



Breaking the informal cycle: integrating artisanal and small-scale mining into the formal economy

Tinotenda Lionel Tingini¹ · Olushola Daniel Eniowo¹

Received: 12 May 2025 / Accepted: 25 September 2025
© The Author(s) 2025

Abstract

Illegality and informality persist in the artisanal and small-scale mining (ASM) sector, despite the increasing drive by various stakeholders on the African continent to formalise the sector. This paper applies five categories of barriers to formalisation, identified in the literature, to analyse the factors hindering the formalisation of the sector, namely: absence of formalisation frameworks, inappropriate frameworks, weak enforcement, exclusionary policies, and broader structural challenges. A narrative literature review reveals that the absence of tailored frameworks leaves ASM operations criminalised and unsupported, while poorly designed or overly rigid regulations fail to align with the sector's diverse socio-economic realities. Weak enforcement, compounded by corruption and limited institutional capacity, sustains illicit practices and undermines regulatory effectiveness. Exclusionary policies, characterised by costly and complex licensing requirements, marginalise ASM operators and drive them further into illegality. In addition, structural issues, including limited access to finance, technology, and markets, entrench reliance on informal networks and perpetuate cycles of poverty and environmental harm. The study found that successful governance of ASM requires context-sensitive policies that balance regulatory interventions with socio-economic realities. The study recommends enhancing institutional capacity and establishing inclusive pathways that enable ASM operators to integrate into the formal economy.

Keywords ASM · Illegal mining · Informal sector · Livelihoods · Mining regulation

Introduction

The artisanal and small-scale mining (ASM) sector is becoming an increasingly significant contributor in the supply of a wide range of minerals globally. For instance, according to the World Bank (2024), this industry now produces nearly 20% of the world's gold, compared with a 4% contribution in the 1990s. Also, it now contributes at least 12% of the world's cobalt, compared to a 5% contribution in the 2000s. It also contributes 80% of the world's production of sapphires, 20% of the world's diamonds, 26% of the world's tantalum, and 25% of the world's tin (Atienza et

al. 2023). The ASM sector is also a major source of livelihood for many marginalised communities globally (Fisher et al. 2009). As illustrated in Fig. 1, the World Bank (2024) estimated that nearly 45 million people in over 80 countries globally are directly employed in ASM, while at least 220 million people globally have their employment linked to ASM-related industries.

Over the last few decades, there has been an increasing drive by various stakeholders, including governments, donor organisations, and artisanal and small-scale mining (ASM) associations, to formalise the ASM sector (World Bank 2024). This is due to their mutual need both to mitigate against the negative impact of ASM and facilitate its potential positive developmental contribution to society (Ondayo et al. 2024). For instance, the proponents of formalisation of ASM argue that by incorporating illegal ASM into a legal government-regulated sphere, this can help reduce the subsector's negative health, environmental, and social effects. It can also enhance the sustainability of the sector by enabling better access to financing and property rights (Hook 2019). However, despite the concerted efforts

✉ Olushola Daniel Eniowo
od.eniowo@up.ac.za

Tinotenda Lionel Tingini
u10466003@up.ac.za

¹ Department of Mining Engineering, University of Pretoria, Mineral Sciences Building, Room 5-50, Main Campus Hatfield, Pretoria, South Africa

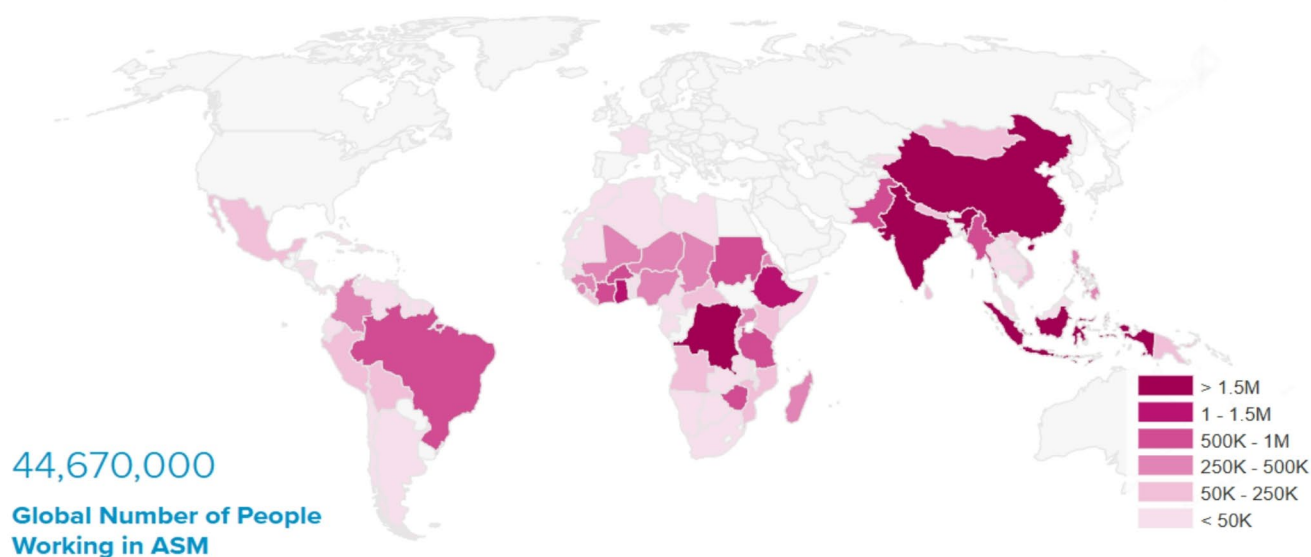


Fig. 1 Global number of people employed in ASM (Delvedatabase.org 2020)

to formalise the sector, informality and illegality persist in ASM (Katz-Lavigne et al. 2024).

Some researchers argue that the persistent informal nature of ASM is a result of the lack of capacity or political willingness by many governments of developing countries to set up and enforce formalised entities (Hook 2019). Others posit that the perpetual informal cycle of ASM has been driven by excessive formalisation pushes, where rigid legislation and policies, which fail to consider the unconventional nature of ASM, have driven ASM miners into conducting their operations illegally (Maconachie and Conteh 2020). For instance, Spiegel (2017) highlights how the heavy-handed enforcement of out-of-reach environmental impact assessments (EIAs) in Zimbabwe was used by state agents to illegalise the sector and ultimately halt the livelihoods of ASM operators. Cote and Korf (2018) also postulate that opportunities for informality are inevitable due to the dynamic and unconventional nature of ASM, which makes the sector difficult to regulate and police, even where systems are in place for formal entities in the ASM space. It is therefore critical to unpack the reasons which have inhibited the pace of the ASM formalisation process. The starting point in unpacking these issues is by first defining what the formalisation of ASM entails.

There remains some ambiguity on a universally accepted definition of ASM formalisation. The definition that probably best captures the donors' perspective on ASM's formalisation is the one outlined by the United Nations (2012), which focuses on artisanal and small-scale gold mining (ASGM). It outlines that formalisation "seeks to integrate ASGM into the formal economy", and that "the process of formalization includes the development or adaptation of

mining (and other) laws or policies to address the challenges of ASGM". There is now consensus that while policy and legal frameworks are important dimensions to the formalisation of ASM, they are, however, just two of the aspects of the formalisation process (Hilson et al. 2019). Other aspects that facilitate the integration of ASM into the formal economy, such as access to finance and technical resources, are also critical dimensions to enable the formalisation process of ASM (Hilson 2020). Part of the reason why the integration of ASM into the formal economy remains elusive is a lack of understanding of what the sector entails. It is therefore critical to define ASM clearly.

There is still no universally accepted definition of ASM, and these varying interpretations of the true meaning of ASM pose challenges for developing effective legislation for the sector. For instance, Marin et al. (2016) categorise ASM into artisanal mining (AM) and small-scale mining (SSM) and postulate that both AM and SSM are in the same production range. Marin et al. (2016) further state that AM is characterised by the use of rudimentary methods and equipment, with mining operations that are often inefficient and informal. Their paper states that once AM is formalised, mechanised and has improved operational efficiency, it can now simply be referred to as SSM. The implication of their postulation is that the focus in the ASM sector must be to upgrade AM to SSM. Veiga and Marshall (2019) agree that AM is defined by its rudimentary nature. However, their paper argues that AM is not limited by production scale and can be found in both small-scale and large-scale production settings, whereas SSM only refers to the production scale of the mining operation, and it can either be conventional or artisanal. Veiga and Marshall's (2019) argument is that

some AM operations can produce a daily output of over ten thousand tonnes of mineral ore and therefore can no longer be categorised as small-scale. Zvarivadza (2018) defines ASM as the use of rudimentary tools to exploit marginal mineral deposits that are not viable to extract on a large scale, through both formal and informal channels. This definition highlights the gap that small-scale mines are filling, given the mineral commodity supply gap, as many large-scale quality ore deposits get diminished.

Informal mining and illegal mining are another set of confusing terms in many mining legislations which are often mixed up (Balag'kutu 2024). Chen (2007) defined informal mining as an umbrella term which encompasses any form of mining activity that is carried out without social or labour protection. Informal mining is also characterised by poor working conditions, inadequate environmental management, and a lack of access to technical and financial resources (Bester and Uys 2023). On the other hand, Hentschel et al. (2002) defined illegal mining as any mining activity that is conducted without appropriate authorisation by the relevant regulators. The formalisation of ASM has the potential to reduce criminality in the sector, which is driven by the regulatory vacuum, including addressing smuggling activities. Regulating the sector could also mitigate against the adverse environmental and safety impacts of ASM operations (Siegel and Veiga 2009). In addition, formalisation could facilitate the integration of ASM into the formal economy by enabling better access to financial services on more favourable terms and by linking the miners to competitive international commodity markets (Hilson and Maconachie 2017). Collectively, these reforms could play a role in contributing to local economies' broader socio-economic development by promoting local enterprise development, job creation, and fiscal revenues.

Hook's (2019) theoretical framework

The ambiguity in the definition of ASM-related terms in mining legislation results in inappropriate formalisation frameworks, which can partly be used to explain why informality and illegality persist in the sector. Several scholars have offered various explanations for ASM's perpetual informal cycle. However, Hook (2019) managed to summarise various explanations into five clearly defined theorisation categories, namely an absence of formalisation frameworks, weak enforcement, inappropriate formalisation frameworks, exclusionary formalisation frameworks, and broader structural issues. Hook (2019) then went on to explain briefly how each of the theorisation categories inhibits the formalisation of ASM. This paper aims to advance Hook's (2019) theorisation categories further to explain the

factors perpetuating the informality in ASM better. Hook (2019) only focused on the formalisation efforts in Guyana and only referenced the formalisation-inhibiting categories provided briefly, as they were not central to his analysis. In contrast, this study places these five formalisation-inhibiting categories at the core of its investigation, applying them to evaluate the formalisation initiatives across the African continent. By doing so, it contextualises the theorised categories' relevance, demonstrating how they encompass many of the factors identified in the literature as perpetuating ASM's informal nature.

The purpose of this study is to expand on Hook's (2019) five theorised categories of factors perpetuating ASM informality by applying them to the formalisation challenges on the African continent. In doing so, the study not only seeks to enhance the relevance and explanatory power of these categories in understanding the persistent nature of the informality in ASM but also to identify and analyse potential pathways and policy strategies for breaking the cycle of informality. Researchers studying ASM have exerted considerable effort to understand the persistence of informality and explore how this can be resolved (Hilson 2007; Siegel and Veiga 2009; Hilson and Gatsinzi 2014; Marshall and Veiga 2017; Bester and Groenewald 2021; Mapisa 2025). While some scholars attribute the persistence of informality in ASM to limited state capacity or a lack of political will (weak enforcement), others contend that excessive (exclusionary) and poorly designed (inappropriate) formalisation regulations that are rigid and overlook local realities drive artisanal miners into illegality (Mkodzongi 2023; Ayambire et al. 2024). Still others postulate that the inherent mobile and fluid (structural) nature of ASM makes regulation of the sector difficult, resulting in inevitable opportunistic instances of informality, even where formal structures are in place (Hook 2019). These diverse views can be explained better by analysing and contextualising the different typologies in which ASM occurs. For instance, studies carried out in jurisdictions such as South Africa, Burundi, and Lesotho show that these countries lack ASM frameworks altogether, while studies focused on countries such as Ghana, Tanzania, and Zimbabwe show that these countries have existing frameworks that are either inappropriate in design, weakly enforced, or exclusionary in practice.

