*
- *Environmental management of waste and any potential pollution sources.*
- *Regular community engagement plan.*

One widely used model or framework for reducing or eliminating workplace hazards is that of the hierarchy of controls (NIOSH 2015). It prioritizes different methods to improve workers health and safety, guiding employers in minimizing risk exposure effectively. Figure 55 displays the controls from most to least effective. The controls are:

- **Risk elimination** – for example replacing hazardous materials with non-toxic alternatives or equipment, including replacing the use of mercury with gold gravity concentrating equipment,
- **Risk substitution** – such as replacing hazardous materials processes or equipment with safer alternatives, or using electric or solar powered instead of diesel powered pumps to reduce exhaust fumes and air pollution,
- **Engineering controls** – for example installing ventilation systems in underground mines, erecting fences around open pits, installing drainage systems to prevent mine or work area flooding, and constructing reinforced adits, tunnels and shafts.
- **Administrative controls** – for example worker rotation to reduce exposure to harsh working conditions and to allow worker breaks to prevent exhaustion or heat stress, provide signage for hazards found around the mine area, and
- Providing workers with appropriate **personal protective equipment (PPE)** – such as work gloves, respirators, including those appropriate for working with mercury, dust masks, hearing protection, hard hats, high visibility work clothes.

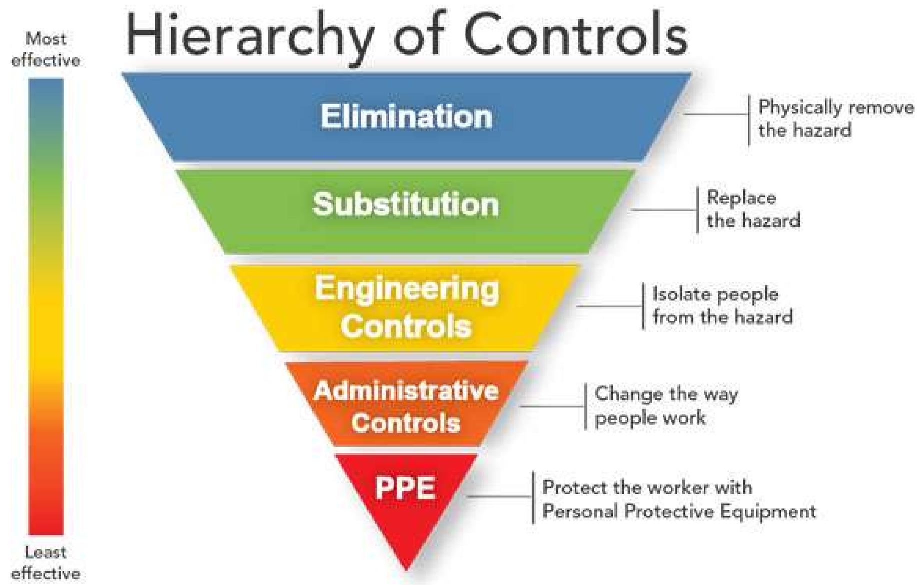

Figure 55. The NIOSH hierarchy of controls for hazards at a worksite. Source: (NIOSH 2015)

A holistic approach to an ASM health and safety management plan can help manage ASM worker's safety and ensure no time is lost due to injury or illness. A combination of these control approaches will allow for a dynamic approach to OSH that will allow for flexibility of changing conditions and environment surrounding an ASM mine (NIOSH 2015). Governments and private organizations or NGOs can help by providing training to ASM workers and incentives for safer mining practices.

Personal Protective Equipment

As mentioned previously, the minimum control for safe working conditions is appropriate PPE. It is imperative for miners to wear PPE to guard against injuries of any kind, as well as immediate or long term exposure to multiple hazards, such as dust, noise or dangerous or toxic chemicals. The importance of workers utilizing and wearing diverse PPE for various hazards to protect themselves must also be emphasized (Table 8).

Table 8. Examples of PPE for different work environments common at ASM sites. Source: (Pact 2019)

Environment	PPE
All working environments	High visibility work suits
Possibility of falling objects	Steal toed shoes, hard hats
High noise environment	Ear plugs, muffs
Possibility of objects impacting eyes	Safety goggles
Possibility of hand injury or exposure to fluids	Work or chemical protective gloves
Possibility of falling	Fall protection, like safety chains, harnesses
Dark working conditions	Head lamps, well-lit tunnels, working spaces

Capacity Building

The importance of safety at the mine cannot be overstated. One way to ensure that all ASM workers are fully aware of the risks they face while working is to have a mandatory **capacity building and training program** included in the health and safety management plan. This capacity building must be regularly conducted to not only ensure compliance but to inform the workers of any changes to the risks present at the mine site. Such programs can include informing the workers of health and safety laws governing their sector and region, to clarify the benefits to safe working and environmental protection, and to encourage adoption of good practices (ITA 2021). Furthermore, regular safety briefings before start of the work shift can remind workers of safe working practices as well as inform of any daily operational specific risks. Moreover, an emergency management plan that includes first aid and CPR trainings can ensure all workers present can perform life-saving measures, in case of accident.

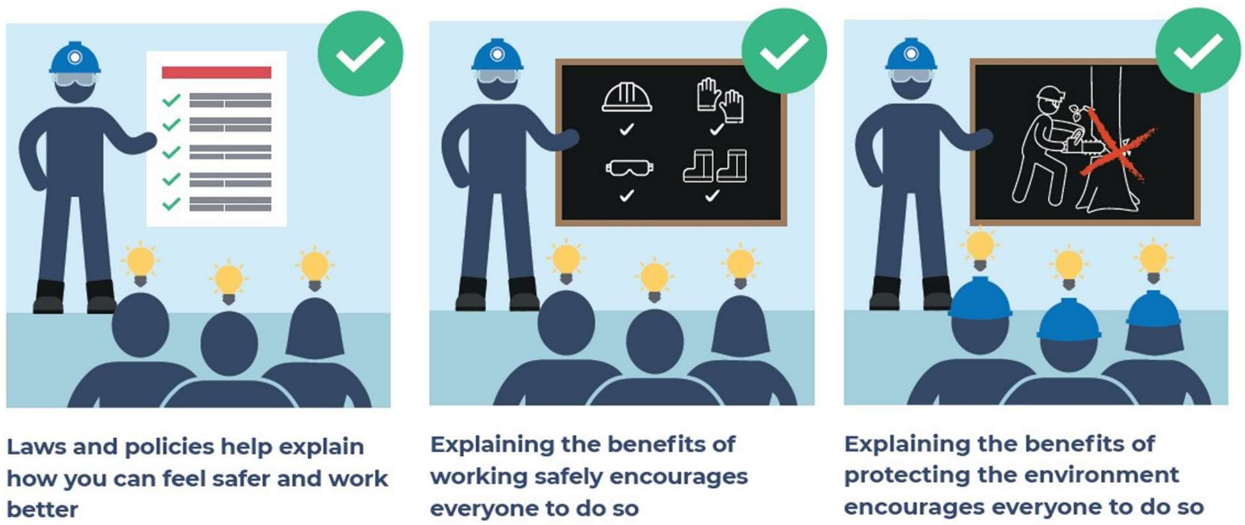

Figure 56. Capacity building and training of the ASM workers on various topics can assist in overall improvements in worker health and safety. Source: (ITA 2021).

Role of mine owners

Mine owners have a very important role in the health and safety of their workers by ensuring the efficiency, safety and sustainability of mining activities. Not only are they responsible for the implementation of and compliance with an OSH management plan, but they are responsible for the protection of workers from hazards in their mines. The elimination of work-related injuries, ill health of workers, prevention of workers developing occupational diseases, or other incidents, and most importantly any work related deaths, is paramount to any ASM produced ore having been considered as responsibly sourced.

It is the role of mine owners to:

- Oversee daily mining activities to ensure good yet efficient work practices are being implemented,
- Providing equipment to workers for efficient operations,

- Ensure safe working conditions by providing capacity building and training, implementing safety measures, providing PPE and building a work culture of the importance workers wearing PPE,
- Providing measures of alleviation of harsh working conditions, such as availability of clean drinking water for worker hydration, as well as shaded stations for resting and clean sanitation,
- Reducing the environmental damage by managing waste responsibly, preventing water pollution buy ensuring toxic waste is not dumped into surface or groundwaters, rehabilitating land after ore has been exhausted,
- Ensuring operations follow legal and regulatory compliance by respecting labour laws, cooperating with government and authorities, ensuring mining licenses are current and allow for active and legal operations, and
- Ensuring community engagement and social responsibilities, such as informing communities about the details of operations, resolving tensions with the communities about issues such as water usage, land rights and environmental protections, and resolving any conflicts.

ASM mine owners can ensure that profit does not come at the expense of safety of workers and the sustainability of the operations by balancing economic goals with well executing environmental health and safety management plan and active engagement with governments, industry, communities.

Group work or exercise

Group Exercise- Identifying and Addressing Environmental Impacts in ASM Operations

Group Exercise World Café Group Exercise (option 2) - Environmental and Social Issues

Group Exercise: Identifying and Addressing Environmental Impacts in ASM Operations

Objective:

To help artisanal and small-scale miners (ASM) recognize environmental impacts from their operations and develop strategies to mitigate them.

---

3. Step 1: Group Brainstorming (30 minutes)

- Divide participants into small groups of 4-6 people.
- Each group receives a large sheet of paper and markers.
- Ask each group to list potential environmental impacts of mining activities in their area. Examples may include:
    - **Deforestation** (cutting down trees for mining or camp setup)
    - **Soil erosion** (removal of topsoil due to excavation)
    - **Water pollution** (washing minerals in rivers, use of mercury)
    - **Air pollution** (dust from excavation)
    - **Wildlife disturbance** (loss of habitat for animals)

---

4. Step 2: Mapping the Impacts (20 minutes)

- Each group draws a **simple map** of their mining site, marking:
    - Mining pits
    - Water sources (rivers, lakes, wells)
    - Vegetation (trees, grassland)
    - Nearby communities
- Using their list from Step 1, groups indicate on the map **where** each impact occurs.

---

5. Step 3: Impact Ranking (20 minutes)

- Groups rank their identified environmental impacts based on:
    1. **Frequency** (How often does this happen?)
    2. **Seriousness** (How much damage does it cause?)
    3. **Reversibility** (Can the damage be fixed?)
- Use a **simple scoring system** (1 = low, 5 = high) to decide which impacts need urgent attention.

6. **Step 4: Mitigation Strategies (30 minutes)**
    - Groups discuss and suggest practical ways to reduce their top-ranked environmental impacts. Examples:
        - **For water pollution:** Create sedimentation tanks to clean water before it flows back into rivers.
        - **For deforestation:** Replant trees in mined-out areas.
        - **For soil erosion:** Create barriers (such as planting grass) to hold soil in place.
    - Each group writes **one simple action plan** for a selected impact.