These various studies highlight how the formalisation of ASM is constrained by a complex interplay of institutional, economic, and socio-political factors, both policy-related and structural. A thorough understanding of these barriers is essential for formulating effective policy responses. The following sections analyse the key obstacles to ASM formalisation, as identified in the literature, and they are structured according to the five categories in Hook's (2019) theoretical framework. The analysis begins by examining the absence

of formalisation frameworks as a key driver of the persistence of informality in the ASM sector and then expands to explore the possible strategies for breaking this cycle, drawing on relevant African case studies. The subsequent sections address the remaining categories in Hook's framework while applying a consistent analytical lens throughout, with each section ending with targeted policy recommendations aimed at fostering the ASM sector's formalisation.

A lack of formalisation frameworks

Hook (2019) defines the lack of formalising frameworks as a systematic regulatory failure to acknowledge and support the sector, either as a standalone economic activity or as a component of a broader alternative non-agricultural livelihood strategy. Several other scholars blame the persistent illegality and informality of the ASM sector on this systematic failure to support and recognise the sector from a policy perspective (Hilson and McQuilken 2014; Hilson et al. 2017). Siwale and Siwale (2017) show that the inadequate attention given to ASM has resulted in inadequate institutional support and recognition of the sector, leaving the ASM miners with no option but to mine illegally. For instance, in South Africa (SA), the mining regulation which universally governs all mining activities in the country is the "Mineral and Petroleum Resources Development Act (MPRDA) of 2002", which states that all mining activities require a mining licence or permit to be considered lawful. However, the process of obtaining such mining permits and licences is designed to cater mainly for large-scale operations, as it is extremely costly, complicated, and protracted. There is no policy specifically designed to cater for the ASM operators, meaning that most ASM activities in the country are operating without a mining licence, and they are therefore criminalised (Bester 2023). Because of the criminalisation of ASM in SA, there is no institutional support provided to artisanal miners in the country. And since the sector is not regulated, it mostly operates outside the law, with minimum accountability and responsibility by miners, since they are not registered (Chuma et al. 2024). ASM is similarly criminalised in Lesotho due to the absence of a regulatory policy framework for the sector. The country lacks legislation that is specifically designed to provide meaningful supportive infrastructure and regulation for ASM. This has caused the sector to remain criminalised and marginal, thus perpetuating the cycle of informality (Makhetha and Maliehe 2020). Burundi's mining code also does not make provisions for ASM and instead groups it together with industrial and mechanised mining. This lack of a specific mining policy framework for the ASM sector results in its limited formalisation in the country (Buruakuyve and Barambona 2024).

Figure 2 illustrates the vicious cycle of informality in the ASM sector, driven primarily by the fact that most ASM operators work without a formal mining licence (Hentschel et al. 2002). This is due to the difficulty in the processes required to secure mining rights, which, in turn, is a result of the lack of policies that specifically cater to the ASM sector (Siwale and Siwale 2017). Ultimately, this results in the criminalisation of ASM operations. The marginalisation of their mining activities also means that ASMs are driven to depend on intermediaries to access markets, with often exploitative and unfavourable terms (Bester 2023). This resultantly perpetuates the cycle of poverty and dependency within the sector.

The African Mining Vision (AMV) is a vision that has been developed by the African Minerals Development Centre (2022) to help foster the establishment of resilient artisanal and small-scale mining (ASM) communities. This vision can be achieved on the continent by formalising the ASM sector and upscaling operations by establishing and harmonising ASM policies, laws, regulations, standards, and codes (African Minerals Development Centre 2022). However, this vision remains elusive, given the lack of formalisation frameworks for the sector in a lot of African countries, including South Africa, Lesotho, and Burundi. Table 1 provides a summary of some of the key sources and findings in the literature that highlight how the lack of formalisation frameworks has propagated informality in the ASM sector. These findings are specifically focused on African countries.

To provide empirical support, Table 2 below gives a summary of the African countries where no ASM-specific formalisation frameworks exist. The lack of formalisation frameworks for the ASM sector can have significant socio-economic, fiscal, safety, and environmental consequences. This is because without regulation and legal recognition, the sector operates illegally, exacerbating associated vices like smuggling, criminality, child labour, unsafe working conditions, and environmental degradation because of unregulated operations. The next section uses a case study in South Africa to support this assertion.

In SA, the criminalisation of ASGM, in particular the targeting of artisanal miners who are derogatorily referred to as "Zama Zamas", reached an inflection point during a government-led operation in Stilfontein in 2024. In the state-sponsored initiative referred to as "Operation Vala Umgodi (Close the Hole)", the SA police and military sealed off the supply routes to an abandoned underground mine shaft, effectively trapping over 4,500 artisanal miners for more than a month (Moeti et al. 2025). This operation ended up in the deaths of over 90 people, which raised serious humanitarian and ethical concerns (Seeletsa 2025). The state's response to the crisis highlighted the deeply



Fig. 2 The vicious cycle of ASM informality (Hentschel et al. 2002; Siwale and Siwale 2017; Bester 2023)

ingrained hostility of the government towards artisanal miners. For instance, when the Minister in the Presidency was questioned about the humanitarian implications of the operation, she responded by saying, “We will smoke them out”. The Minister of Mineral Resources was dismissive of the possibility of legalising artisanal mining when he stated, “... Give licences to [the illegal miner] ... to steal gold. Mozambicans, Zimbabweans, and Lesotho nationals. It’s a criminal activity. It’s an attack on our economy by foreign nationals in the main”. These remarks highlighted the government’s framing of ASGM as a national security threat instead of a socio-economic phenomenon (Hoskins 2025). This framing ignores the structural drivers of artisanal mining in the country, which have deep roots in the historical exploitation of immigrant labour in SA’s gold mining industry. Historically, SA’s large-scale mines were operated based on exploiting cheap immigrant labour. Today’s “Zama Zamas” are therefore a continuation of this labour system; only now, in the absence of formal mining houses, criminal syndicates have stepped in to exploit the same vulnerable mining workforce for profit (Bester and Uys 2023). The SA government’s punitive approach of criminalising artisanal

miners only exacerbates the marginalisation of these artisanal miners, instead of addressing the root causes, namely unemployment, economic desperation, and historical disenfranchisement (Bester 2023). It is recommended that a more humane and economically balanced approach would involve putting measures in place to integrate ASGM into the formal economy of the country through regulation and recognition of the sector’s legitimacy as a viable livelihood alternative for marginalised communities (Mapisa 2025).

Inappropriate formalisation frameworks

According to Hook (2019), inappropriate formalisation frameworks can be defined as efforts to formalise ASM operations, which nonetheless institute requirements and processes that are misaligned with the local cultural and socio-economic contexts, resulting in miners disregarding or circumventing them. In countries where ASM is prevalent, governments and donors are now coming to the realisation that criminalising and not recognising the sector is not going to make it go away, and they are thus

Table 1 Summary of the findings on the lack of ASM formalisation frameworks

Author(s) and year	Country	Key Finding
South African Government (2002; 2008)	South Africa (SA)	The MPRDA does not make provisions for artisanal mining, and ASM is mostly criminalised.
Nyamunda (2012)	Zimbabwe	Highlights how a lack of clear policy resulted in the Chiadzwa diamond field being regarded as a mining free-for-all. This was followed by a period when the state's military agents violently assumed control of the area under the banner of Operation "Dzokerera Kumusha (Go Back Home)".
Makhetha and Maliehe (2020)	Lesotho	Illustrates how Lesotho still criminalises ASM due to the absence of a regulatory policy framework for the sector, resulting in ASM remaining marginalised and thus perpetuating the cycle of informality.
Bester (2023)	SA	Highlights that despite the release of a draft ASM policy framework by the SA government in 2022, it has still not been adopted and implemented, resulting in the continued criminalisation of ASM operators.
Bester and Uys (2023)	SA	Shines a spotlight on the failure of the SA government's current strategy of dealing with ASM using police clampdowns, due to the ongoing criminalisation of the sector.
Katz-Lavigne et al. (2024)	Democratic Republic of Congo (DRC), and Zimbabwe	Analyses how artisanal miners are often perceived as criminals, with a tendency to blur the distinction between artisanal miners and violent actors, bundling them as "one and the same".
Buruakuyve and Barambona (2024)	Burundi	Showcases how Burundi's mining code does not make provisions for ASM. The lack of a specific mining policy framework for the sector has resulted in its limited formalisation in the country.

Table 2 List of African countries where no ASM-specific formalisation frameworks exist

Country	Legislation	Author (Year)
Kenya	No legal ASM framework.	National Council for Law Reporting (2024)
Egypt	ASM is technically prohibited as there is no legal provision for it.	Abulnaga (2021)
South Africa	The MPRDA does not make provisions for artisanal mining.	Bester (2023)
Lesotho	ASM is illegal as there are no dedicated legal provisions for it.	Makhetha and Maliehe (2020)
Burundi	Burundi's mining code does not make provisions for ASM.	Buruakuyve and Barambona (2024)

starting to collaborate on efforts to recognise, regulate, and formalise the sector officially (Siegel and Veiga 2009). While there is a growing acceptance that ASM is becoming a critical component in the rural economy, there is also an increased propensity by governments to put in place inflexible policy and regulatory frameworks targeted at the ASM sector that fail to recognise its realities (Hilson and Gatsinzi 2014). In some countries where the formalisation of ASM has been initiated, the requirements and processes introduced to formalise the sector are unable to cater to the local socio-economic and cultural sensitivities. This ultimately results in ASM miners being left with little option but to either evade or ignore these formalisation attempts (Hook 2019).

Verbrugge and Besmanos (2016) postulated that one of the reasons for the inappropriate formal frameworks is a false assumption regarding the blanket homogeneity of the ASM sector. Their paper argues that one of the formalisation process's flaws has been the fact that it has focused primarily on recognising ASM mineral rights, but it has fallen short in addressing the informal nature of ASM's labour force and in dealing with the complex organisational power dynamics found in the sector. Hilson and McQuilken (2014) argue that despite the growing recognition of the ASM sector's economic significance, particularly in rural economies, the sector still occupies a peripheral place in African countries' agendas on economic development. This has resulted in an overall poor understanding of the sector at the policymaking level, resulting in policies and regulations being created based on ideas that are inaccurate and an overgeneralisation of the ASM sector (Hilson et al. 2022).

Figure 3 illustrates four key strategic objectives that can be embedded into government policies to ensure that formalisation efforts are more appropriate for ASM. To begin with, the government policies must aim to improve the regulatory environment for ASM (Hentschel et al. 2002). They must also aim to alleviate poverty in ASM communities by providing institutional support to develop the sector. The tailor-made government policies must also promote local value-addition opportunities for ASM and customise taxation frameworks for the sector in a way that discourages illicit trade and leakages. The policies must also advocate for sustainability by promoting good corporate governance in the sector and enhancing the environmental, health, and safety aspects of ASM (Martinez et al. 2023). These four strategic objectives are designed to pursue a unified approach towards the formalisation of ASM. Poverty alleviation, regulatory improvement, sustainability, and stabilising the fiscal and macroeconomic ASM ecosystem are interconnected, rather than being mutually opposed. The Venn diagram

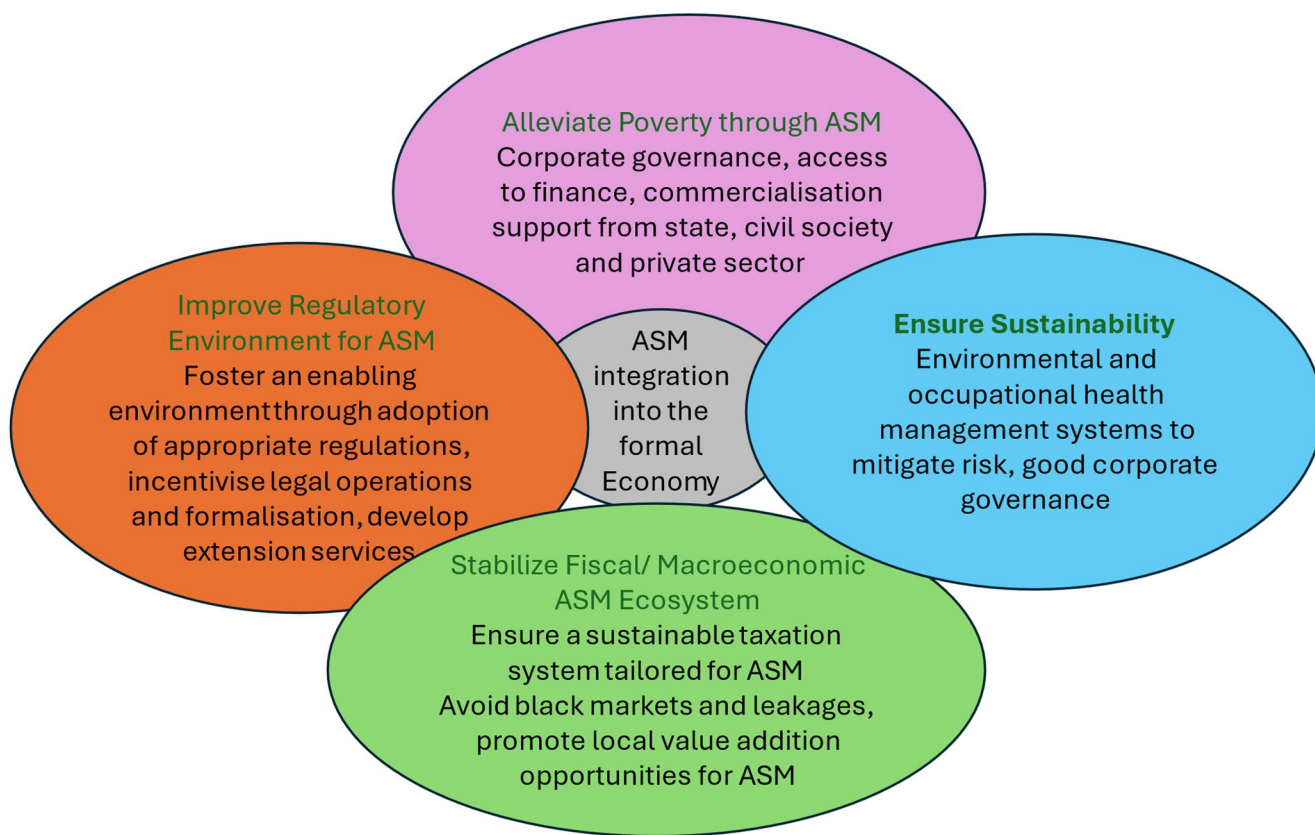


Fig. 3 Four strategic objectives required in policies for the formalisation of ASM (Hentschel et al. 2002; Martinez et al. 2023)

format intentionally reflects these overlaps, highlighting that successful formalisation needs a holistic approach, where advancements in one area promote synergies with others. For instance, improving the regulatory environment can enable better access to finance and improve corporate governance, which can enhance poverty alleviation through ASM. This, in turn, can help ensure sustainability in the sector and also improve fiscal stability. Thus, while each of the objectives presents its own unique challenges, collectively, they can be leveraged to pull in the same direction: towards the integration of ASM into the formal economy.

Table 3 gives a summary of the key findings on how inappropriate formalisation frameworks are hampering attempts to formalise the sector. The emphasis is on the need for policymakers to enhance their understanding of the ASM sector’s complex dynamics and avoid a rigid and over-generalised framework.

While Ghana has made efforts to formalise ASM operations and officially recognises artisanal mining as a legitimate source of livelihood, the formalisation efforts in the country have, to a large extent, been viewed as unsuccessful. This is based on empirical evidence which indicates that at least 85% of the ASM operations in Ghana still operate in

the informal/illegal economy (Kumah 2022). Adu-Baffour et al. (2021) argue that this persistent cycle of informality in the ASM sector in Ghana is due to the top-down nature of the country’s regulatory frameworks, which create a disconnection between the policymakers and the ASM communities. This is caused by a lack of comprehension by the policymakers of the sector’s complex operational and socio-economic dynamics (Mensah 2021). Hilson and McQuicken (2024) characterised the formalisation system in Ghana as highly bureaucratic, time-consuming, and costly. This makes compliance with the regulations targeted at ASM unattainable to most of the artisanal miners it aims to regulate. In addition, Kumah (2022) identified a lack of government consultation with ASM operators as the reason why government regulations and formalisation efforts are not suited to match the realities of the livelihoods of ASM communities and therefore remain mostly unadopted. Sinding (2025) postulates that if the objectives of formalisation are not adequately communicated and there is no buy-in, ASM operators may just circumvent these formalisation attempts. This underscores the need for a paradigm shift in the governance of ASM to a regulatory system that adopts grassroots engagement and a flexible policy design that reflects the sector’s complexity and diversity.

Table 3 Summary of the findings on inappropriate ASM formalisation frameworks

Author(s) and Year	Country/Region	Key Finding
Hilson and Gatsinzi (2014)	Sub-Saharan Africa	Highlights how the rigid regulatory frameworks fail to reflect on the reality that ASM has become an integral part of rural economies.
Spiegel (2014)	Zimbabwe	Illustrates how simplified interventions to get rid of illegal mining can result in uneven consequences that end up marginalising the sector.
Hilson and McQuilken (2014)	Sub-Saharan Africa	Argues that there is a lack of understanding of the sector, resulting in an overgeneralisation and speculation of “unfounded ideas” about ASM’s activities at the policy-making level.
Dzimunya et al. (2018)	Zimbabwe	Argues that for formalisation efforts to be effective, there needs to be an integrated approach to formulating policies targeted at ASM, with an emphasis on understanding the needs of the stakeholders, including ASM demographics.
Hilson and Maconachie (2020a)	Sierra Leone, and Liberia	Argues the current regulatory frameworks are misaligned with the capabilities and needs of ASMs, thus impeding formalisation efforts.
Paschal et al. (2024)	Sub-Saharan Africa	Advocates for government policies that help simplify formalisation procedures to enable easier compliance with the conditions of formal sources of finance.
Ayambire et al. (2024)	Ghana	Argues that the informality in ASM is driven by the lack of participation by ASM operators in the policymaking process, resulting in the operators perceiving the regulations targeted at the sector as being unfair.

Weak enforcement

Hook (2019) defines weak enforcement as the difficulties encountered by states to enforce regulations, thus creating space for illegal mining to proliferate. As many ASM operations in developing countries are conducted in remote areas, government regulating agencies, who are mostly not well equipped to navigate tough terrain, struggle to ensure compliance with formalisation regulations. This results in the lawless reign by illegal miners (Spiegel 2012). In addition to the states’ limited capacity to minimise informality,

the regulatory agencies’ officials are, in many instances, complicit and collude with illegal miners. This is because the artisanal miners are oftentimes backed or sponsored by powerful players who are commonly given leeway to circumvent the formal processes and regulations (Mkodzongi 2023). For instance, ASM miners are made to pay informal taxes or bribes and enter into other informal arrangements with local authorities to allow them to operate without interference. These informal agreements between the ASM miners and government officials benefit both the cash-poor ASM operators who cannot afford to pay the full amount required to obtain a mining permit and the often underpaid government officials who are presented with an opportunity to earn a supplementary income (Van Bockstael 2014). Baddianaah et al. (2023) concluded that illegality in ASM persists due to the high level of corruption at both the local and national government levels, weak capacity by state institutions to enforce the ASM laws, political interference, and a lack of consultation with local miners, landowners and chiefs. Table 4 gives a summary of some of the key findings on how weak enforcement has affected the formalisation of ASM. It is highlighted that several players in the political economy

Table 4 Summary of the findings on weak enforcement of the regulations in the ASM sector

Author(s) and Year	Country/Region	Key Finding
Mawowa (2013)	Zimbabwe	Suggests that a network of both political elites and low-ranking state agents is not only complicit but capitalises on the informality of the sector to accumulate income.
Van Bockstael (2014)	Liberia	Argues that informality persists because of the state’s lack of capacity to enforce mining legislation and questions whether the legislation is actually feasible.
PanAfGeo (2022)	Democratic Republic of Congo	Identifies state officials as facilitators of ASM informality for personal gain.
Ayambire et al. (2024)	Ghana	Argues that an increased policing force is ineffective if it’s not accompanied by stakeholder engagement.
Balag’kutu (2024)	Ghana	Highlights the fragmented governance of ASM, resulting in miners resorting to creating their own governance systems in the mining fields.
Teku (2025)	Ethiopia	Argues that despite the current regulatory efforts, limited government capacity and resources, as well as inconsistent enforcement, has hindered the formalisation of ASM.

of the ASM miners, including the government authorities, politicians, and connected businesspeople, benefit from the status quo of an unregulated, informal ASM sector.

Adranyi et al. (2024) conducted a case study on Ghana's ASM, and the findings highlighted how poor institutional capacity is undermining the formalisation efforts in the country due to weak enforcement of the ASM regulations. One of the factors contributing to this weak enforcement is the centralisation of the permitting and licencing process, which can only be done in the Ministry of Mines's national head office in Accra. This lack of decentralisation results in major inefficiencies and delays, which ultimately dissuade prospective artisanal miners from complying. In addition, during the study, government agencies, including the Mineral Commission and the Environmental Protection Agency, also reported significant resource constraints, including a lack of personnel, insufficient funding, and inadequate logistical support (e.g., monitoring tools and vehicles). Despite there being ASM operations in 13 out of 16 of Ghana's administrative districts, the Mineral Commission only had a presence in 9 of the districts, while the Environmental Protection Agency does not operate in several of the districts with intensive ASM activities (Mineral Commission 2021). These deficiencies inhibit the implementation of monitoring and evaluation initiatives, which further weaken the regulatory oversight in the country. In addition to this, the poor coordination between the different agencies aggravates enforcement challenges. This is because the different regulatory agencies targeted at the ASM sector operate in silos, often with policy mandates that are not clearly defined, with limited cross-agency collaboration, resulting in uncoordinated state efforts.

In addition to inhibiting formalisation efforts, another undesired effect that is cultivated due to weak enforcement is the illicit trade of the mineral products produced from unlicensed ASM operations (Paschal and Kauangal 2025). For instance, Semberya (2025) highlights how Tanzania is losing approximately 30% of its total gold production due to gold smuggling because of criminal networks that are capitalising on the unregulated nature of the ASGM in Tanzania. It is estimated that 90% of the 20 tonnes of gold produced by the ASGM operations in Tanzania is smuggled. This equates to approximately US\$1 billion in revenue (Semberya 2025). While the Tanzanian government has tried to address these gold leakages by making efforts to formalise the sector by setting up official gold trading centres, these efforts have had limited success, as over 95% of the 1.5 million ASM operators in the country still operate illegally. This has been attributed to a combination of weak border controls, corruption, and poor official prices offered by these centres (Transparency International 2025). These studies reinforce the need for the strengthening of regulatory agencies

dealing with the ASM sector. One way to achieve this is by implementing institutional reforms that include the decentralisation of regulatory processes, the setting up of clear regulatory agency responsibilities and roles, and an increase in budgetary allocation to enhance the regulatory capacity of these state agents. Better wages for the state regulatory agents and a no-nonsense approach to bribes can also help curb corruption.