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7. **Step 5: Group Presentations & Discussion (40 minutes)**
    - Each group presents their map, rankings, and action plan.
    - A group discussion follows:
        1. Which environmental impact is the most urgent?
        2. What are the challenges in implementing the solutions?
        3. How can miners work together to reduce environmental harm?

---

8. **Conclusion:**
    - Highlight that **responsible mining** can help sustain resources for future generations.
    - Encourage miners to start with **small, practical steps** to improve their environmental management.

This interactive approach helps miners **visualize their impact**, **prioritize concerns**, and **take ownership** of solutions. Would you like any modifications to better suit your audience?

Group Exercise (option 2): World Café Format - Environmental and Social Issues

The World Café Format

The World Café is a format for a fully interactive and collaborative group session. Participants are divided into smaller working groups (5-6 people per group), who will deep-dive into specific issues related to **environmental and social aspects in artisanal and small-scale mining in [insert country]**. Depending on the number of participants, 2-4 different 'stations' in a room are set up where participants are invited to discuss a specific topic area (i.e. one topic area per station). Participants spend up to 10 minutes at each station, before moving to the next one. Participants will cover all 'stations'/topic areas by the end of the group exercise. At the end of the session, participants come together in a plenary session to share results from the different groups, highlight common conclusions and takeaways from the discussion.

Setup

- The whole session lasts for 1 hour:
    - Introduction to the group exercise: 5 mins
    - 2 stations x 20 mins (+ changing stations) = 40 mins
    - Plenary discussion & conclusion = 20 mins
    - Each station has one moderator who steers the discussion and prompts participants to share their views and experiences
    - When participants move to a new station, they take stock of the discussion the previous groups had regarding that specific topic area.
- Technical requirements:
    - Ideally one big room with 2 different tables
    - Each table has a flipchart, pens/markers and stickers or post-its

Concept of the session

The World Café format needs a concept which defines:

- Topic areas for each station
- Type of questions asked to participants at each station

Topic areas

The World Café exercise will focus on environmental and social issues that the participants are facing with in their daily operations. It is proposed that the 3 stations cover the following 3 topic areas:

- **Environmental issues**
- **Social and economic issues**

The questions of the table will be useful for participants to share their experiences, challenges and tools/knowledge they think they would benefit from. Here is a first list of potential questions to be asked for each of the 2 stations. Depending on the knowledge of participants, 2-3 questions could be selected.

Station 1: Environment

1. If we cluster the most common environmental impacts of mining into the following groups, can you provide specific examples for each category?

Water	Soil	Air	Habitat / Wildlife / Biodiversity

2. Based on your experience and type of operations, what are some common environmental impacts that ASM operations could have on the environment? Are there specific issues related to manganese or copper mining?
3. Can you share a specific example that you have encountered in your mining activities?
4. What is your approach for managing environmental issues at your mine? Do you have a documented environmental management plan in place?
5. What tools or knowledge do you feel are needed to ensure negative environmental impacts in ASM operations are minimized or avoided?

Station 2: Social

1. What are some of the key social and economic issues of mining (in general) for the following groups?

Local population	Women	Children

2. What are the main social and economic issues for artisanal and small-scale miners in your community or region? Are there specific cases related to the commodities in focus?
3. Share a personal experience or observation regarding social issues faced by workers or communities of ASM activities.
4. Which measures are you taking to prevent any potential social issues related to your operations?
5. What tools or knowledge do you feel are currently lacking in ensuring the proper management of social issues in ASM operations?

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8.5. Mining as a Business

Module Title	Mining as a Business
Module Aims	This module aims to provide participants with knowledge on how to approach artisanal and small-scale mining as a business.
Specific Learning Outcomes	Upon completing the module participants will, through assessment activities, show evidence of their ability to: • Understanding the basic principles of developing a business plan. • Understand the fundamentals of how to create and manage the budget of an ASM business'. • How to identify key stakeholders to ASM business operations • Understand benefits of formalization of ASM operations, workers and mine owners
Comprehensive Learning Outcome	The course ultimately aims to build capacity among ASM workers and potential mine owners, promoting more financially sustainable businesses.
Module Content	1. Business fundamentals, financial planning & budgeting 2. Formalization – Challenges and opportunities.
Methods of Facilitating Learning	This Module will be facilitated through modular lecturing, role plays, group discussions and presentations.
Reflection on learning outcomes	Roles Plays, group presentations and feedback from the trainees, evaluation forms
Student Support & Learning Resources	Workshop manuals Information will be provided periodically on relevant publications, internet resources and other reading material.

Unit 1: Business fundamentals, financial planning & budgeting

Introduction

As mentioned in previous modules, artisanal and small-scale mining (ASM) is a considerable source of income for millions of people around the world. While many workers who participate in ASM activities are subsistence miners, in other words for them ASM is a poverty driven activity, there are also an increasing number of educated and opportunistic individuals working in the ASM sector who are active as entrepreneurs, those who are concession owners, license holders, operate in a mechanized way and have employees (IGF 2017). In this unit, we will be presenting information to support this burgeoning professionalization of the sector, and provide formalization and financial information, for supporting ASM as a developing business.

Business Planning

The fundamentals of any successful business operations, whether it be for ASM operations or any other business sector, are developed in good business planning and sound business management. As with any business, the more successful it becomes, the further the business plan needs refining to account for the dynamics of growing operations. Those involved in ASM activities for subsistence tend to lack financial literacy and thus lack knowledge of the fundamentals that could improve their operational efficiency via informed decisions about investments, expenses and savings. Management training of individuals in ASM can help miners and mine owners improve their productivity and profitability.

Business Plan – *A tool used when starting a new business. It helps the potential business owner to develop a well thought out plan before operations begin. It includes the following elements:*

- ***Mission Statement****: Goals for the company in the short-, medium-, and long-term*
- ***Business Overview****: Business name, description of what the business does or sell, type of industry, product or service-, risk-, and local competitor identification*
- ***Operating Plan****: Location of business, lease or own property, number of employees, equipment needed, environmental concerns, list of employees*
- ***Marketing Plan****: The strategy to reach customers and to for continued growth*
- ***Action Plan****: Determine what needs to be done first before operations can start – such as hiring employees, finding a supplier or property to work from, ordering equipment or furniture etc.*
- ***Financial Plan****: Budgeting and forecasting for sustainable business operations, including an inventory of all assets (cash, sources of finance, equipment on hand and needed)*
- ***SWOT Analysis*** – Analyses of company's current and potential strengths, weaknesses, opportunities, and threats to success.

One of the first exercises prospective business owners and managers must do is to envision and develop a **business plan** based on their ideas and operational plans. It is an important and effective tool that investors or financial institutions can use to evaluate whether the business is a candidate for financing (APEC and AGC 2019). A good business plan is more than just a document, it can act as a road map to guide the company. A clearly written plan can also attract and fuel the excitement of potential investors and assist the business in acquiring loans from financial institutions. See the **spotlight box** for details of what this plan should contain.

One method used to develop new or to improve existing business models is what is known as the business model canvas. It is a blank template consisting of nine fields representing the building blocks or essential elements of a successful business: **Key partners, activities, and resources, value propositions, customer relationship, channels, customer segment, cost and revenue structure** (Figure 57). It offers a way to visualize and map a business' pathway and analyze the key drivers for how a business idea can come to fruition.

Figure 57. A general example of the standard Business Model Canvas. Source: (Digital Enterprise 2025)

Whether business model canvases can be applied by ASM mine owners to become more successful remains an open area of study. Recently, researchers have developed rather a community based business model canvas that has been successfully applied to the artisanal and small scale gold mining (ASGM) sector in Burkina Faso. The question the posed was what kind of business model could be developed to engage the ASGM sector to eliminate the use of mercury and to have more sustainable operations. They developed the community based business model canvas that encourages more interdisciplinary research in mining and mine management to be used by mining cooperatives to enable more stakeholders, such as community organizations, local government, or NGOs, for involvement in mercury free mineral extraction (Fritz and Lara-Rodríguez 2022). Figure 58. Example of a) a standard and b) community based business model canvas developed for an ASM gold mining operations. Source: (Fritz and Lara-Rodríguez 2022) shows an example of the standard and Figure 58b the community business model canvases developed for the sector. For every business, even in the ASM sector,a business model canvas is site specific and requires adapting to local communities, environments, actors, and the specific mineral being mined.

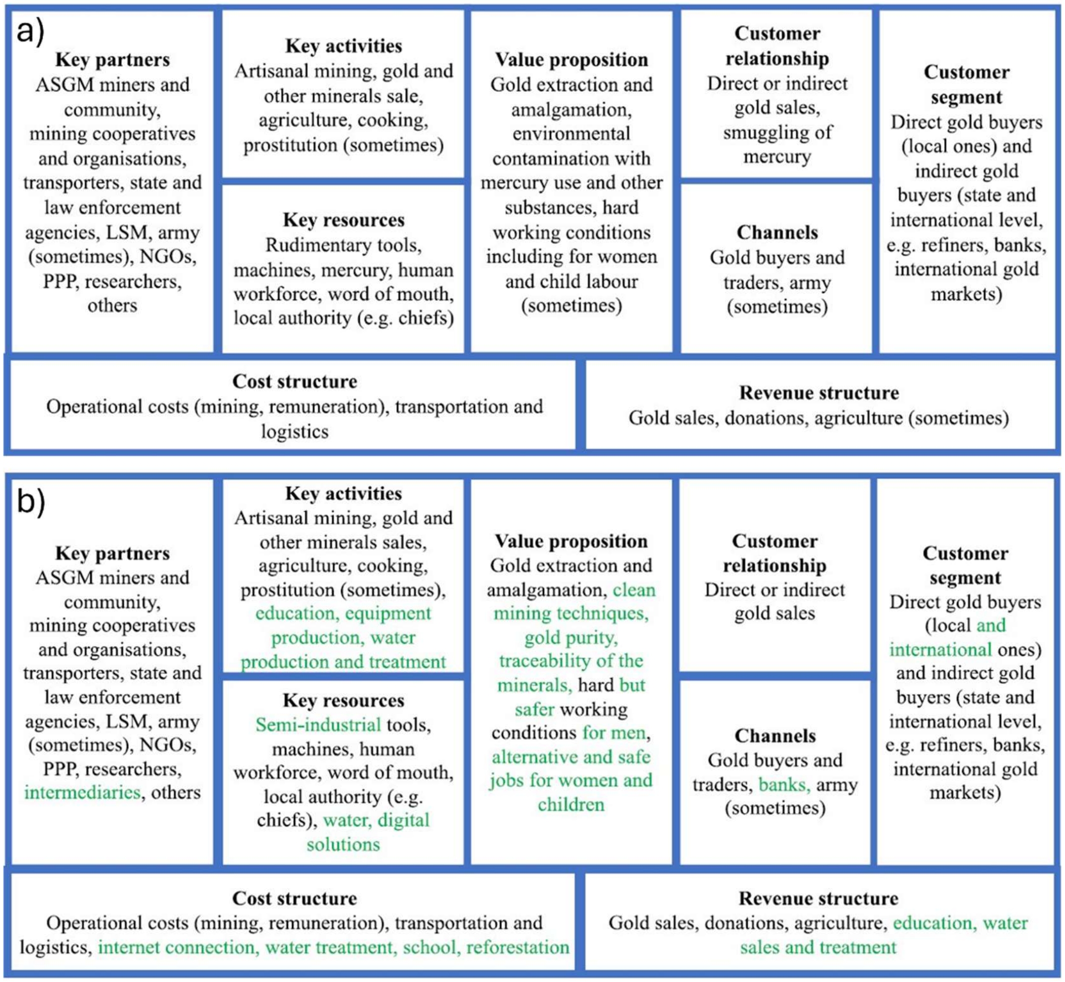

Figure 58. Example of a) a standard and b) community based business model canvas developed for an ASM gold mining operations. Source: (Fritz and Lara-Rodríguez 2022)