Exclusionary formalisation frameworks

Exclusionary formalisation frameworks refer to regulatory systems that impose disproportionately restrictive requirements, such as expensive or complex permitting procedures that effectively marginalise ASM operators (Hook 2019). Some researchers argue that the informality and illegality in ASM are not only driven by a lack of formalisation, inappropriate policies, or a lack of enforcement, but also by excessive formalisation policies that are highly restrictive to ASM operations (Tschakert 2009; Hilson and Maconachie 2017). For instance, a study by Hilson et al. (2021) revealed that the drive to formalise the ASM sector in Mozambique has been inhibited by the bureaucratic licensing process and an overlap of responsibilities of two state agencies responsible for regulating the sector. Spiegel (2014; 2017) highlights the effects of the nationwide police crackdown on ASM miners in Zimbabwe. This crackdown targeted ASM operators' non-compliance with the country's environmental impact assessment (EIA) policy and illegal mining and gold trading. The result was the virtual criminalisation of the sector that even affected other ASM miners who were licenced and making efforts to formalise. This heavy-handed approach to enforcement destroyed the livelihoods of thousands of households dependent on the sector. It also proved counterproductive and ineffective in addressing the environmental problems and illicit gold flow issues, as compliance with the EIA report requirements was beyond the affordability of most ASM miners (Yingi and Chitongo 2021). Verbrugge and Besmanos (2016) and Hilson and Maconachie (2017) also expand on how bureaucracy often leads to the creation of informality. For instance, it was found that the numerous political and fiscal administrative requirements, such as the high costs of permits, patronage, and the rent-seeking tendencies of state regulators, act as obstacles hindering ASM operators' willingness to enter into the formal economy (Verbrugge and Besmanos 2016). Legalistic scholars also theorise that ASM operators opt to work informally to avoid excessive costs and bureaucracy (Hilson and Maconachie 2017).

Table 5 gives a summary of some key finding on the way exclusionary frameworks inhibit ASM formalisation. The

Table 5 Summary of the findings on the exclusionary frameworks

Author(s) and Year	Country	Key Finding
Tschakert (2009)	Ghana	Highlights that between 300,000 and 500,000 ASM operators mine illegally without a license and are thus criminalised and marginalised. Argues for the government to adopt a more “just” participatory approach to policymaking targeted at the sector.
Spiegel (2012)	Africa	Notes the ambiguity in the regulatory frameworks which has resulted in uncertainty for the ASM operators about whether “illegal miners” are eligible to participate in training and funding initiatives, or whether those programs are only reserved for legal miners.
Spiegel (2017)	Zimbabwe	Highlights how the heavy-handed enforcement of expensive environmental impact assessments (EIAs) was used by state agents to halt the livelihoods of ASM operators, and it was also used by authorities as a means to extract rent from the ASM operators.
Siwale and Siwale (2017)	Zambia	Argues that formalisation efforts by the state have been leveraged as a mechanism for government control, resulting in ASM operators being displaced.
Hilson et al. (2017)	Ghana and Niger	Highlights numerous scenarios where ASM operators have opted not to formalise their mining operations due to the bureaucracy and high costs involved.
Mkodzongi (2023)	Zimbabwe	Asserts that due to the significant role that ASM plays in rural livelihoods, the government must shift from its antagonistic approach, which criminalises ASM, and instead adopt a policy framework which facilitates formalisation of the sector.

focus here is on African countries where despite the prevalence of the sector, existing policies still marginalise the sector, preventing it from integrating into the formal economy.

Spiegel (2014) conducted a case study which investigated how a state-sponsored nationwide clampdown in Zimbabwe, referred to as “Operation Chikorokoza Chapera (No More Illegal Mining)”, had a profound effect on the livelihoods of both unlicensed and licensed ASGM operators. This crackdown was characterised by physical violence and the structural shutdown of many ASGM operations, resulting in 25,000 artisanal miners being imprisoned between 2006 and 2007. This crackdown had a lasting effect on the artisanal mining community in the country, as a significant number of the miners arrested were handed heavy sentences, with 9,000 miners reportedly still in jail in 2013. “Operation Chikorokoza Chapera” was largely motivated by Zimbabwe’s economic crisis. A shortage of foreign exchange reserves led the Reserve Bank of Zimbabwe (RBZ) to offer below-market gold prices, using the

“Gold Trade Act of 1940” that conferred it as the exclusive purchasing authority of gold in the country. At some point in 2006, the RBZ’s official price for gold was equal to less than 8% of the international market price (Spiegel 2009). These uncompetitive pricing structures imposed discouraged participation in official gold trading via the RBZ, resulting in an escalation of smuggling in 2006. This prompted the Zimbabwean government to depict informal artisanal mining as a national security threat. The state, led by the RBZ, then made efforts to criminalise ASGM in the country by framing it as a threat to macroeconomic stability due to leakages in foreign currency. The environmental degradation caused by the ASGM was also used to justify the clampdown. At the same time, prohibitive EIA and licencing requirements resulted in the exclusion of the majority of the ASM operators from legal participation (Spiegel 2017). Though the state-sponsored initiative was originally directed at curbing gold smuggling, this operation soon grew into a nationwide state security campaign that even ended up targeting licensed miners. In addition to the violent arrest of tens of thousands of miners carried out during this operation, an enduring consequence of the crackdown was that it instilled widespread fear that displaced many people from their primary source of livelihood. Many never dared to return to mining. As illustrated in Table 6, a significant number of miners and mineral traders remained incarcerated as of December 2012 as a direct result of the government’s aggressive enforcement strategy (Spiegel 2014).

This case study demonstrates how a punitive approach to the regulation of ASM can have a profound adverse effect on the livelihoods of already marginalised communities. It is therefore recommended that future policy implementations adopt a more balanced approach that is both humane and context-sensitive to ASM governance: an approach that encourages inclusion and human development support over criminalisation and exclusion.

Table 6 Mineral traders and miners in seven of Zimbabwe’s prisons at the end of 2012 (Spiegel 2014)

Prison Location	Number of ASM operators incarcerated for legal violations
Gwanda	3000
Masvingo	2165
Kwekwe	2050
Mutare	1739
Gweru	1650
Kadoma	889
Hwange	350

Broader structural issues

In addition to the above-mentioned policy and regulatory factors used to explain the dominance of informality and illegality in the ASM sector, other researchers have come to realise that other structural conditions also play a role in preventing ASM miners from running formalised mining operations (Hilson et al. 2018; Maconachie and Con-teh 2020). These factors include socio-economic factors, knowledge, technological factors, factors to do with access to markets and capital, etc. (Martinez and Smith 2021; Otoi-jamun et al. 2021). The following section unpacks these broader structural issues affecting the formalisation process of the ASM sector in more detail.

Limited access to finance

Several studies have highlighted that lack of access to formal lines of finance is one of the major issues inhibiting the formalisation of the ASM sector. For instance, it is argued that ASM operators find it difficult to obtain loans from banks due to their lack of collateral and/or poor bankable feasibility study outcomes. This lack of access to capital ultimately affects the viability and scalability of their operations (Eniowo et al. 2022b). Thus, one of the key dimensions of integrating the sector into the formal economy is enabling the ASM actors to gain access to the formal financial system (United Nations Environmental Programme 2012). It is therefore important to unpack the factors inhibiting the ASM sector from gaining access to formal finance.

Kumah et al. (2020) postulate that one key factor inhibiting the sector's access to formal financing is that ASM operations are often found in marginalised and rural communities. Because the ASM communities are marginalised, most ASM miners must rely on borrowing capital from family and friends, or on other informal sources of credit that are more accessible to them (Hilson and Ackah-Baidoo 2011). Even in communities where financial services are accessible, loan applications by ASM miners are often rejected. Local banks are often not interested in engaging with the ASM sector due to its perceived risk and poor reputation (Eniowo et al. 2022a).

Ofosu and Sarpong (2022) argue that even when banks make provisions to offer loans for the ASM sector, this form of finance is often unattainable and not appropriately suited for the sector's needs. According to the United Nations Environmental Programme (2020), this is because such finance often comes with conditions requiring collateral, or with high interest rates and non-flexible repayment terms. It is also often attached to stringent diligence expectations, which often have high costs of compliance. Resultantly,

this misalignment implies that ASM operations generally struggle to gain access to formal channels of finance.

The ASM operators are forced to rely on informal sources of financing from external “sponsors” as a result of the limited opportunities to access formal lines of credit, and these sponsors are often the buyers of the minerals (Pact 2015). These informal loans, however, often come attached to unfavourable conditions, including the ASM operators having to sell their mineral products to the buyers (sponsors) at below-market value (Eniowo et al. 2022b). These informal financing arrangements thus ultimately contribute to the vicious cycle of informality in the ASM sector (World Bank 2023).

The study by Sinding (2025) identifies the ASM sector's operational inefficiency as a contributing factor to its failure to access formal channels of funding. For instance, when evaluating the viability of projects, investors and bankers usually require detailed business plans with discounted cash flow analyses generated from verifiable data. However, this data is usually hard to generate in an ASM setting, and even when the data is available, there is a lack of capacity to evaluate it and use it to prepare financial and technical models. For instance, the conventional mining engineering approach of evaluating a prospective mining project starts by evaluating the geophysical and geochemical data of the mining area, and this is followed by drilling exploratory boreholes. The drill cores are then recovered and taken to laboratories for assessment to enable an estimation of the reserves and ultimately to conduct a feasibility study. The ASM operators usually encounter significant hurdles in proving their mineral reserves, and this proof is a prerequisite for formal funding. Marin et al. (2016) proposed the “minimum reserve” approach to help address this obstacle. With this approach, ASM operations only need to prove 1/100 of their reserves to prove the feasibility and viability of their mining operation, while large-scale mining (LSM) operations have to provide proof of a greater proportion of their reserves. Adaptation of this “minimum reserves” approach can help improve investors' confidence in the ASM sector (Marin et al. 2016). Another mechanism that can be used to enhance the financial inclusion of the ASM sector into the formal economy is the creation of cooperatives and resource pooling. These cooperatives can then be used to apply for low-interest loans or to access financial grants from governments and donors. Paschal et al. (2024) highlight that empirical evidence from Tanzania and Rwanda demonstrates that the cooperatives model has successfully allowed ASM operators to access government grants and credit facilities to sustain and expand their mining operations.

Technical factors

Although large-scale mining (LSM) and ASM are two divergent mining techniques, each with their own unique history, impacts on health, safety, and the environment, and governance issues, these mining subsectors often converge and sometimes conflict (Grant and Wilhelm 2022). For instance, illegal ASM miners sometimes invade LSM-owned concessions, resulting in major conflicts. In some instances, state-controlled law enforcement agencies, including the military, are called to intervene (Marshall and Veiga 2017). Despite this often-conflicting relationship, several lessons can be drawn from LSM that can be used to enhance the integration of ASM into the formal economy (Hilson et al. 2020). This can allow both branches of the mining sector to forge mutually beneficial working relationships.

A typical illustration of this can be drawn from the Antioquia region of Colombia, where small-scale miners have mixed artisanal mining techniques with semi-mechanised methods. The ASM sector in the region has outperformed other regions in the country due to the ASM miners' collaboration with a publicly listed large-scale mine called *Mineros* (Tarra et al. 2022). *Mineros* has implemented a coexistence model with the ASM miners called “MOFORMAL”, with which it has been able to integrate over 500 ASM miners operating within its mining concessions into the formal mining sector. The ASM miners have been given technical support through this model to ensure they mine in an environmentally sustainable manner and to address certain business and social aspects (Mineros 2023).

In essence, the “MOFORMAL” model is a form of subcontracting to ASM miners by the LSM operator that enables ASM operators to operate on the LSM operator's concessions. This LSM operator took the responsibility of managing the EIA and developing a business plan before the ASM miners started mining. Using an “operational contract”, the LSM operator also took the responsibility of covering the operational and logistical costs of transporting the mined concentrate, the processing costs, and paying any royalties and taxes related to the gold production process (Mineros 2024). This model presents an example of how an amicable form of coexistence can be established between conventional LSM operations and artisanal miners. It also highlights how the involvement of the LSM can help in solving several of the social, financial, and environmental challenges related to ASM (Aubynn 2009). This can be achieved by allowing ASM miners to operate under supervised autonomy and by LSMs providing technical and economic support to improve the sustainability of the ASM operations (Tarra et al. 2022).

In the African context, African governments have committed to developing policies that will assist the ASM sector

in becoming integrated into the formal economy through the provision of technical support. This is articulated through the “African Mining Vision”, which emphasises the significance of setting up training centres for artisanal miners called “centres of excellence” (COEs) (African Minerals Development Centre 2022). According to Rupprecht (2015), the COE concept is nothing new, and it has received mixed results over the past decades. For instance, several ASM COEs have been established in Tanzania with the support of the World Bank (World Bank 2020). The results of these COEs have been lukewarm, highlighting the complexity of formalising ASM. The mixed results also highlight the fact that external intervention frameworks may be misaligned with the needs of the ASM operators (Hilson and Maconachie 2020). For instance, the results observed by studying these COEs show that some ASM operators are hesitant to formalise, as they deem remaining informal to be financially beneficial to their operations. In addition, it is observed that the introduction of better mining or processing technology does not necessarily translate into the integration of ASM into the formal economy. In some instances, informal ASM thrives due to the exploitation of unpaid or cheap labour (Kinyondo and Huggins 2021). According to Klein (2022), the need for these informal ASM operations to formalise may therefore be secondary.

The study of these COEs also highlights that they need to supply services that are in demand in the sector to attract ASM operators. These in-demand services include giving ASM operators access to geological information, providing them with loans, renting out equipment, and providing financial management training to the ASM miners. In addition, the COEs must be financially self-sustaining instead of being reliant on external donor funding to increase the chances of success. It is also important that these COEs gain the support of state agencies and the local government authorities overseeing the sector (Kinyondo and Huggins 2020). Stocklin-Winberg et al. (2019) also argue that the training programs must be designed to be reflective of the realities of the context in which they are set up rather than being restricted by the specifications made by donors funding these programs for the training projects to be successful. The use of a bottom-up approach will also contribute to their success, as Hilson (2007) attributes the failure of many donor programs targeted at ASM to the top-down strategies that the funding agencies often devise.

While the needs of ASM are complex and varied, one common factor which is evident is the need for the sector to mechanise and the significant impact that technology has in developing the sector (Teschner et al. 2017). According to Doumbouya et al. (2024), the technology needs of ASM are not necessarily cutting-edge technology, as even “minor technology level” innovations, like the introduction of metal

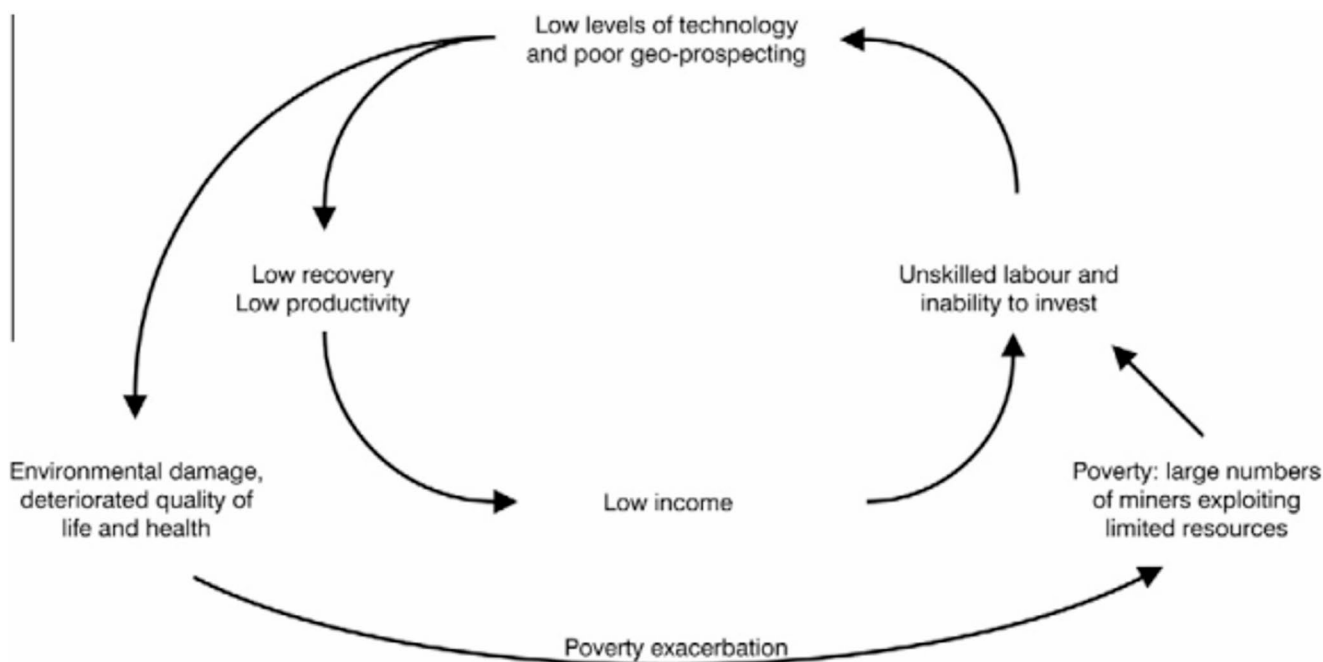


Fig. 4 A vicious poverty cycle for ASMs perpetuated due to a lack of access to technology (Hilson and Ackah-Baidoo 2011)

detectors, fan motors, pumps, air compressors, and sampling techniques, can make a profound impact on the ASM operations. As an example of this, Mabhena (2012) highlights how access to metal detector technology has had a profound impact on the expansion of ASM in southern Zimbabwe. This showcases how access to even low-level technology can greatly enhance the efficiency of ASM operations.

Figure 4 below highlights that a vicious poverty cycle is perpetuated in ASM due to low levels of skills and a lack of access to the appropriate mining technology. This results in inadequate knowledge of the ore body, low productivity, poor mineral recovery rates, degradation of the environment, and adverse effects on health. This ultimately leads to low income generation and the exacerbation of poverty in ASM communities.

In the 1990s the Zimbabwean government, in combination with international donors, supported the setting up of local milling centres where ASGM miners could come and have their ore processed for a fee (United Nations Economic Commission for Africa 2002). These centres were also made to facilitate training for ASM miners to enhance their skills in geology, mining methods, environmental management, business planning, and health and safety. One well-known example of such a milling centre is the Shamva milling centre (Hilson and McQuilken 2014). According to Spiegel (2015), this project was conceptualised by a group of NGOs and was viewed as a proactive step in enhancing the economic viability of ASM through technology-sharing. It provided an economically viable custom milling service for ASGM miners in the Shamva area and was heralded by the

United Nations Economic Commission as a “best practice in small-scale mining” and as “the most significant support service ever provided for SSM”. The project was initially very impactful, as it was reported that ASGM income rose by up to 30% when the Shamva milling facility opened (Hentschel et al. 2002).

According to Pact (2015), the reason the project was initially so successful was because it addressed the real need that the ASGM miners had to access efficient processing technology. In addition, the presence of government-backed gold buyers when it was opened, offering market-related prices to ASGM miners for the milled gold, created an incentive for the ASGM miners to utilise the facility to access the market. Unfortunately, although the early phase of the project was successful, various challenges were encountered with the project over time. The milling facility was initially meant to service 40 ASGM operations within a 50 km radius; however, by the end of the decade, the facility was processing ore for at least 500 ASGM operations within a 200 km radius (Bester and Groenewald 2021). This overwhelming demand meant that ASM miners had to queue for weeks to get their ore processed. According to Hilson (2002), the facility was initially run by qualified managers, but the subsequent hasty transfer of the management of the Shamva milling facility to the local ASGM miners’ association is often blamed for leading to its demise. This is because inexperienced and unqualified managers were appointed to run the facility after the takeover by the association, resulting in cashflow problems (Kinyondo and Huggins 2020).

One key lesson that this case study highlights is the positive impact that access to technology can have on the ASGM sector. The overwhelming demand for such a facility from ASGM miners also highlights that any successful interventions by donors, governments, and investors must be able to meet the direct needs of the miners. This case study also highlights the need to come up with sustainable and commercially viable business models for the ASGM sector. It also highlights the importance of having good management systems for any ASGM project to flourish.

Environmental factors

To integrate ASM fully into the formal economy, it is important to address the negative environmental attributes associated with the sector. The United Nations Environmental Programme (2020) highlights the significance of environmental aspects when discussing ASM formalisation. For instance, their report states that ASGM is the biggest contributor to environmental mercury pollution, accounting for roughly 35% of the world's total pollution. According to Martinez and Smith (2021), state policymakers and regulators regard formalisation as a tool with which to ensure better regulation and governance of the ASM sector, particularly when dealing with the sector's negative environmental connotations, including mercury pollution and deforestation. It is therefore important to delve into these environmental factors and how they affect ASM's integration into the formal economy.

To start with, ASM's negative impact on the environment has led to poor public perception generally about the sector (Ondayo et al. 2024). However, while it's easy to put the blame for the environmental degradation squarely on the ASM miners, governments must also take some responsibility (Verbrugge and Besmanos 2016). This is because the governments have struggled to formalise the sector due to their lack of capacity to enforce environmental compliance. This is exacerbated by the fact that most ASM operations are situated in areas that are extremely remote and have very few, if any, state agents to monitor their activities (Hilson et al. 2019; Mimba et al. 2023). Mining corporations that previously held the mining leases also often neglect to follow the proper mine closure procedures, thereby creating opportunistic avenues for artisanal miners to access and exploit these abandoned mine sites (Eniowo 2025). The negative impact of ASM on the environment is well documented (Yu et al. 2024), so there have been efforts made to conserve it. Zvarivadza (2018) also adds that ASM miners cannot just be "wiped away" as the ASM sector is often the only livelihood source in these marginalised communities. When addressing the negative environmental impacts of ASM, it is thus

critical to find sustainable solutions that balance the need to conserve the environment with the need to safeguard the livelihoods of the marginalised mining communities (Ngom et al. 2022). Spiegel (2009), however, argues that the top-down restrictive strategies that have been used to deal with the environmental impacts of ASM have not been effective. These include the banning of the trade and use of mercury and the tightening of regulations on ASM mining. This is because the often-marginalised, poverty-afflicted ASM communities are trapped using mercury and other environmentally degrading mining practices due to their limited access to alternative improved technologies and techniques.

Veiga and Marshall (2019) suggest that one way to address this problem is for governments to work with donor organisations in programs that can initiate capacity-building in ASM communities. This can be achieved by promoting mining techniques and technology alternatives that use mercury-free processes. Smith (2019) argues that a more holistic approach is needed to understand the motivations and challenges of the ASM communities so that the environmental conservation initiatives targeted at ASM can be more effective. In other words, environmental interventions should be offered in combination with interventions designed to address the ASM communities' needs. Martinez et al. (2022) have proposed that "voluntary mineral certification programs" be established and administered by a set of international donor agencies. These programs must be structured in a way that incentivises the ASM miners who comply with environmental and safety practices. This can be achieved by facilitating their access to international markets so that certified ASM miners can get better prices for their mineral products.

On the other hand, governments can use recent advances in technology, such as the "Google Earth Engine", in combination with other technologies like machine learning software, to improve their monitoring of the impact of ASM activities on the environment (Yu et al. 2024). However, it is important to emphasise that any state enforcement intervention needs a balanced approach. For instance, lessons can be drawn from the impact of the nationwide police crackdown in Zimbabwe, which targeted environmental non-compliance in ASM, as it destroyed the livelihoods of many marginalised communities that were dependent on the sector (Spiegel 2017).

Socio-Economic factors

To integrate the sector fully into the formal economy, it is important to explore the socio-economic factors associated with ASM. As a starting point, it is important to understand why people are drawn or driven into the ASM sector. Rushemuka and Cote (2024), while acknowledging the

precariousness of ASM as a livelihood, argue that people do not always go into ASM out of necessity, as many also choose to do so as they are enticed by the prospects of wealth creation that ASM presents. In many African countries like Ghana and Zimbabwe, the rate of unemployment is high, so a growing proportion of graduates are joining the ASM sector (Mamuse and Mandaza 2017). According to Arthur-Holmes et al. (2022), university graduates in these countries are joining the ASGM sector primarily due to a lack of alternative employment opportunities, to diversify their income, or because it offers them an opportunity to start their own businesses in this sector, as it has the potential to generate high profit margins compared to other sectors.