Business Expenses

Once the ASM business is operational, the management must be profitable if it is to be sustainable. Sound business management begins with understanding the **basics of budgeting** and bookkeeping. A budget is simply just a spending plan based on two details, the total income and expenses of a business. Budgeting is a way to allocate cash resources to the strategic priorities identified in your business plan. It is a way of keeping track of the income and expenditures and available cash on hand for the business and can be simple or complex. It looks at a business' total costs including the **direct** (salaries, equipment, fuel, etc.) and **indirect** (housing, childcare, school fees, etc.) expenses (Figure 59) and compares them with the **income** (or the amount of money being earned) and generates the amount of **profit** the business has made.

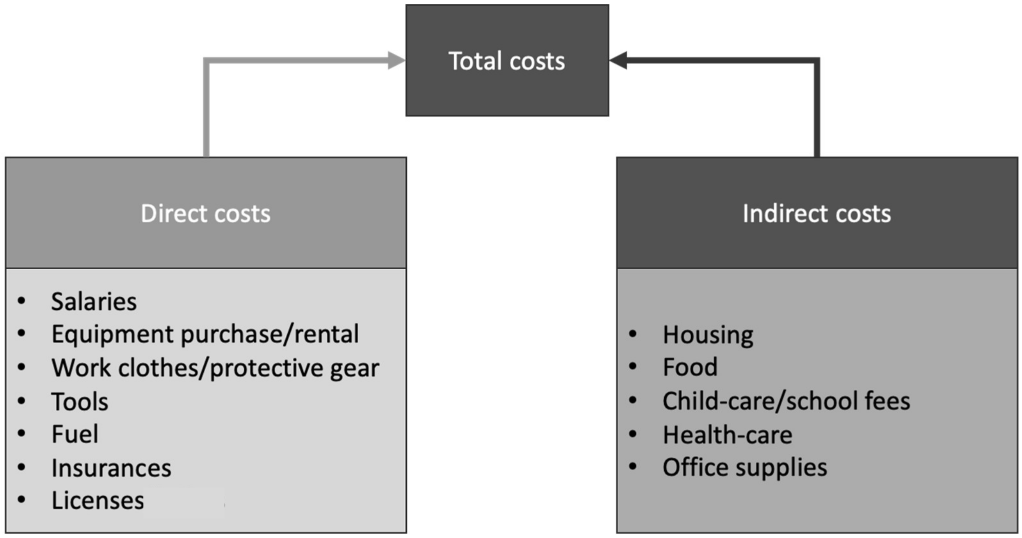

Figure 59. A schematic diagram showing the business items classified as either direct or indirect costs.

There are many methods to record-keeping and generally the more detailed, the more precisely a business owner can understand their cash on hand and anticipate how successful the business operations are and where improvements to efficiency can be made. Furthermore, good budgeting and complete record keeping is important for managing relationships with service providers and can assist potential lending institutions in understanding how well the business is performing and whether or not it will be able to repay any approved loan (ILO 2015). Simple record keeping techniques such as using **green ink** to track all **income** and **red ink** to track **costs** can assist in understanding the financial situation of the business. Examples of simple systems of record keeping are shown in Figure 60.

a)

Date	Description	Sale (MGR)	Expense (MGR)
31.07.2024	Income from gold sale	**5’000’000.00**	
31.07.2024	Salary paid out		**3’000’000.00**

b)

Date	Description	Cash			Income from sale (MGR)	Direct costs from material (MGR)	Direct costs labour (MGR)	Indirect costs (MGR)
		Income (MGR)	Costs (MGR)	Balance (MGR)				
31.07.2024	*Income from gold sales*	**5’000’000**		**5’000’000**	**5’000’000**			
31.07.2024	*Salary paid out*		**3’000’000**	**2’000’000**			**3’000’000**	
01.08.2024	Purchased gloves and bags for minerals		**800’000**	**1’200’00**		**800’000**		
01.08.2024	Stationery and training fees		**300’000**	**900’000**				**300’000**

Figure 60. Examples of a) simple systems tracking only two parameters income (from gold sales) versus salary and b) a more detailed system tracking income and direct, indirect costs. Source: (Planet GOLD 2021)

Once a business begins monthly record keeping, it can also understand in aggregate the overall yearly business profit and yearly cumulative profit. Profit is the total income minus the total costs. This generates the profit or loss for the month. The cumulative profit or loss is then the sum of the monthly net profit or loss. This is displayed in Figure 61. When viewed over the whole year, one can understand the overall performance of the business. Such record keeping is crucial for external organizations such as lending institutions, to determine the health of the business and for the business owner to better plan for the future.

	January	February	March	April	May	June	July	August	September	October	November	December	Total
INCOME (MGR)													
1. Income from gold sale	5’000’000	8’000’000	3’000’000	6’000’000	8’000’000	7’000’000	3’000’000	0	0	0	0	0	40’000’00
2. Income from other sale	0	0	0	0	0	0	0	2’000’000	1’000’000	3’500’000	500’000	1’500’00	8’500’000
TOTAL INCOME	**5’000’000**	**8’000’000**	**3’000’000**	**6’000’000**	**8’000’000**	**7’000’000**	**3’000’000**	**2’000’000**	**1’000’000**	**3’500’000**	**500’000**	**1’500’000**	**48’500’000**
COSTS (MGR)													
1. Direct costs for materials	800’000	900’000	200’000	400’000	700’000	600’000	200’000	600’000	400,000	1’200’000	150’000	500’000	6’650’000
2. Direct costs for labor	3’000’000	3’000’000	3’000’000	3’000’000	3’000’000	3’000’000	3’000’000	800’000	800’000	800’000	800’000	800’000	25’000’000
3. Indirect costs	200’000	200,000	200’000	200’000	200’000	200’000	200’000	200’000	200’000	200’000	200’000	200’000	2’400’000
TOTAL COSTS	**4’000’000**	**4’100’000**	**3’400’000**	**3’600’000**	**3’900’000**	**3’800’000**	**3’400’000**	**1’600’000**	**1’400’000**	**2’200’000**	**1’150’000**	**1’500’000**	**34’050’000**
Profit / Loss	**1’000’000**	**3’900’000**	**-400’000**	**2’400’000**	**4’100’000**	**3’200’000**	**-400’000**	**400’000**	**-400’000**	**1’300’000**	**-650’000**	0	**14’450’000**
Cumulative Profit / Loss	1’000’000	4’900’000	4’500’000	6’900’000	11’000’000	14’200’000	13’800’000	14’200’000	13’800’000	15’100’000	14’450’000	14’450’000	**14’450’000**

Figure 61. An example of a more detailed system of tracking income and direct, indirect costs showing an entire year of operations. Source: (Planet GOLD 2021).

People in Business

A crucial exercise for those interested in elevating their ASM activities into a business will be to identify those the people involved in the overall operations, whether it be directly at the mine site or others involved in the sale of the minerals or in the governance of the sector on a regional or national level as a whole. This is generally known as stakeholder mapping and is an important exercise in planning a business. Generally, any potential stakeholder group identified in the ASM sector usually belongs to one of three groups, those involved in ore extraction and **production**, in **trade** of the product and in **regulation** of the sector (Anglo American 2025). Stakeholders directly involved with production can vary from customers, suppliers, investors, owners, employees, and contractors. Some involved in the trade of the minerals could be, for example, transporters or individuals at buying counters. The final group of stakeholders represents an important group for the ASM, those involved in the regulation of the sector. These generally consist of local or regional government representatives, for example from the ministry of mines or of the environment but can also include those from local or national land or forestry commissions. Often it is representatives from these government agencies who work with the ASM for example, to harvest high-value trees prior to mining or dealing with land reclamation and remediation after operations cease, or government individuals who assist ASM mine owners with identifying and managing ASM concessions. Some stakeholders involved ASM sector, and their roles and responsibilities are listed in Table 9.

Table 9. Potential stakeholder groups common in the ASM sector. Source: (Falck et al. 2024)

Stakeholders	Stakeholder activity
ASM Operators	ASM Miners
	ASM processors, including people involved in crushing, grinding, sieving, panning, etc.
Buyers	Buyers of mineral products, potentially represented by local agents
Financiers	Individuals or organisations who supply equipment or financial support to ASM operators to carry out their activities
Co-operative or association leaders	Representatives of ASM miners thar are operating through a co-operative or association structure
Government regulators	Local, regional, or national agencies, incl. mining and environmental inspectors
Government official	Local, regional, or national officials from non-mining related agencies
Other industry actors	Other companies (incl. LSM) operating within the same region with potentially overlapping interests
	Industry associations that may have a viewpoint or endorsed an approach to work with ASM operators
International organisations or initiatives	Focus on improving the situation of ASM operators through aid, education, or financing programmes
Communities and their individual members	Local community, pre-existing or newly formed by ASM activities
	Local communities near LSM operations, if different from above
	Communities in the region
Specially affected groups	Indigenous communities
	Children or forced or bonded labour working in ASM operations
Advocacy groups	Human rights, social justice, environmental and community-based groups working locally, regionally, nationally or internationally
Civic organisations	Churches, trade and labour organisations, charitable organisations, and other NGOs working in community development, capacity building and other overlapping programmes in the ASM region
Internal	Employees, cooperative members, contractors, shareholders, management and directors (of small- and large-scale mining companies).