On the other hand, Osei and Yeboah (2023) state that most young rural ASM miners aspire to escape the sector as an occupation. They only venture into ASM as it enables them to raise enough money to further their studies, establish their own businesses, or secure professional jobs. The respondents from their study cite the precarious nature of ASM, including safety and health hazards and a lack of financial stability, as the reason why they do not see long-term prospects in the sector. Kumah et al. (2020) add support to this postulation by linking poverty to ASM and stating that ASM miners are trapped within a vicious poverty cycle. These varying motivations and reasons why people end up in ASM highlight the need to understand the

intricacies when dealing with the sector and the importance of interventions that are context-specific (Li and Goerzen 2024). Eniowo (2022) further illustrates that ASM is not homogenous by categorising ASM activities into different categories, namely traditional ASM, seasonal ASM, rush or influx ASM, shock-pull ASM, and cohabiting ASM. These varying forms and causes of ASM imply that the governments in different regions need to apply different approaches to their interventions on ASM to ensure effective formalisation drives.

Given the varied socio-economic drivers that influence individuals' involvement in ASM, it is imperative that any regulatory intervention aimed at formalising the sector should adopt a multi-faceted approach (Zvarivadza 2018). This approach must be crafted to align with the diverse motivations of the ASM actors and be designed strategically to incentivise formalisation. Figure 5 illustrates the taxonomy of the key factors that can potentially improve the willingness of ASM operators to transition into the formal economy. These factors are categorised into four broad domains, namely business enterprise, legal, moral, and economic factors. The business enterprise factors include, for instance, policy measures that encourage the entry into the sector of trained professionals such as mining graduates. Their formal education and technical competence bring professionalism into the sector and thereby increase the

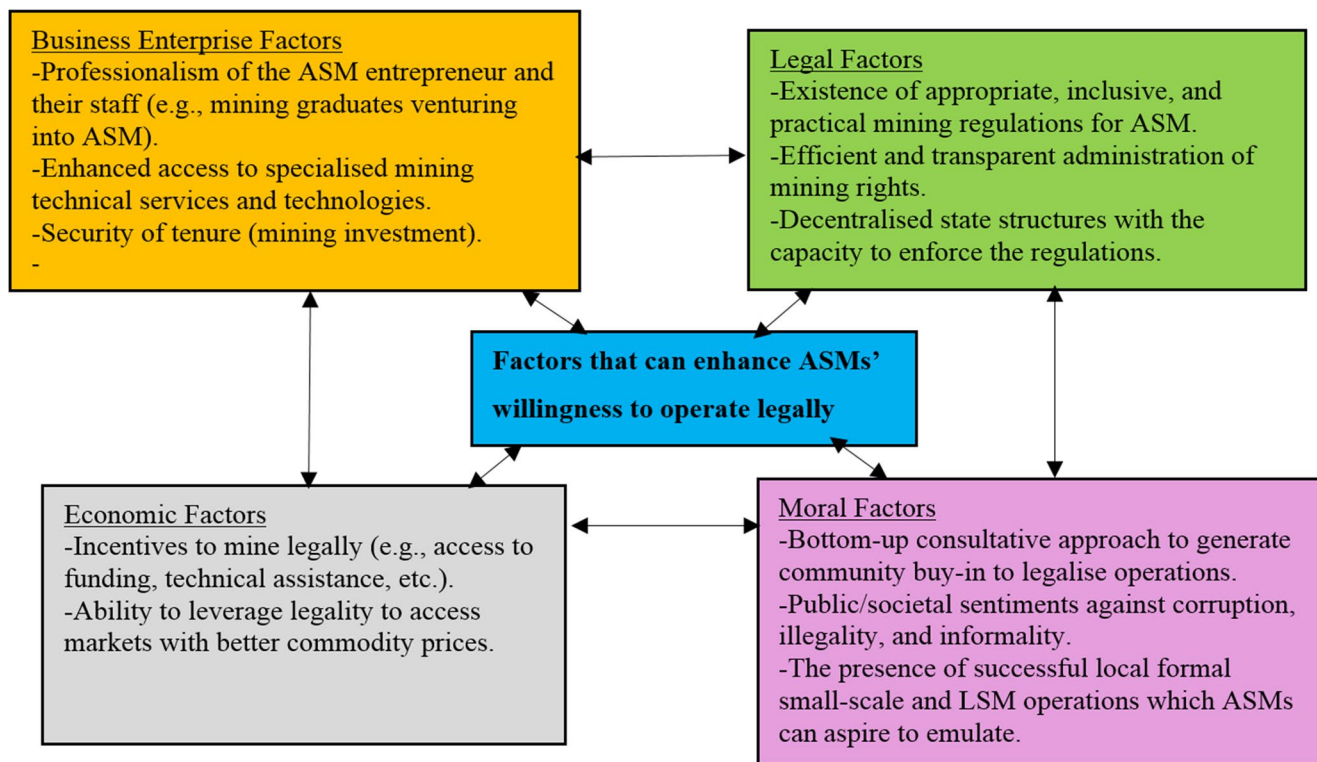


Fig. 5 Factors that can enhance ASMs' willingness to operate legally (Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development 2018; Zvarivadza 2018)

propensity for participation in legalised mining operations. The provision of access to specialised mining training and modern technologies can further reinforce the appeal of formalising the ASM operations. Economic incentives, such as facilitating access to more favourable markets and finance, can also be pivotal in encouraging voluntary compliance. Legal conditions that include simplifying licencing procedures and decentralising regulatory institutions for better access can also significantly reduce the barriers to formalisation. In addition, moral factors, such as the visibility of successful formalised ASM enterprises, can have a demonstrative effect that motivates other operators to follow suit. A cultivated anti-corruption culture, as well as a consultative approach by regulators, can help generate buy-in from ASM actors to formalise their operations (Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development 2018).

Clifford (2022) gives a pessimistic view of the ASM sector, arguing that the sector will not contribute meaningfully to the United Nations' 2030 "Sustainable Development Goals" (SDGs) or to any sustainable development in the foreseeable future. According to the study, nobody really cares enough about the sector and refereeing policymakers' priorities at a global level. It is then argued that ASM is viewed as having less of an impact compared to other global socio-environmental concerns like climate change. This global view then streams down to national views, where the sector is viewed in a negative light due to the difficulties experienced in trying to manage it. In fact, governments are often biased towards the easier and more guaranteed sources of funds from the LSM sector. This ultimately results in the sector being overlooked easily or avoided altogether (Zvarivadza 2018). Moreover, Musah (2025) argues that ASM often exacerbates pre-existing socio-economic inequalities by enabling a select group of a few individuals to reap economic gains disproportionately, while the wider community is simultaneously left to bear the resulting social costs and environmental degradation. The research outlines a study conducted in Ghana's Anansie District as an example of this, which shows that over 80% of the ASM operations in the region are male dominated. This contrasts with the relatively balanced gender participation rate in small-scale agriculture, with approximately 55% female and 45% male participation in the sector.

However, other scholars differ from these pessimistic views, particularly in reference to the ASM sector on the African continent. For instance, Kamlongera (2011) highlights how ASM has tremendous prospects to contribute to the rural economy of Malawi. However, the research notes that the exploitation of ASM miners by the buyers in the country, inadequate access to formal markets, and insufficient support from the government are crippling the ASM

sector. Fisher et al. (2009) explore the ASM sector's contribution to poverty reduction in Tanzania and suggest that the individuals involved in ASM have a lesser likelihood of being trapped in poverty compared to those in other occupations. Hilson and Maconachie (2020b) postulate that there is increasing empirical evidence showing that ASM has become the largest non-agricultural income source in the rural areas in Sub-Saharan Africa, in large part because it is a poverty-driven activity in marginalised communities with limited employment opportunities.

In facilitating the integration of ASM into the formal economy, there is also a need to understand the strong linkages found between ASM and small-scale farming from a socio-economic perspective. According to Baddianaah et al. (2021), the earnings from ASM are often invested into small-scale farming through the purchase of agricultural inputs. Conversely, ASM also negatively affects farming by degrading agricultural land and contributing to labour shortages. Moyo et al. (2022) describe the relationship between ASM and small-scale farming as "paradoxical, pulling together and apart". The research goes on to highlight this paradox by using a Zimbabwean cattle farming region as a case study, where climate change and shrinking grazing pasture have resulted in traditional farming communities diversifying into the ASGM in the area. From one standpoint, ASM provides earnings that are utilised to acquire farming inputs, and ASM miners provide a market for the farmed produce. On the other hand, ASM competes with and degrades the agricultural ecosystem in the area. Mkodzongi and Spiegel (2019) thus advocate for a more nuanced understanding of ASM and small-scale farming linkages, including the class and labour dynamics, to enhance the integration of ASM into the formal economy.

Table 7 below gives a comprehensive summary of the findings on how the broader structural issues are hindering the integration of ASM into the formal economy. One key feature is the need to understand the intricacies of ASM by using a holistic approach when unpacking the complexities of the sector. The solutions proposed to facilitate the formalisation of ASM must therefore be multi-faceted and cover the broad structural challenges faced by the sector. Traoré et al. (2024) conducted fieldwork in the Kéniéba District in Mali to showcase the impact and challenges related to ASM in the area as a result of the rise in the price of gold on the global market. The researchers noted that the ASM sector was growing in the district. They also highlighted that ASM was not only providing direct mining opportunities for the community but also stimulating a diverse range of auxiliary entrepreneurial activities, including catering, trade, and skilled services like welding. However, the Mali government's regulation of ASM imposes restrictions on mechanisation. The ASM operators are restricted from

Table 7 Summary of the findings on the broader structural issues in ASM

Author(s) and Year	Country/Region	Key Finding
Siegel and Veiga (2009)	Uganda	Postulates that capitalisation of the ASM miners is key to enabling formalisation efforts to be effective.
African Union (2009)	Africa	Argues that the sector is mainly a poverty-driven activity and emphasises the need to harness the sector's "broader linkages" with the SDGs.
Hilson and Ackah-Baidoo (2011)	Ghana	Asserts that government initiatives to offer microcredit facilities to ASM operators can incentivise them to formalise.
United Nations Environmental Programme (2012)	Tanzania, Uganda	Argues that the "polluter pays principle" applicable to LSM is difficult to implement in ASM, and advocates for a preventative approach when dealing with the sector, where ASGM operators are helped to move away from mercury usage and release to begin with.
Mamuse and Mandaza (2017)	Zimbabwe	Proposes that technical colleges/universities can support government efforts by providing the required training and technical support to ASM operators. Mining schools can also encourage their graduates to venture into formalised ASM.
Hilson et al. (2018)	Ghana, Mali, Sierra Leone	Highlights that government agencies' lack of expertise on ASM makes it difficult for the state to formulate practical strategies to foster formalisation.
(Zvarivadza 2018)	DRC, Zimbabwe	Postulates that the facilitation of technical capacity-building in combination with legal obligations enables the elimination of illegal mining.
Maconachie and Conteh (2020)	Liberia	Advocates for a bottom-up approach to understanding why informality persists, despite the growing interest of policymakers and donors to formalise the ASM sector.
Otoijamun et al. (2021)	Nigeria	Identifies inadequate state and donor support, a lack of access to mining technology and equipment, poor infrastructure, challenges with mineral marketing, and limited education and mining skills as the factors hindering the formalisation of ASM.
Baddianaah et al. (2021)	Ghana	Argues that for ASM to be integrated into the formal economy, its activities should not come into conflict with other sources of livelihood, like agriculture.
Kinyondo and Huggins (2021)	Tanzania	Highlights the need to align ASM formalisation efforts with the SDGs, particularly in advocating for a reduction of ASM's impact on the environment.
Eniowo et al. (2022a)	Nigeria	Highlights that ASM operators' inability to conduct feasibility studies, their lack of technical mining knowledge, and their lack of collateral inhibits their formalisation efforts.
Moyo et al. (2022)	Zimbabwe	Highlights how the negative effects of ASM in comparison to those of alternative land-use activities, such as cattle ranging, exacerbate the negative perception of the sector. This poor perception of it inhibits its integration into the formal economy.
Ofosu and Sarpong (2022)	Ghana	Notes that the continued lack of sustainable integration of ASM into the formal economy can be attributed to the lack of a saving and investment culture in the sector.
Grant and Wilhelm (2022)	Ghana, Sierra Leone, Guinea, Burkina Faso	Highlights that LSM is the predominant focus in the developmental discourse, with regional and global developmental initiatives failing to recognise ASM as a potential key source of local employment and economic development.
Arthur-Holmes et al. (2022)	Ghana	Proposes the prioritisation of community development that is locally centred as a means of increasing the success of ASM formalisation efforts. Suggests that ASM's linkages to other sectors must be developed and that the labour dynamics in the sectors must be reconfigured.
Klein (2022)	Madagascar	Argues that formalisation efforts often fail because they fail to recognise the pre-existing traditional local institutions that are embedded in marginalised rural communities before attempting to transform them.
Osei and Yeboah (2023)	Ghana	Highlights that youths often participate in ASM activities as a transitional step to make enough money so that they can further their education, get more secure employment, or set up a business. They move away from ASM as soon as they can because of the perceived hazards and risks associated with the mining activities.
Eniowo (2024)	Nigeria	Argues that ASM operations can become more environmentally sustainable if they have access to sufficient formal funding. Funding can also enable the achievement of healthier and safer operations in the ASM sector and facilitate the attainment of the SDGs.
Bester (2025)	South Africa, DRC	Highlights how labels, such as describing artisanal miners as "Zama Zama miners", can further marginalise groups that are already vulnerable and explores how LSM companies can support ASM.