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Unit 2: Formalization – Challenges and opportunities

Introduction

In recent years there has been a push to formalize the ASM sector, which is viewed by experts in the field to be essential to the professionalisation of the sector and to improve the workers financial stability and quality of life. Indeed, many ASM workers are trapped in a perpetual cycle of poverty caused in part by informality. This poverty trap is a result of the inability of ASM workers to diversify its income earning activities, the lack of income alternatives available, and an inability to mechanise operations due to a lack of access to capital (Hilson and Pardie 2006). Rudimentary technology leads to low productivity, low income and the inability to invest in improvements. Furthermore, it also leads to environmental damage, to poverty exacerbation and subsequently to a larger number of individuals working in the sector, given there are no alternatives (Hilson and Pardie 2006). This trap is displayed in Figure 62. Efforts for formalisation of the sector can begin to alleviate some of these issues.

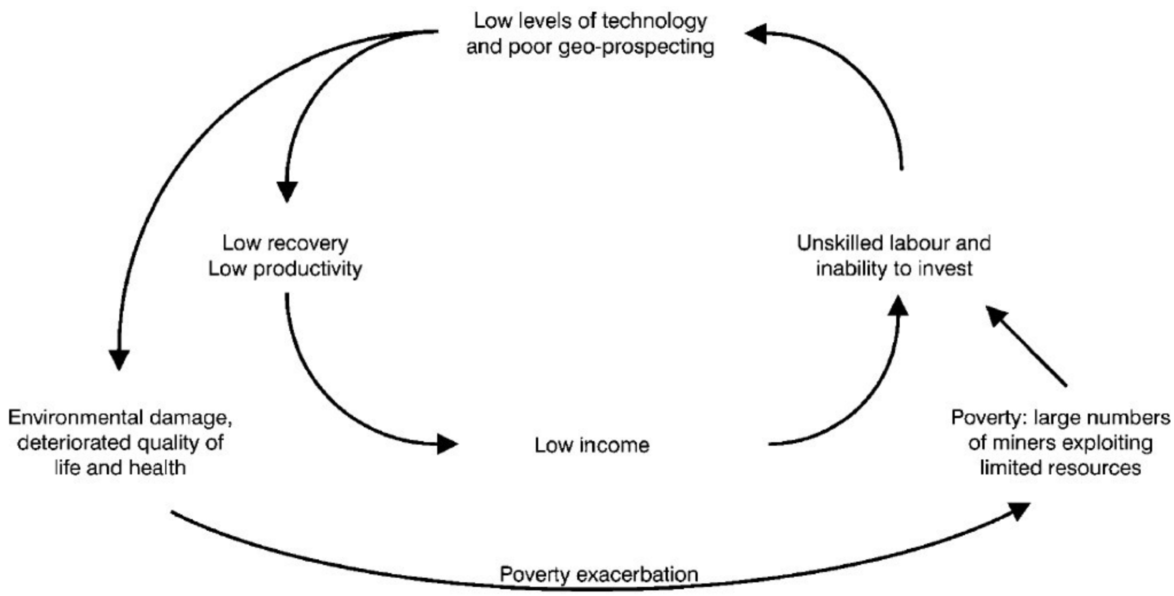

Figure 62. The perpetual cycle of poverty of informal ASM workers. Source: (Hilson and Pardie 2006)

What is formalisation and how can workers in the ASM sector begin this process? Indeed, the movement to formalize the sector has been growing over the past decades. Formalization has been defined as the development by which subsistence ASM miners, or those who earn income via ASM activities in an informal way, bring their mining activities and operations to the formal space through legal, regulatory, and policy frameworks, abiding by local and regional laws and regulations and be subsequently be overseen by the relevant authorities (IGF 2017). Formalisation would enable the marginalized or low-skilled miners or mining labours to be integrated into the formal economy (IGF 2017). See the spotlight box to understand the key terms associated with formalisation.

Key Terms as defined by the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF, 2017)

Formalisation – The process of bringing informal income-earning activities and economies into the formal sector through legal, regulatory, and policy frameworks, as well as the extent to which such laws and regulations are successfully activated, implemented, and enforced by the relevant authorities.

Formal ASM – Operations that have the requisite licenses and permits required by law, and conform to regulations, policies and management practices.

Informal ASM – Operations that do not have the requisite licenses and permits required by law, but through social and cultural norms, rules and practices that have developed over many decades have a "social license to operate" from the local community, or other local actors who do not have power or authority vested by the state to award mineral rights, concessions, and permissions to mine.

Legalisation / regularisation – The legality refers only to the legal regulatory framework that makes ASM legal.

Licensed and Legal ASM – Operations that have a mining license and any environmental permits and permissions as required by law.

Unlicensed / Illegal ASM – Operations that do not have a mining license and any environmental permits and permissions as required by law.

Challenges to formalisation of the sector

There are numerous challenges to formalisation of the ASM that have left those working in the sector in the poverty trap. For example, numerous regulatory barriers in many countries across Africa hinder the ASM sector from becoming fully formalized. It is known that millions of artisanal workers are operating outside of the legal framework giving thus the overall negative view of the sector. However, frameworks for regulating ASM are often a "scaled-down" version of policies managing large scale mining, which is often then maladapted for the specific local context (Mutemeri et al. 2016). Researchers have shown that this leaves the ASM in an awkward bureaucratic context with some provisions unworkable or arbitrary, for example illogical limitations on mining depth with no consideration for size or shape of the ore body, or even restrictions or prohibition on ASM mechanisation (Mutemeri et al. 2016). They propose instead a regulatory and policy shift towards an outcomes-based approach (Figure 63). This new paradigm would be one that instead embraces a "pro-poor" ASM policy and integrates strategy, people, resources, transparency and accountability while focusing on achieving outcomes for the ASM, while enabling continuous learning and adapting and reporting on their performance (Foreign Affairs, Trade and Development Canada 2014; Mutemeri et al. 2016). Policy makers must consider the poverty-driven characteristics of the sector and thus redesign policies to remove the barriers that prevent brining miners into the legal domain (IGF 2017).

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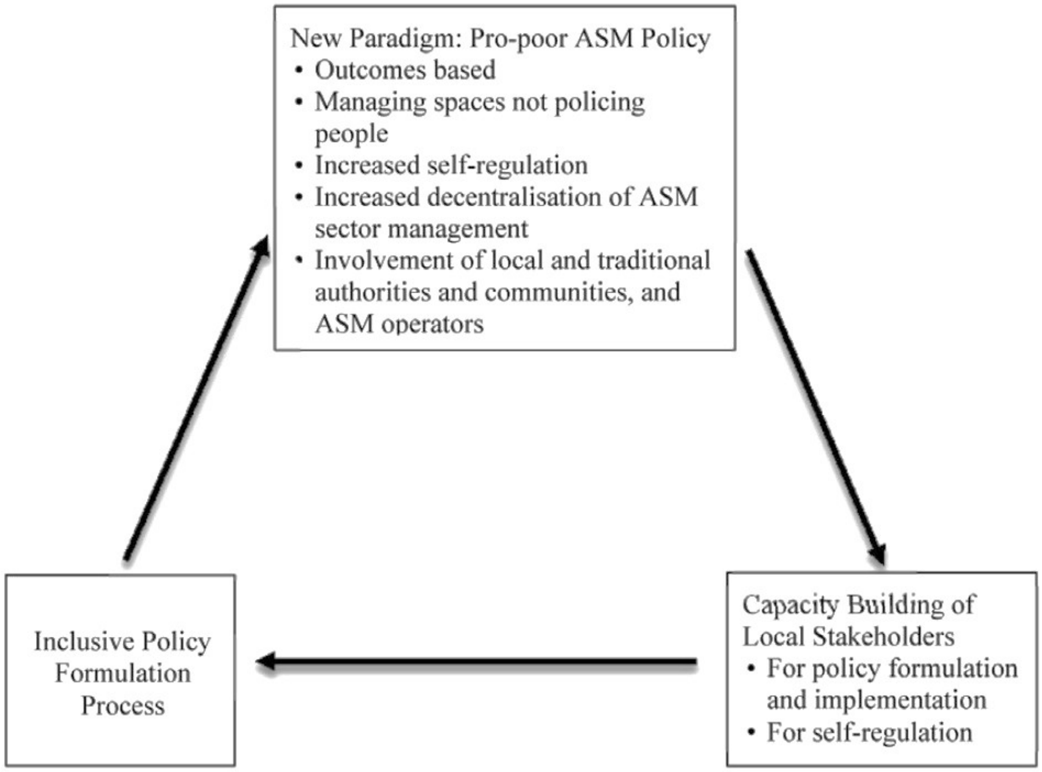

Figure 63. Key components of a new ASM regulatory and policy paradigm shift. Source: (Mutemeri et al. 2016)

There are economic constraints that prevent widespread ASM formalization with the sector. As mentioned, the poverty trap the ASM workers find themselves in is difficult to escape. Given that debt plagues the sector, the inability to access finance due to their informality and non-legal status creates many economic barriers to improvement. Widespread formalization needs to be broad-based and include the operations of all workers, not just those ASM who are opportunistic entrepreneurs (Hilson and Hilson 2015; IGF 2017). Furthermore, economic success factors for ASM development include the establishment of small-scale lending policies, and loans specifically for small-scale mining projects, as well as establishing the government as the grantor so that collateral is not necessary while establishing that the lenders determine the amount of the loan after assessment from the government (IGF 2017; UNECA 2002). Formalisation of the ASM sector will expand if their access to finance is improved. Further discussion on ASM access to various financing options is described in **Unit 6**.

Additional social and cultural factors contribute to the difficulty in widespread formalization, particularly for women in the ASM sector. Often women's roles have been relegated to ore processing, like washing, sieving, sorting, amalgamation and amalgam decomposition, and historically has not included the actual mining (IGF 2018). Indeed, it has been said that women in the mine underground is seen as "bad luck" and thus they are relegated to the less profitable roles, further keeping women in the poverty trap. Moreover, traditionally influenced legal constraints prevent women from formalization, such as their exclusion from owning land or mineral rights (IGF 2018). To address these cultural and other challenges and to promote formalization, women in mining groups have been established across Africa. Since 2015, the Association of Women in Mining in Africa (AWIMA) has been aiming for a more transparent and equitable mining of mineral resources and a sustainable growth of the mining sector for all stakeholders, especially women (AWIMA 2024).

Opportunities to formalization of the sector

It is now understood that formalization is rather a process that incorporates many different dimensions of improvements to the ASM sector, including advances in regulatory frameworks governing ASM, making financing more accessible for the workers in the sector and breaking down antiquated cultural views by advancing the role of women. Experts in the field suggest that by taking a human rights based, two pronged approach (Figure 64), one that includes obligations and participation by both the ASM actors and governments, can begin to address the challenges to formalization (de Haan 2018; UNITAR and UNEP 2018). Indeed, modest but meaningful progress has been made in the years since the idea of formalization was first developed.

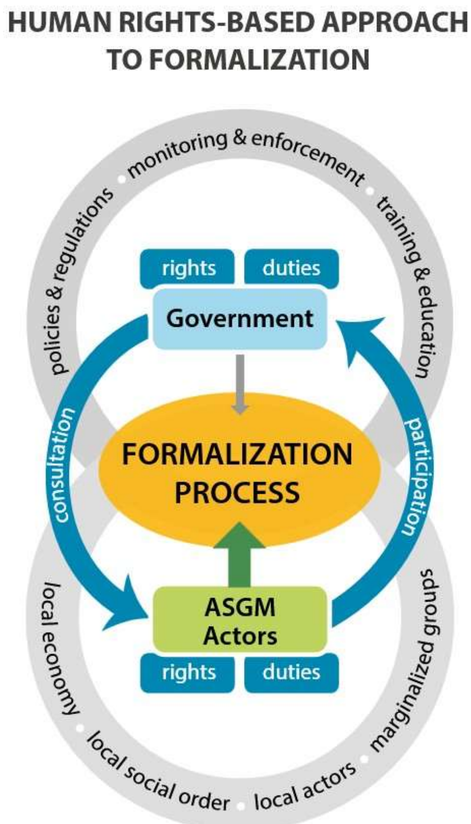

Figure 64. The human rights-based approach to formalization includes interaction between both ASM and governments. Source: (UNITAR and UNEP 2018).

One example of a successful implementation of a formalization programme was in Colombia between 2014 and 2020. There a large scale gold mining company allocated several areas of its own mining concessions, to an organization of ASM operators, granting them legal access to the land and its associated minerals (Jiménez, Smith, and Holley 2024). This cooperation between the two entities supported ASM formalization by giving opportunities for the sector to adopt to technical and business procedures, gave them access to geological and mining information and various extractions methods while also providing financial assistance (Jiménez, Smith, and Holley 2024). Its success was due in large part to not just the

ASM workers complying with legal obligations but also adaptations made by the LSM company, and the government, in terms of providing capacity building, and adapting laws to suit the local context (Jiménez, Smith, and Holley 2024).

In Ghana, the government has launched a program called the Community Mining Scheme (CMS) to promote sustainable and responsible mining practices and provide legal mining opportunities to ASM and local communities. The CMS aims to encourage community participation in ASM, to create jobs, improve working conditions, minimize environmental degradation and subsequently improve the conditions of members of the sector (Minerals Commission 2021). The programme is implemented by the Minerals Commission and establishes a community mining oversite committee to promote and develop mining operations and ensure compliance with relevant legislation (Minerals Commission 2021). Furthermore, efforts have been made to refine Ghanian ASM gold with the recent opening of Ghana's first refinery (Adombila 2024). Such efforts at adding value and prevention of the smuggling of ASM gold out of the country, will lead to increased formalisation of and improvements in the livelihoods of the ASM sector in the country.

Group work or exercise

Group Exercise – Starting a Business Plan for ASM

Group Exercise - Steps to ASM Formalization

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Training Worksheet - Starting a Business Plan for ASM

1. Executive Summary Exercise

Objective: Understand the key components of an ASM business.

- Describe the purpose of your ASM business in one sentence.

- List three main goals for your mining operation.

1.
2.
3.

2. Business Description Exercise

2.1 Business Name: What will you name your mining business?

2.2 Business Type: Circle one - Sole Proprietorship / Partnership / LLC

2.3 Location: Where will your mining operation be located?

2.4 Legal Structure: What legal steps have you taken (or need to take)?

2.5 Business Goals: List three ways you plan to make your ASM business sustainable and profitable.

1.
2.

3. ________________________________

3. Market Analysis Exercise

3.1 Industry Overview: Research and describe one current trend in the ASM sector.

____

____

____

3.2 Target Market: Who are your primary customers? List at least three potential buyers.

1. ________________________________
2. ________________________________
3. ________________________________

3.3 Competitive Analysis: Identify two strengths and two weaknesses of your potential business.

1. ________________________________
2. ________________________________
3. ________________________________
4. ________________________________

4. Business Operations Exercise

4.1 Mining Process: Outline the step-by-step process you will use to extract and process minerals.

Step 1: ________________________________

Step 2: ________________________________

Step 3: ________________________________

4.2 Equipment and Tools: List five essential tools and equipment you will need for mining operations.

1. ________________________________
2. ________________________________
3. ________________________________
4. ________________________________

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5. ____________________

4.3 Workforce and Management: Identify key roles required for your business and how many people you need in each role.

Role 1: ____________________

Role 2: ____________________

Role 3: ____________________

5. Financial Plan Exercise

5.1 Start-up Costs: Estimate the initial costs for setting up your ASM operation.

- Land acquisition: $____________
- Equipment purchase: $____________
- Labor costs: $____________
- Other expenses: $____________

5.2 Revenue Model: How will you make money? Choose at least two revenue sources.

1. ____________________
2. ____________________

5.3 Profitability Projection: Calculate your expected revenue and costs for the first year.

- Expected Revenue: $____________
- Estimated Expenses: $____________
- Expected Profit: $____________

6. Risk Management & Sustainability Exercise

6.1 Environmental Considerations: List three steps you will take to minimize environmental damage.

1. ____________________
2. ____________________
3. ____________________

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6.2 Legal & Regulatory Compliance: Identify at least two legal requirements you need to fulfill.

1. ____________________
2. ____________________

6.3 Social Responsibility: List two ways you will support the local community.

1. ____________________
2. ____________________

7. Conclusion & Action Plan

- What are your next three steps in launching your ASM business?

1. ____________________
2. ____________________
3. ____________________

This worksheet serves as a practical guide for prospective ASM mine owners, helping them develop a structured plan for their mining operations.

Training Worksheet: Steps to ASM Formalization

Instructions:

This worksheet is designed to guide Artisanal and Small-Scale Miners (ASM) through the process of formalizing their mining operations. Answer the questions based on your current mining practices and identify the steps needed to become fully formalized.

Section 1: Understanding Legal Requirements

1. **What are the mining laws and regulations in your country?**

---

2. **What permits or licenses are required for ASM formalization?**

---

3. **Which government agencies regulate mining activities in your area?**

Section 2: Organizing Miners into Cooperatives or Associations

4. **Are you currently part of a mining cooperative or association? Yes / No**
    - If yes, what are its benefits?
      ____
      ____
      ____
    - If no, what steps can you take to join or form one?
      ____

____

____

5. **What advantages do cooperatives provide for ASM formalization?**

Section 3: Securing Mining Rights and Land Access

6. **Do you have a legal mining permit or land rights to operate? Yes / No**
   - If no, what are the steps needed to obtain one?

     ____

     ____

7. **Are there land disputes or conflicts in your mining area? Yes / No**
   - If yes, how can these conflicts be resolved?

     ____

     ____

Section 4: Implementing Environmental and Safety Standards

8. **What are the environmental impacts of your mining activities?**

9. **Have you adopted safer mining techniques (e.g., mercury-free methods, waste management)? Yes / No**
   - If no, what are the barriers to adopting safer methods?

     ____

     ____

10. **What safety measures are in place at your mine site?**

____

____

Section 5: Developing Financial and Market Access

11. **How do you currently sell your gold or minerals?**

____

____

12. **Have you explored ethical or fair-trade markets? Yes / No**
    - If no, what steps can you take to access these markets?
      ____
      ____

13. **Do you have access to financial support (e.g., loans, grants, microfinance)? Yes / No**
    - If no, what financial support options are available?
      ____
      ____

Section 6: Building Partnerships and Government Support

14. **What organizations or stakeholders support ASM formalization in your area?**

____

____

15. **Have you attended any government or NGO training on formalization? Yes / No**
    - If no, where can you find such training opportunities?
      ____

16. **What partnerships can help in your journey to formalization?**

____

____

____

Section 7: Monitoring and Continuous Improvement

17. **Do you keep records of production, income, and expenses? Yes / No**

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- If no, what system can you use for better record-keeping?
  ____
  ____

18. **How do you ensure compliance with mining regulations?**

____

____

19. **What improvements can you make in your mining operations to support formalization?**

____

____

Conclusion & Action Plan

- Based on your answers, list **three key actions** you will take to move toward formalization:
  1. ____
  2. ____
  3. ____

Use this worksheet to assess your progress and create a step-by-step plan for achieving formalization in your mining activities. Share your findings with trainers and discuss strategies to overcome challenges during the training session.

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2.6. Module 6: Access to Finance

Module Title	**Access to Finance**
Module Aims	This module aims to provide participants with a comprehensive understanding of the various national and international financial instruments and marketing opportunities available for ASM practitioners.
Specific Learning Outcomes	Upon completing the module participant will, through assessment activities, show evidence of their knowledge in: • Challenges and bottlenecks associated with accessing and providing finance • Various formal and informal funding opportunities • Way to reach to official markets to trade their products.
Comprehensive Learning Outcome	The course ultimately aims to prepare ASM practitioners to strengthen their financial literacy, enabling more resilient, efficient, and sustainable mining operations.
Module Content	1. Challenges with accessing and providing finance 2. Formal and informal funding opportunities (local and international) 3. Access to markets
Methods of Facilitating Learning	This Module will be facilitated through modular lecturing, role plays, group discussions and presentations.
Reflection on learning outcomes	A group exercise using a "Roles Play" format, group presentations and feedback from the trainees
Student Support & Learning Resources	Workshop manuals, presentations, group work handouts Additional information on relevant publications, internet resources and other reading material will be provided.

Unit 1: Barriers to Accessing and Providing Finance for ASM

The ASM sector often expresses frustration over the lack of financial support from banks and investors, citing limited access to credit and funding opportunities. Indeed, financing ASM is not a common activity for most traditional funding organizations, such as international commercial banks, financial investors, or export credit agencies (Albery et al. 2024). As such, before exploring existing financing opportunities, it is important to understand the challenges and barriers from both perspectives—accessing finance (demand side) and providing finance (supply side) (Planet Gold 2020; ZELA 2021; Falck et al. 2024).