using mechanised equipment because of the implementation of these state enforcement measures, and they thus continue to rely on rudimentary tools. In Mali, the ASM is also restricted by confinement to designated corridors, which further inhibits formalisation of the sector. This restrictive

approach by the state, while perhaps justified as a mechanism for minimising the negative impact of the sector, particularly on the environment, fails to appreciate its potential socio-economic and developmental benefits. Based on these observations, it is recommended that regulators should

adopt a holistic ecosystem-based view of the sector, as this could greatly improve the understanding of ASM's integration into local economies. This approach would challenge the reductive narratives which overlook the sector's developmental potential, particularly on the African continent.

Conclusion

The formalisation of ASM is a multi-dimensional process framed at integrating the sector into the formal economy. This paper categorised the persistent barriers to ASM's formalisation into five interrelated dimensions, namely, the absence of formalisation frameworks, the presence of inappropriate policies, exclusionary regulations, weak enforcement, and broader structural constraints. In this study, African case studies were used to expand on these dimensions. For instance, South Africa was used to illustrate how a lack of institutional recognition can entrench informality, while Ghana was used to highlight how rigid and inappropriate regulatory frameworks often fail to reflect the socio-economic realities of ASM communities. In addition, Tanzania was used to show how weak enforcement, driven by the complicity of regulatory actors and compounded by a lack of resources, often results in the thriving of gold smuggling, resulting in the further entrenchment of the sector into informality and illegality. Zimbabwe was used to show how exclusionary regulatory efforts that are overly stringent and burdensome can have detrimental effects by further marginalising the people dependent on the sector for their livelihood. Broader structural constraints, such as limited access to technology and finance, were shown to further embed informality.

The adoption of cooperative models and the minimum reserve approach are recommended as critical mechanisms for financial inclusion of the sector into the formal economy. However, empirical evidence in countries like Tanzania and Rwanda has shown that the success of such models is dependent on supportive regulatory environments. Ultimately, this study shows that these barriers to formalisation are not mutually exclusive but rather closely interconnected. Therefore, a more holistic, ecosystem-based and integrative approach that incorporates socio-economic, environmental, institutional, and political dimensions is pivotal for developing inclusive formalisation strategies for the sector. This approach would not only strengthen regulatory effectiveness but also acknowledge the ASM sector's role in supporting local livelihoods, as well as its potential for sustainable development. It is imperative that any regulatory intervention aimed at formalising the sector should adopt a multi-faceted approach, given the varied socio-economic drivers that influence individuals' involvement in ASM. In

addition, this paper recommends that further cost-benefit analysis studies be conducted to gain a better understanding of the trade-offs and impacts of these formalisation efforts. This is to ensure that future interventions towards the sector are both economically viable and socially responsive.

Author contributions T.L. Tingini: Conceptualization, Methodology, Formal analysis, Writing original draft & editing. Eniowo O.D. : Supervision, review.

Funding Open access funding provided by University of Pretoria. The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

The data supporting this review are drawn from previously published literature and are accessible through the cited references. No new datasets were created.

Declarations

Ethical approval Not relevant.

Consent for publication Not needed.

Consent to participate Not needed.

Competing Interests The authors have no relevant financial or non-financial interests to disclose.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Abulnaga BE (2021) Re-inviting mining for Egypt- a framework for small and artisanal mining. In: Elkhoully AA, Negm A (eds) Management and development of agricultural and natural resources in egypt's desert. Springer, Cham, pp 89–119
- Adranyi E, Stringer LC, Altink H (2024) Artisanal and small-scale gold mining governance and cross-sectoral policy coherence in Ghana. *Resour Policy* 96(105235):1–15
- Adu-Baffour F, Daum T, Birner R (2021) Governance challenges of small-scale gold mining in Ghana: insights from a process net-map study. *Land Use Policy* 102(105271):1–16
- African Minerals Development Centre (2022) Artisanal mining in Africa. African union. Conakry, Guinea
- African Union (2009) African mining vision. African union. Conakry, Guinea

- Arthur-Holmes F, Busia KA, Vazquez-Brust DA, Yakovleva N (2022) Graduate unemployment, artisanal and small-scale mining, and rural transformation in Ghana: what does the 'educated' youth involvement offer? *J Rural Stud* 95(3):125–139
- Aubynn A (2009) Sustainable solution or a marriage of inconvenience? The coexistence of large-scale mining and artisanal and small-scale mining on the Abosso goldfields concession in Western Ghana. *Resour Policy* 34(1–2):64–70
- Ayambire R, Nunbogu AM, Cobbinah PB et al (2024) Constructing alternative interpretation: embeddedness of illegality in small-scale mining. *Extr Ind Soc* 17(101430):1–12. <https://doi.org/10.1016/j.exis.2024.101430>
- Baddianaah I, Tuu GN-y, Baatuwue BN (2021) Livelihood implications of artisanal gold mining in farming communities: insight from the Wa East District, Ghana. *Ghana J Geogr* 13(3):85–120
- Baddianaah I, Baatuwue BN, Adams A-M (2023) Governance challenges in Ghana's artisanal and small-scale mining (galamsey) sector: is stakeholder interaction the way forward? *Afr J Sci Technol Innov Dev* 15(3):376–385
- Balag'kutu TA (2024) Governance fragmentation and agency of miners in Ghana's artisanal mining sector. *Geoforum* 156(104148):1–11
- Bester V (2023) Towards a sustainable artisanal gold mining sector in South Africa: proposed developmental initiatives. *J Rural Stud* 97(1):375–384
- Bester V (ed) (2025) Artisanal and small-scale mining and large-scale mining titans. In: *The untold story of Zama Zama miners in South Africa*. *Clinical Sociology: Research and Practice*. Springer, Cham pp 123–137
- Bester V, Groenewald L (2021) Corporate social responsibility and artisanal mining: towards a fresh South African perspective. *Resour Policy* 72(August):1–10
- Bester V, Uys T (2023) Artisanal mining and its drivers in the South African context. *Extr Ind Soc* 15(September):1–9
- Buruakuyve E, Barambona JM (2024) Burundi's mining code and environmental law. *Open J Soc Sci* 12:341–351
- Chen MA (2007) Rethinking the informal economy: linkages with the formal economy and the formal regulatory environment. *DESA Working Paper* 46. United Nations Department of Social and Economic Affairs, New York
- Chuma M, Fields TL, Mutemeri N (2024) A conceptual framework for reframing artisanal and small-scale mining: understanding characterization of artisanal and small-scale mining in South Africa. *J South Afr Inst Min Metall* 124(6):311–318
- Clifford JM (2022) Artisanal and small-scale mining and the sustainable development goals: why nobody cares. *Environ Sci Policy* 137(3):164–173
- Cote M, Korf B (2018) Making concessions: extractive enclaves, entangled capitalism and regulative pluralism at the gold mining frontier in Burkina Faso. *World Dev* 101(C):466–476
- Delvedatabase.org (2020) Delve. <https://www.delvedatabase.org/data>. Accessed 30 September 2024
- Doumbouya IK, Dessertine A, Vinches M, Cerceau J (2024) Mechanization of artisanal and small-scale gold mining in Guinea: socio-technical trajectory of a rural mining site in upper Guinea. *J Rural Stud* 112(4):1–12
- Dzimunya NZ, Mapamba LS, Dembetembe G et al (2018) Formalization of a roadmap to maximize the contribution of artisanal and small-scale mining in Zimbabwe. *The Southern African Institute of Mining and Metallurgy, Johannesburg* p 43
- Eniowo OD (2022) Prediction of creditworthiness of a viable artisanal and small-scale mining operation. Dissertation, University of Pretoria
- Eniowo OD (2024) Exploring the risk factors to formal financing for artisanal and small-scale mining operations. *Soc Impact* 3(100043):1–5
- Eniowo OD (2025) When closure fails: Uncovering the environmental impact of gold rewashing on abandoned mine sites in Southwestern Nigeria. *World Dev Perspect* 38(100682):1–9
- Eniowo OD, Kilambo SR, Meyer DL (2022a) Risk factors limiting access to formal financing: perceptions from artisanal and small-scale mining (ASM) operators in Nigeria. *Extr Ind Soc* 12(Nov):101–181
- Eniowo OD, Meyer LD, Kilambo LD, Gerber LJ (2022b) Implications of credit constraints on the formalisation of artisanal and small-scale mining (ASM) in sub-Saharan Africa. *J South Afr Inst Min Metall* 122(3):97–106
- Fisher E, Mwaipopo R, Mutagwaba W et al (2009) The ladder that sends Us to wealth: artisanal mining and poverty reduction in Tanzania. *Resour Policy* 34:32–38
- Grant AJ, Wilhelm C (2022) A flash in the pan? Agential constructivist perspectives on local content, governance, and the large-scale mining–artisanal and small-scale mining interface in West Africa. *Resour Policy* 77(April):1–11
- Hentschel T, Hruschka F, Priester M (2002) Global report on artisanal and small scale mining. International Institute for Environment and Development, London
- Hilson G (2007) What is wrong with the global support facility for small-scale mining? *Prog Dev Stud* 7(3):235–249
- Hilson G (2020) Formalization bubbles: a blueprint for sustainable artisanal and small-scale mining (ASM) in sub-Saharan Africa. *Extr Ind Soc* 7(Nov):1624–1638
- Hilson G, Ackah-Baidoo A (2011) Can microcredit services alleviate hardship in African small-scale mining communities? *World Dev* 39(7):1191–1203
- Hilson G, Gatsinzi A (2014) A rocky road ahead? Critical reflections on the futures of small-scale mining in sub-Saharan Africa. *Futures* 62(May):1–9
- Hilson G, Maconachie R (2017) Formalising artisanal and small-scale mining: insights, contestations and clarifications. *Area* 49(4):443–451
- Hilson G, Maconachie R (2020a) Artisanal and small-scale mining and the sustainable development goals: opportunities and new directions for sub-Saharan Africa. *Geoforum* 111(October):125–141
- Hilson G, Maconachie R (2020b) Entrepreneurship and innovation in Africa's artisanal and small-scale mining sector: developments and trajectories. *J Rural Stud* 76(3):150–163
- Hilson G, McQuilken J (2014) Four decades of support for artisanal and small-scale mining in sub-Saharan Africa: a critical review. *Extr Ind Soc* 1(1):104–118
- Hilson G, Hilson A, Machonachie R et al (2017) Artisanal and small-scale mining (ASM) in sub-Saharan Africa: reconceptualizing formalization and 'illegal' activity. *Geoforum* 83(2):80–90
- Hilson G, Zolnikov TR, Ortiz DR (2018) Formalizing artisanal gold mining under the Minamata convention: previewing the challenge in Sub-Saharan Africa. *Environ Sci Policy* 85(2):123–131
- Hilson G, Goumandakoye H, Diallo P (2019) Formalizing artisanal mining 'spaces' in rural sub-Saharan Africa: the case of Niger. *Land Use Policy* 80(October):259–268
- Hilson G, Sauerwein T, Owen J (2020) Large and artisanal scale mine development: the case for autonomous co-existence. *World Dev* 130(1):1–19
- Hilson G, Mandlane S, Hilson A et al (2021) Formalizing artisanal and small-scale mining in Mozambique: concerns, priorities and challenges. *Resour Policy* 71(Feb):1–15
- Hilson G, Bartels E, Hu Y (2022) Brick by brick, block by block: building a sustainable formalization strategy for small-scale gold mining in Ghana. *Environ Sci Policy* 135(September):207–225
- Hook A (2019) Fluid formalities: insights on small-scale gold mining dynamics, informal practices, and mining governance in Guyana. *Resour Policy* 62(May):324–338