The main barriers to 'accessing finance' are as follows:

- **Legal Status:** The informality (or sometimes illegality) of ASM operations prevents formal financial institutions from engaging with them due to the lack of legal recognition.
- **High Risk Profile:** The risk profile of the ASM sector is considered to be high when compared with the risk tolerance of potential funders (Albery et al. 2024; Planet GOLD 2020b)
- **ESG Compliance Challenge:** Formal funding organizations require high environmental, social and governance (ESG) standards from a potential project they would invest in. Compliance with these standards is not easy for ASM and may require significant upfront capital (Planet GOLD 2020b).
- **Small Scale:** Most ASM operations are too small, and the high transaction costs make them unattractive to commercial banks and investors (Planet GOLD 2020b).
- **Limited Scalability:** The limited prospects for further and more lucrative ancillary business or lack of opportunities for scalable finance (Planet GOLD 2020b).
- **Business and Financial Literacy Gaps:** Many ASM operators do not have the formal business and management training that would enable then to make their case to financial institutions (Planet GOLD 2020b). Lack of financial records makes if difficult for financial institutions to evaluate the amount of loan the miners qualify for or their capacity to repay that loan (ZELA 2021).
- **Lack of collateral security:** the majority of artisanal and small scale miners do not have the collateral that is required by a financial institution as a precondition to get a loan (ZELA 2021).
- **Insufficient Geological Data:** This criterion is essential for financial institutions to evaluate the potential returns on their investments (Planet GOLD 2020b). A geological report offers essential insights into the mineral content and deposits of a specific area or mine, providing assurance that sufficient resources exist to support sustainable extraction and loan repayment (ZELA 2021).
- **Lack of Consistent Government Interventions:** Governments play a vital role in offering continuous, long-term support for training, capacity building, and business services within the sector. The absence of these services can lead to the loss of funding opportunities (Planet GOLD 2020b).

Sources: Planet Gold 2020; ZELA 2021; Falck et al. 2024

Considering these barriers, the investors are also facing challenges to 'provide finance' to ASM. As mentioned in Module 2, investors and financial institutions are required to follow relevant voluntary and mandatory standards when making any decisions about their investment opportunities. For example, one of these standards is the Principles of Responsible Investment (PRI), which is a tool to leverage investor's power for better environmental, social and governance performance. The six basic principles of responsible investment are shown in Figure 65.

Figure 65. Six principles of responsible investment. Source: GREALOGICS[35]

Some of the most important challenges for providing finance to the ASM sector are listed below (Planet GOLD 2020b):

- **Reputational and ESG Risks**: Financial institutions are hesitant to fund ASM due to its negative public image, associations with informality, environmental harm, and links to money laundering or conflict zones.
- **High Cost of Due Diligence**: The lack of standardized due diligence toolkits and reliable monitoring mechanisms makes assessing ASM projects costly and unappealing for finance providers.
- **Limited Experience in ASM Financing**: Many financial institutions lack expertise, evaluation frameworks, and intermediaries to assess and manage ASM investments effectively. The main challenges ae lack of established track record or scalable financing models, absence of intermediaries to bundle projects and reduce risk, lack of impact metrics for investors seeking measurable social or environmental returns.
- **Few Investable Projects** – ASM lacks well-structured investment proposals and intermediaries to bridge the gap between miners and financiers. Additionally, investment portfolios often require larger minimum amounts than ASM enterprises can manage (Planet GOLD 2020b).
- **Regulatory and Policy Barriers** – Legal restrictions on foreign investment, unpredictable policies, and banking regulations (e.g., interest rate caps) limit ASM's access to financing. Some investors are also restricted from operating in sanctioned countries or high-risk regions (Planet GOLD 2020b).
- **Absence of Tailored Financial Instruments:** Due to the barriers mentioned above, most of the formal finance providers do not have dedicated funding instruments or solutions that would meet to the needs and conditions of the ASM sector (Planet GOLD 2020b).
- **Limited Banking Operations**: A barrier to ASM lending was previously the lack of banking operations in-country given the remoteness of ASM operations (Albery et al. 2024).

Sources: Planet Gold 2020, ZELA 2021

[35] https://x.com/CREALOGIX/status/1384115243089948673/photo/1

Unit 2: Existing financing opportunities

Securing financing for ASM operations remains challenging due to various obstacles mentioned above. In recent years, different financiers have explored and implemented a range of financing structures. The following sections outline examples of these funding opportunities, categorized into formal and informal financing models. It is important to note that many of these financing opportunities and examples primarily apply to gold mining and are based on a comprehensive study conducted by Planet Gold (Planet GOLD 2020a, Planet GOLD 2020b). Their relevance to other minerals may vary, but these approaches can serve as a baseline framework and be adapted based on the specific commodity and regional context.

Formal Funding Opportunities

Microcredits or microfinance refers to small loans or financial services to miners who are unable to access credit from conventional financial institutions due to the informal (and sometimes illegal) nature of their operations. These loans can be used for purchasing equipment, acquiring necessary materials, or improving mining techniques. Microfinance institutions (MFIs) offer flexible repayment plans to accommodate the unpredictable income of ASM operators. For example, microfinancing in ASM might involve a miner receiving a loan from a microfinance institution to purchase basic tools or machinery. In return, the miner would pay back the loan over time with modest interest rates, often with a focus on supporting local economic development and improving the living standards of communities involved in ASM (Paschal, Kauangal, and Nuhu 2024; Planet GOLD 2020b). Despite being an opportunity, securing microcredits is still a challenge for many ASM communities due to the challenges mentioned above (Albery et al. 2024). A summary of some implemented microfinancing schemes and their general characteristics is shown in Table 10 (Planet GOLD 2020a) .

Table 10. Summary of general characteristics of selected microfinancing schemes, Source: modified after (Planet GOLD 2020a)

Summary of general characteristics of selected microfinancing schemes	
Type of lender	Government, microfinance institutions, NGOs, donors and rural banks
Loan size	$5,000–350,000
Purpose	Working capital financing, Purchase of input, Purchase of non-current assets such as excavators, washing plant installation
Process	➢ Client or MFI initiates contact ➢ Client is informally prequalified, where possible ➢ Client submits full application for loan along with supporting documentation ➢ MFI conducts due diligence including inspection review of client's control to site, resources and equipment ➢ MFI commissions appraisal of collateral, where applicable ➢ MFI commissions inspection of client's domicile and office premises, where an effective address system does not exist ➢ MFI conducts Credit Committee meetings to decide on case ➢ If Credit Committee approves Client, loan is issued

Summary of general characteristics of selected microfinancing schemes	
Collateral required	➢ The noncurrent asset for which the funds are being sought (these could be the digging equipment, the installed washing bay or motor vehicles to be used for the business ➢ Cash deposit (down payment of between 30-50% of the amount being borrowed) ➢ Payment protection insurance on the amount to be borrowed ➢ Personal guarantee ➢ Third party corporate guarantee ➢ Equity ownership in the borrower's entity of about 30-40% ➢ Titled landed property
Process duration	1–4 (barring all delays due to client submission of required documents)
Credit terms	Interest rates: 24–36 per annum Repayment Frequency: Monthly or bi-monthly Penal charges: Where loans are defaulted on. The consequences are either a repossession of leased equipment, auction of collateralised asset and/or legal action Customer signs post-dated cheques to cover loan period Loan duration: 1–2 years

Bank loans: One of the most common services of banks is to provide loans to businesses, offer investment products and provide financial services to their customers. However, due to the challenges mentioned above, most commercial lending schemes are not tailored to ASM conditions and needs (Planet GOLD, 2020). Despite these challenges, there are good examples of this type of financing. For example, in Kenya, commercial lenders like K-Rep Bank and Rafiki Microfinance and some banks in Ghana and Zimbabwe have experimented with lending to ASM operators. These loans are often highly collateralized, have high interest rates and strict repayment schedules, making them accessible to a specific group of ASM operators (Planet GOLD 2020a). A summary of some commercial loan schemes and their general characteristics is shown in Table 11.

Table 11. Summary of general characteristics of commercial loans schemes for ASM. Source: modified after (Planet GOLD, 2020a)

Summary of general characteristics of commercial loan schemes for ASM	
Type of lender	Commercial bank
Loan size	$20,000– 1,000,000
Purpose	Working capital financing, Purchase of input, Purchase of non-current assets such as excavators, washing plant installation, Advisory services
Process	➢ Client or MFI initiates contact ➢ Client is informally prequalified, where possible ➢ Client submits full application for a loan along with supporting documentation

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Summary of general characteristics of commercial loan schemes for ASM	
	➢ MFI conducts due diligence including inspection review of client's control to site, resources and equipment ➢ MFI commissions appraisal of collateral, where applicable ➢ MFI commissions inspection of Client's domicile and office premises, where an effective address system does not exist ➢ MFI conducts Credit Committee meetings to decide on case ➢ If Credit Committee approves Client, loan is issued.
Collateral required	➢ The noncurrent asset for which the funds are being sought (these could be the digging equipment, the installed washing bay or motor vehicles to be used for the business ➢ Cash deposit (down payment of between 30-50% of the amount being borrowed) ➢ Payment protection insurance on the amount to be borrowed ➢ Personal guarantee ➢ Third party corporate guarantee ➢ Equity stake in the borrower's entity of about 30-40% ➢ Titled landed property
Process duration	Typically, 4–6 (could be stretched out if client fails to produce all required documentation)
Credit terms	Interest rate: 24–30% annum Frequency: Monthly Penal charges: In case of default leading to repossession (if leased), sale of collateral, legal action Customer signs post- dated cheques to cover loan period Loan duration: 1–4 years

Government and donor-backed support: To improve access to commercial finance, some governments and international donor agencies offer **credit schemes**. While well-intentioned, these initiatives may not always yield positive long-term results, often due to poor implementation, lack of sustainability, or unintended market distortions. A successful example is the Chile's state-owned ENAMI, which supports ASM with grants, loans, and technical assistance. It also buys and processes ore, enabling ASM miners to sell under the same conditions as large-scale producers. This model has helped 1,200 ASM producers sustain operations, employing 20,000 workers (Planet GOLD 2020a).

Governments occasionally support ASM through mining funds, which are financed by national budgets and mining revenues. These funds may be allocated to community projects or directly to ASM, often focusing on equipment supply or leasing. One notable example is Fidelity Printers and Refiners in Zimbabwe, a lending facility owned by the Reserve Bank. It is designed to finance gold mining equipment for Zimbabwean-owned businesses. While this initiative has been recognized as a positive example, the application process is reportedly highly stringent, requiring extensive documentation on mine management, technical aspects, and financial records (Planet GOLD 2020a).

Blended finance, a government- and donor-backed approach, integrates public or philanthropic funds (such as grants or guarantees) with private investment to mitigate risks and attract commercial financing for high-risk sectors like ASM. By sharing potential losses, this model makes ASM financing more viable for financial institutions. Examples include government-backed loan guarantees or donor-funded capacity-building initiatives to enhance miners' access to commercial credit. The ultimate goal is to develop financially sustainable businesses with positive social and environmental impacts while gradually reducing dependence on public funding as private investors gain confidence (Planet GOLD 2020b).

Equity Finance: This type of financing involves an investor taking partial or full ownership of an entity in exchange for providing capital. A key feature of equity finance is that the investor can exercise some decision-making control by participating in the entity's governance (Planet GOLD, 2020b).

- Private equity investors: These include individuals investing directly or groups of individuals operating as a consortium (Planet GOLD, 2020b).
- Impact investors require measurable social and/or environmental impacts as well as positive financial returns. Both private and public entities can make impact investments. Such investments can be in the form of debt or equity. Significantly, impact investment does not involve a complete sacrifice of financial returns but can offer returns that are comparable with conventional investments. Impact investors can include specialized funds, foundations, development finance institutions, family offices, high-net-worth individuals (HNWIs), and a small number of pension funds (Planet GOLD 2020b).

Downstream offtakers: In some cases, downstream refineries or mineral traders are interested in offtake or streaming agreements with ASM operators, providing upfront payments in exchange for discounted minerals. Offtakers are usually not considered as formal investors because they prioritize capital preservation over high returns. While offtakers are often not long-term financiers for the sector, they can play a crucial role in strengthening ASM in the short to medium term, bridging financial gaps until more sustainable funding sources emerge (Planet Gold 2020). However, for these agreements to have a meaningful impact, they must be structured within clear regulatory frameworks and incorporate ESG criteria to promote responsible and sustainable mining practices.

Leasing: Leasing is another popular form of finance for small businesses such as ASM. A lease is a financial instrument that either grants the right of use or control of a tangible asset, such as property, vehicles, or equipment, to the lessee in exchange for periodic payments. Where a lease only involves the right of use of an asset, the lessor maintains control and ownership of the asset while the lessee has the right to use the asset in exchange for periodic payments. In some leasing (lease-to-own or lease to purchase) programs, asset ownership eventually transfers to the ASM operator (Planet GOLD 2020b). An example of an existing leasing scheme is given in the text box below.

Support from large scale mines: Collaborations between ASM operations and larger mining companies can yield mutual benefits for both parties. These partnerships can take various forms, including joint ventures, operating agreements, or corporate social responsibility (CSR) initiatives. In previous cases, specifically applicable to gold mining, support has been in form of providing funds, onsite mineral purchasing, access to machinery and processing facilities and leasing concession areas. Other types of

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support such as training on environmental and technical issues has also been reported for in various countries (Planet GOLD 2020b).

The Impact Facility (TIF), a UK based non-governmental organization, has developed a lease-to-purchase scheme aimed at enhancing economic and environmental outcomes within the artisanal and small-scale mining sector in East Africa. Key aspects of this scheme include:

- **Equipment Access:** TIF provides ASM operators with affordable access to high-quality mining and processing equipment on a lease-to-own basis.
- **Professional Support:** The initiative offers technical assistance from mining engineers to improve operational efficiency and environmental practices.
- **Performance-Based Advancement:** Leasing terms are structured to reward improvements in ESG practices, allowing ASM operators to access more advanced equipment as their ESG standards enhance.

Initially launched in Western Kenya, the program has expanded to include partnerships with mines in Tanzania and Uganda, with plans to increase the number of active partnerships significantly by 2025. In the first assessment of their approach the organization highlighted the following learnings:

- Lease-to-purchase models are **more attractive to miners**, enabling them to access and eventually own equipment without permanent debt.
- **Investors benefit** as equipment can be reclaimed and redeployed if necessary.
- **Starting with lower-risk**, mobile equipment (e.g., water pumps) and gradually introducing higher-risk, fixed assets (e.g., winches) reduces financial exposure.
- Builds a **track record of responsible lending** before committing to larger investments.
- **Dynamic payment breaks** allow ASM to pause or reduce payments during production downtimes.
- **Aligning leasing fees with actual production cycles** lowers default risk and supports long-term financial sustainability.

Source: The Impact Facility website: https://www.theimpactfacility.com/tif-leasing-model-explained-successes-failures-and-what-next/

Informal Funding

Due to the challenges associated with access to formal financing or the challenges associated with obtaining it, artisanal and small-scale miners often turn to informal lenders. These financiers operate outside legal commercial frameworks (Planet Gold, 2020). While informal financing is more accessible for ASM, it often comes with significant risks, such as unfavourable agreements, perpetual debt cycles, and potential links to illicit financial flows. Additionally, since these financial sources are not tied to ESG criteria, there is little incentive for ASM operators to improve their environmental, social, and governance practices (Planet Gold 2020). The most common types of informal financiers are explained below:

Cooperatives and community-based initiatives: Community resource pooling and cooperatives play a crucial role in improving financial access for ASM. These cooperatives not only offer low-interest loans to members but also attract funding from governments, civil society organizations, and donors. Financial support can be provided in various forms, including cash, equipment, and consumables (Paschal, Kauangal, and Nuhu 2024). One notable model is the Village Savings and Loans Associations (VSLA), which helps communities establish self-sustaining financial groups. Unlike microfinance institutions, VSLA members benefit directly from interest payments, as the funds remain within the group. After a one-year cycle, each member receives a share of the accumulated savings and interest, which can be reinvested in businesses, household needs, or a new savings cycle to further grow their funds (IMPACT 2023). The steps for this type of financing implemented in a project in the DRC is shown in Figure 66.

Figure 66. The steps for creating a Village Savings and Loans Associations, taken from a project (AFECCOR) implemented by IMPACT in the DRC. Source: (IMPACT, 2023)

Mineral dealers: These financiers, also known as 'mineral brokers' or 'middlemen', provide informal loan to miners in return for mineral rights and ownership (Paschal, Kauangal, and Nuhu 2024; Planet GOLD 2020b). This arrangement gives miners access to much-needed capital while allowing buyers to acquire mineral resources at minimal upfront costs and lower prices (Paschal, Kauangal, and Nuhu 2024). Agreements between dealers and miners can take various forms, including contract sales, partnership agreements, joint ventures, or the provision of equipment, support staff, and technical assistance. However, in many cases, mineral buyers have been reported to exploit these financial arrangements by manipulating weighing scales and offering unfairly low prices, further disadvantaging miners (Paschal, Kauangal, and Nuhu 2024; Planet GOLD 2020b).

Illicit foreign investors: In recent years, foreign investors have increasingly sought to participate in ASM, either directly or by providing financial and equipment support in exchange for access to mineral resources. Although ASM licenses in most African countries are restricted to local citizens, weak enforcement and oversight have enabled foreign companies to engage in these activities. Their involvement often takes the form of loans, offtake agreements, or equipment provisions. Studies indicate that the use of advanced machinery—often unsuitable for small-scale operations—has led to significant environmental damage while offering minimal benefits to local miners and communities (Paschal, Kauangal, and Nuhu 2024).

Innovative financing models

In recent years, innovative financial solutions are being developed to unlock the full potential of ASM and facilitate their access to finance and official markets. These solutions are using various tools and schemes such as digital platforms, blockchain technologies, blended finance, alternative lending models, carbon credits, and cooperative financing. Some examples are explained below.

Mobile Money Services: This technology is transforming financial transactions, particularly in rural areas and the ASM sector. It allows ASM operators to receive payments, manage their finances, and access new financial tools—an essential service in remote regions where traditional banking is unavailable. Additionally, it reduces dependence on cash transactions, minimizing the risk of theft. Some of these services also help miners build credit profiles for loan access and provide microinsurance to safeguard against unforeseen risks (Planet GOLD 2020b).

Digital Market Place for ASM: The London-based Blended Capital Group and the non-profits Capitals Hub Canada, the Amsterdam-based Capitals Coalition and Colombia’s Alliance for Responsible Mining are planning to develop a Digital Marketplace for achieving fair, responsible and integrated value chains. This tool is created to democratize access to capital by connecting various investor categories with ASM opportunities. It enables a mix of investors, some focused on financial returns and others on social and environmental impacts, to collectively fund ASM projects. For example, a project might receive funding from both traditional investors and those interested in gender equity or reforestation, enhancing its value. The tool is using blockchain technology to ensure security and prevent corruption, while transparent standards like Fair Mined and CRAFT (for responsible ASM) will guide the marketplace’s operation (Karpati 2024).

Cobalt Credits: Cobalt Credits is an innovative credit system designed to address the challenges of artisanal and small-scale cobalt mining, particularly in the Democratic Republic of Congo (DRC). This system allows downstream companies to financially contribute to the improvement of artisanal mining operations committed to responsible practices. Through this "book and claim" model, companies can purchase credits representing the responsible production of cobalt. The funds generated from the sale of Cobalt Credits are allocated according to the priorities for mine development, set by a dedicated Fund Allocation Committee (FAC), that includes miner representatives, representatives of the Women Washer’s Association, with the guidance of the FCA and the mine cooperative. The key steps in applying and implementing Cobalt Credits are shown in Figure 67 (Fair Cobalt Alliance 2024).

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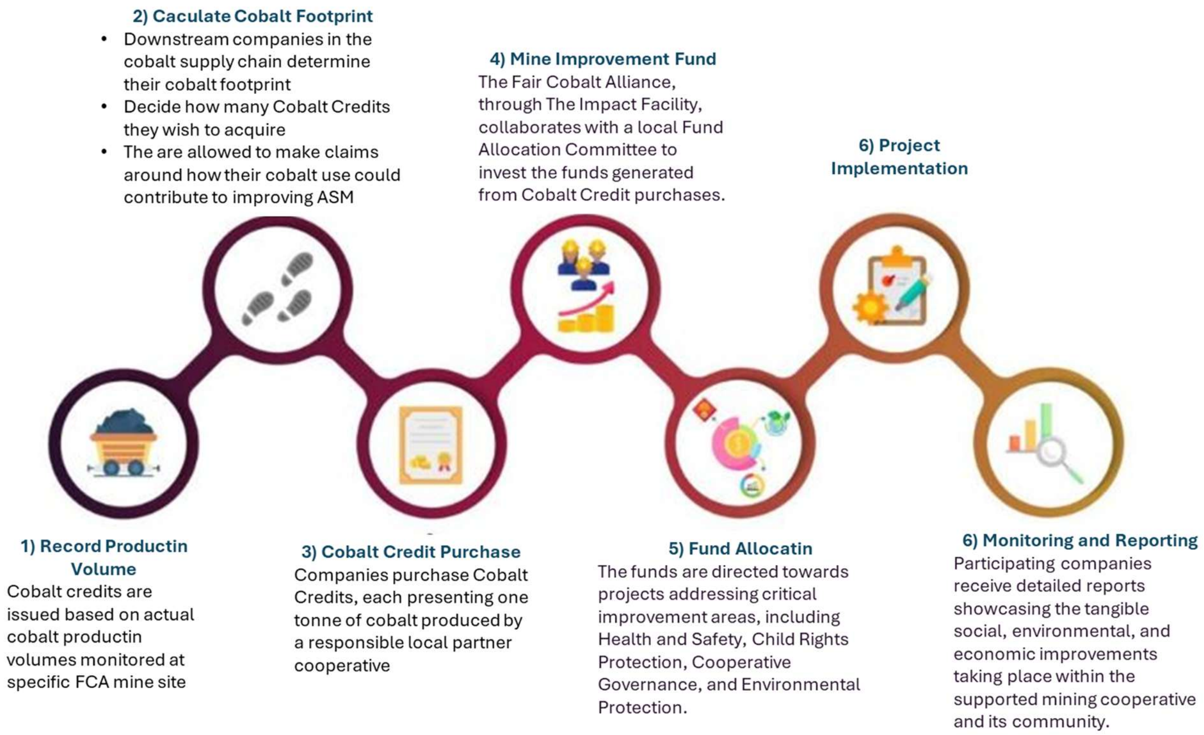

Figure 67. How does Carbon Credit work? Source: modified after (Fair Cobalt Alliance 2024)

Group Work or Exercise

Group exercise: Funding Opportunities for Artisanal and Small-Scale Mining

Group Exercise – Funding Opportunities for ASM

Objective:
To develop a deeper understanding of the challenges associated with financing ASM, participants will engage in a structured discussion and analysis. This exercise will encourage them to examine the issue from multiple perspectives—both as ASM operators seeking financing and as funding organizations evaluating investment risks and opportunities. More importantly, the participants will be asked to share real examples from their own experiences, highlighting the benefits and risks of these funding sources.

Duration: 100 minutes

Materials Needed:

- Flipcharts or whiteboard
- Markers and sticky notes
- Handouts with financial models (formal & informal)
- Case study scenarios

Activity Steps:

1. Introduction (10 minutes)

- Explain the activity and its objective. The exercise has two parts, where each part is followed by a presentation and reflection session.

---

2. Group Work

Part 1 (30 minutes): Challenges of financing: The first part will be a **role play exercise** where one group plays the role of a funding organization, and the second group represents the ASM sector.

- Divide participants into two Groups:
  - Group A: represents the ASM sector → Participants can select a name for their group
  - Group B: plays the role of a funding organization (e.g. a bank/financial institute/large mining company, etc) → Participants can select a name for their group
- Each group will have 30 minutes time to discuss and define the main challenges they have in ‘accessing finance’ (Group A) and in ‘providing finance’ (Group B)
- After 30 minutes they come together to share their points with the other group

Part 2 (40 minutes): Analyse and compare different financial opportunities and share experiences

- Assign each group two financial models (**formal microfinancing, offtake agreements, leasing, community and village loans**).
- Each group discusses their assigned financing model using these guiding questions:

  1. **How does this financing method work?**

2. **What are the requirements?**
3. **What are the benefits for ASM miners?**
4. **What are the risks or challenges?**
5. **What regulatory or ESG considerations are important?**
6. **Can this model be combined with others for better results?**

Each group writes key points on a flipchart.

---

3. Presentation & Discussion (10 minutes)

- Each group presents their findings (3-5 minutes per group).
- Facilitator leads a discussion comparing financial models, identifying **best practices** and **potential risks**.

---

4. Conclusion & Reflection (10 minutes)

- Facilitator summarizes key takeaways.
- Open floor for participants to discuss **which financing models would work best for their specific ASM context**.
- Participants write **one key insight or action plan** on a sticky note and share.

Expected Outcomes:

- Participants gain a **clear understanding of different financing opportunities** for ASM.
- They can **identify suitable financial options** for their operations.
- Awareness of **risks, regulatory concerns, and ESG factors** in financing.

Encourages **collaborative problem-solving** in ASM communities.

Module 6 - Bibliography

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4. Reflection on learning outcomes

To determine the effectiveness of the training program and to understand the areas of improvement for future capacity building for the ASM sector, participants in the three capacity building programs were asked a series of questions. The delivery of feedback solicitation was by both group discussion as well as independent and anonymous surveying. For future trainings, constructive feedback must contain information about not only the course content and the topics that were or were not covered but about their learning comprehension. For example, given that each participant may learn differently, these surveys must also contain questions about the manner in which the content could be delivered that may be more conducive to their own personal learning style. The course designers and facilitators can then modify and improve the training content to accommodate for a mixture of ways a person may understand, expresses and remember information. The ultimate goal is to then ensure that through this comprehension, the participants may utilise the knowledge gained in the capacity building.

Respondents were asked to describe their reflections on a number of different aspects of the training, including:

- How they felt overall about the learning atmosphere?
- How relevant was the training content to the participants mining operation or their personal development?
- What topics covered did the participants find most useful?
- What topics were not covered that should have been covered? Or what topics that were covered that could have been covered in more detail?
- How effectively did the trainers deliver the course content? What are areas for improvement?

Feedback forms or discussion rounds can then be designed by the facilitators and trainers to gather information on specific aspects of the capacity building.

Feedback from participants

Overall, in all three ASM capacity building programmes delivered thus far the overwhelming majority of the participants found the aspects of technical training to be the most useful. Specifically, the capacity building in the topic of geology, in mineral processing and mining methods were well rated. Many miners expressed their wishes for additional knowledge on local mineral beneficiation, which is in general a problem in the regions where the trainings occurred.

> *"We thought the technical training in geology was the most useful for our day to day operations. However, it would be great if we could also learn more about the opportunities for value addition and mineral processing in Zambia."*
>
> *-Artisanal manganese miner from Zambia*

Given the assistance and participation of individuals from various country AWIMA organizations, one topic that was appreciated by the participants were those that involved women miners.

> *“Initiatives like the ASM Academy are invaluable for women in mining. They provide essential knowledge and skills in areas like proper mining techniques, safety protocols, and financial management. Personally, I'm a product of such academies, and they have equipped me and other women with the tools needed to succeed in the sector. Continuing and expanding these initiatives is crucial for empowering more women in mining.”*
>
> *- Small-scale miner of gold and other minerals in Zimbabwe*

On the question of what a participant wishes for future ASM capacity building, many participants expressed a desire for additional trainings, again to be designed specifically for the ASM miners. Many participants feel that such capacity building programmes are not common in the regions where they mine. Given this, many miners wished that such programmes would be designed with follow up activities in mind.

> *“Trainings such as these should not be a one-time event but rather include follow up trainings every 6 months or yearly...These capacity building programs can assist the ASM in the country to keep the sector awake and in development.”*
>
> *-Artisanal miner in Madagascar involved in lithium, 3T mineral extraction*

The topic of environment, heath, and safety is always of high importance for ASM participants of such capacity building. Specifically, how mining more efficiently, knowing more about the ore deposit can influence safe and sustainable mine practices. This was particularly important to many women miners in the trainings in the three countries.

> *“My plan is to train other women miners in my community on the knowledge I gained, especially regarding sustainable mining practices and safety measures. Personally, I'll also implement the use of machinery in my operations to improve efficiency and reduce health risks associated with manual labor. Additionally, I'll utilize the knowledge gained about identifying minerals to optimize our mining processes.”*
>
> *-Artisanal gold and lithium miner from Zimbabwe*

Overall, the majority of participants found the training to be of high value and the insights gained in the event will be something that they can utilize to better their own operations. Many participants were appreciative of knowledge about the regulations in their country and other aspects of formalization and professionalization of their operations from mining for substance to mining as a business. Furthermore, the opportunity for miners to network and engage with other miners in their region was appreciated.

"This was also a great networking event, to meet and exchange with other miners in our country doing similar things. It would be nice to have even more participants from more regions."

-Artisanal mica and 3T miner from Madagascar

"We learned a lot, especially about identifying rocks and understanding which minerals are associated with them. Additionally, we gained knowledge about the importance of being licensed as miners to avoid legal issues. Moreover, we now understand the significance of using proper protective equipment while mining. Previously, we used to mine without such equipment, but now we know why it's essential to comply with safety regulations. Finally, we learned about transitioning from mining for survival to viewing it as a business model through learning from others and exposure to best practices."

-Artisanal lithium miner from Zimbabwe

Measuring success and impact

Example Capacity Building Program Feedback Form

Program Details:

- Program Name: ____________________________
- Date: ___________________________________
- Location: ________________________________
- Facilitator(s) / trainers: _________________________

Participant Information (Optional):

- Name: ____
- What mineral(s) do you mine: ___________________________________
- Role/Position in your operations: ____________________________

Feedback Sections:

1. **Overall Experience**
   - How would you rate the overall experience of the capacity building for artisanal and small-scale miners? (Scale: 1-5)
     [ ] 1 - Poor
     [ ] 2 - Fair
     [ ] 3 - Good
     [ ] 4 - Very Good
     [ ] 5 - Excellent
   - What aspects of the trainings did you find most valuable?

     ____

     ____

     ____

   - How would you rate the overall atmosphere? Did you find it conducive to learning? (Scale: 1-5)
     [ ] 1 - Poor
     [ ] 2 - Fair
     [ ] 3 - Good
     [ ] 4 - Very Good
     [ ] 5 – Excellent

2. **Content and Relevance**
   - How relevant was the content to your mining project or personal development as a miner? (Scale: 1-5)
     [ ] 1 - Not relevant
     [ ] 2 - Somewhat relevant
     [ ] 3 - Neutral
     [ ] 4 - Relevant
     [ ] 5 - Highly relevant
   - What topics were most useful?
   - What additional topics would you like to see included in future trainings?

3. **Facilitation and Delivery**
   - How would you rate the effectiveness of the facilitators & trainers? (Scale: 1-5)
     [ ] 1 - Poor
     [ ] 2 - Fair
     [ ] 3 - Good
     [ ] 4 - Very Good
     [ ] 5 - Excellent
   - What aspects of the training methods were most effective?
   - Any suggestions for improvement (i.e., more group work, more detailed lectures, etc.)?

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4. **Logistics and Organization**
   - How satisfied were you with the organization of the program? (Scale: 1-5)
     [ ] 1 - Very Dissatisfied
     [ ] 2 - Dissatisfied
     [ ] 3 - Neutral
     [ ] 4 - Satisfied
     [ ] 5 - Very Satisfied
   - Was the venue and were training materials and lectures adequate? If not, please provide suggestions.
   - How satisfied were you with the organization of the field visit? (Scale: 1-5)
     [ ] 1 - Very Dissatisfied
     [ ] 2 - Dissatisfied
     [ ] 3 - Neutral
     [ ] 4 - Satisfied
     [ ] 5 - Very Satisfied
   - Did you find it useful to visit an active ASM mine? If not, please provide suggestions on what could have been done better at the mine site.

5. **Impact and Application**
   - How do you plan to apply what you have learned?

- What support would help you implement these learnings in your own mining operations?

6. **Additional Comments and Suggestions**
   - Any other feedback or recommendations for future capacity-building programs for the ASM sector?

Thank you for your valuable feedback!

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