- Hoskins JM (2025) 10 February) Understanding the real crisis behind illicit mining in South Africa. Cape Times INSERT THE URL, PAGE NUMBER AND DATE ACCESSED
- Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (2018) Global trends in artisanal and small-scale mining (ASM): a review of key numbers and issues. International Institute for Sustainable Development, Winnipeg
- Kamlongera PJ (2011) Making the poor 'poorer' or alleviating poverty? Artisanal mining livelihoods in rural Malawi. *J Int Dev*. <https://doi.org/10.1002/jid.1836>
- Katz-Lavigne S, Mkodzongi G, Nyandoro M (2024) Bandits' and machete gangs: the criminalization of artisanal and small-scale mining in the Democratic Republic of Congo and Zimbabwe. *Extr Ind Soc* 19(101504):1–12
- Kinyondo A, Huggins C (2020) Centres of excellence' for artisanal and small-scale gold mining in Tanzania: assumptions around artisanal entrepreneurship and formalization. *Extr Ind Soc* 7(2):758–766
- Kinyondo A, Huggins C (2021) State-led efforts to reduce environmental impacts of artisanal and small-scale mining in Tanzania: implications for fulfilment of the sustainable development goals. *Environ Sci Policy* 120(June):157–164
- Klein BI (2022) Local institutions and artisanal mining: governance forms in the goldfields of Madagascar. *J Rural Stud* 92(2):269–283
- Kumah R (2022) Artisanal and small-scale mining formalization challenges in Ghana: explaining grassroots perspectives. *Resour Policy* 79(102978):1–10
- Kumah C, Hilson G, Quacoe I (2020) Poverty, adaptation and vulnerability: an assessment of women's work in Ghana's artisanal gold mining sector. *Royal Geog Soc* 52(2):617–625
- Li S, Goerzen A (2024) Improving global value chain governance: empowering women through third-party interventions within institutionally fragile contexts. *J World Bus* 59(101533):1–19
- Mabhena C (2012) Mining with a 'vuvuzela': reconfiguring artisanal mining in Southern Zimbabwe and its implications to rural livelihoods. *J Contemp Afr Stud* 30(2):219–233
- Maconachie R, Conteh FM (2020) Artisanal mining and the rationalisation of informality: critical reflections from Liberia. *Canadian Journal of Development Studies / Revue canadienne d'études du développement* 41(3):432–449
- Makhetha E, Maliehe S (2020) A concealed economy?: artisanal diamond mining in Butha-Butha district, Lesotho. *Extr Ind Soc* 7(July):975–981
- Mamuse A, Mandaza EZ (2017) The role of training institutions in formalising artisanal and small-scale mining: paper presented at 11th Zimbabwe International Research Symposium – 16–17 February 2017. Midlands State University, Harare
- Mapisa MJ (2025) The Zama Zama gold rush in Southern Africa: an act of poverty alleviation, exploitation, or criminality? A case of South Africa. *Afr J Dev Stud* 15(2)
- Marin T, Seccatore J, De Tomi G, Veiga M (2016) Economic feasibility of responsible small-scale gold mining. *J Clean Prod* 129(April):531–536
- Marshall BG, Veiga MM (2017) Formalization of artisanal miners: stop the train, we need to get off! *Extr Ind Soc* 4(March):300–303
- Martinez G, Smith NM (2021) Formalization is just the beginning: analyzing post-formalization successes and challenges in Peru's small-scale gold mining sector. *Resour Policy* 74(October):1–10
- Martinez G, Smith NM, Veiga MM (2022) Voluntary gold certification programs: a viable mechanism for improving artisanal and small-scale mining in Peru? *J Rural Stud* 94(June):54–62
- Martinez G, Smith N, Malone A (2023) I am formal, what comes next? A proposed framework for achieving sustainable artisanal and small-scale mining formalization in Peru. *Extr Ind Soc* 13(101227):1–11
- Mawowa S (2013) The political economy of artisanal and small-scale gold mining in central Zimbabwe. *J South Afr Stud* 39(4):921–936
- Mensah L (2021) Legal pluralism in practice: critical reflections on the formalisation of artisanal and small-scale mining and customary land tenure in Ghana. *Extr Ind Soc* 8(4):1–29
- Mimba ME, Mbafor PUT, Fils SCN, Nforba MT (2023) Environmental impact of artisanal and small-scale gold mining in East Cameroon, Sub-Saharan Africa: an overview. *Ore Energy Resour Geol* 15(September):1–10
- Mineral Commission (2021) Mineral commission. <https://www.mincom.gov.gh/contact-us/>. Accessed 23 Jul 2025
- Mineros (2023) Sustainability report. Mineros S.A., Antioquia, Colombia. <https://www.mineros.com.co/news/mineros-announce-results-of-general-shareholders-assembly-2023>. Accessed 15 Apr 2025
- Mineros (2024) The company history. Mineros S.A., Antioquia, Colombia. <https://www.mineros.com.co/investors/financial-reports>. Accessed 15 Apr 2025
- Mkodzongi G (2023) Artisanal and small-scale gold mining and rural transformation in post-land reform Zimbabwe: a broad overview. *J Rural Stud* 100(2):1–7
- Mkodzongi G, Spiegel S (2019) Artisanal gold mining and farming: livelihood linkages and labour dynamics after land reforms in Zimbabwe. *J Dev Stud* 55(10):2145–2161
- Moeti T, Weir-Smith G, Mokhele T (2025) Illegal mining in the North west: examining hotspots and socio-economic risk. Spatial insights, 15 Edn. Human Sciences Research Council, Pretoria
- Moyo F, Ncube M, Ndlovu T (2022) The competing nature-based livelihood-strategies: artisanal small-scale mining (ASM) perspectives in agricultural-communities in Umzingwane District, Zimbabwe. *Afr J Public Adm Environ Stud* 1(2):171–199
- Musah BI (2025) The impact of artisanal small-scale mining on environmental sustainability: implications for the attainment of the sustainable development goals (SDGs) in Ghana. *Environ Sci Pollut Res* 32:15546–15573. <https://doi.org/10.1007/s11356-025-36668-x>
- National Council for Law Reporting (2024) The mining (Licence and Permit) regulations: legal notice 87 of 2017. Kenya Law, Nairobi
- Ngom NM, Mbaye M, Baratoux D et al (2022) Recent expansion of artisanal gold mining along the Bandama river (Côte d'Ivoire). *Int J Appl Earth Observ Geoinf* 112(June):1–16. <https://doi.org/10.1016/j.jag.2022.102873>
- Nyamunda T (2012) Navigating the hills and voluntary confinement: Magweja and the socio-economic and political negotiation for space in the diamond mining landscape of Chiadzwa in Zimbabwe, 2006–2009. *New Contree* 65(December):111–138
- Ofosu G, Sarpong D (2022) Mineral exhaustion, livelihoods and persistence of vulnerabilities in ASM settings. *J Rural Stud* 92(April):154–163
- Ondayo MA, Watts MJ, Mitchell CJ et al (2024) Review: artisanal gold mining in Africa—environmental pollution and human health implications. *Expo Health* 16(4):1067–1095. <https://doi.org/10.1007/s12403-023-00611-7>
- Osei L, Yeboah T (2023) Imagining a future from the pit: future aspirations of young artisanal-small scale miners in rural Northern Ghana. *Cogent Soc Sci* 9(2167316):1–15
- Otoijamun I, Kigozi M, Abdulraman SO et al (2021) Fostering the sustainability of artisanal and small-scale mining (ASM) of barite in Nasarawa State, Nigeria. *Sustainability* 13(2):1–23
- Pact (2015) A golden opportunity: scoping study of artisanal and small scale gold mining in Zimbabwe. Pact, Harare. INSERT THE DATE ACCESSED. <https://www.pactworld.org/library/golden-opportunity-artisanal-and-small-scale-gold-mining-zimbabwe>
- PanAfGeo (2022) Artisanal and small-scale mining handbook for Southern African region. European Geoscience for Society, Brussels

- Paschal M, Kauangal J (2025) Determinants of formalised mineral market outlet choice decision of artisanal and small-scale gold miners in Geita, Tanzania. *Resour Policy* 100(105441):1–9
- Paschal M, Kauangal J, Nuhu S (2024) The existing financial sources for artisanal and small-scale mining in mineral-rich countries in sub-Saharan Africa: a review. *Mineral Economics* 37:45–53. <https://doi.org/10.1007/s13563-023-00397-9>
- Rupprecht SM (2015) Needs analysis for capacity Building of artisanal miners in central Africa. University of Johannesburg, Johannesburg
- Rushemuka MN, Cote M (2024) Artisanal and small-scale mining through a labour regime lens: consolidating a research agenda on labour exploitation. *J Rural Stud* 105(December):1–11
- Seeletsa M (2025), 18 March Illegal mining: more than R30m spent on police operations at Stilfontein. *The Citizen*. <https://www.citizen.co.za/news/stilfontein-illegal-mining-police-operation-vala-umgodi/>. INSERT THE DATE ACCESSED
- Semberya D (2025), 11 May Untaxed, underground: the high cost of gold smuggling, illicit trade. *The Guardian* <https://www.ipmedia.com/the-guardian/features/read/untaxed-underground-the-high-cost-of-gold-smuggling-illicit-trade-2025-05-10-095619>. INSERT THE DATE ACCESSED
- Siegel S, Veiga MM (2009) Artisanal and small-scale mining as an extra-legal economy: de Soto and the redefinition of formalization. *Resour Policy* 34(1):51–56
- Sinding K (2025) Artisanal mining policy development. *Mineral Economics* 38:461–471. <https://doi.org/10.1007/s13563-025-00497-8>
- Siwale A, Siwale T (2017) Has the promise of formalizing artisanal and small-scale mining (ASM) failed? The case of Zambia. *Extr Ind Soc* 4(Jan):191–201
- Smith NM (2019) Our gold is dirty, but we want to improve: challenges to addressing mercury use in artisanal and small-scale gold mining in Peru. *J Clean Prod* 222(March):646–654
- South African Government (2002) Mineral and Petroleum Resources Development Act 28 of 2002. South African Government, Cape Town
- South African Government (2008) Mineral and Petroleum Resources Development Amendment Act 49 of 2008. South African Government, Cape Town
- Spiegel SJ (2009) Labour challenges and mercury management at gold mills in Zimbabwe: examining production processes and proposals for change. *Nat Resour Forum* 33(3):221–232
- Spiegel SJ (2012) Microfinance services, poverty and artisanal mine-workers in Africa: in search of measures for empowering vulnerable groups. *J Int Dev* 24(May):485–517
- Spiegel SJ (2014) Legacies of a nationwide crackdown in Zimbabwe: operation chikorokoza chapera in gold. *J Mod Afr Stud* 52(4):541–570
- Spiegel SJ (2017) EIAs, power and political ecology: situating resource struggles and the techno-politics of small-scale mining. *Geoforum* 87(October):95–107
- Tarra JA, Restrepo OJ, Veiga MM (2022) Coexistence between conventional alluvial mining and artisanal mining to deal with problems associated with informality in the lower Nechí river Basin-Colombia. *Resour Policy* 78(102821):1–8. <https://doi.org/10.1016/j.resourpol.2022.102821>
- Teku D (2025) Geo-environmental and socio-economic impacts of artisanal and small-scale mining in Ethiopia: challenges, opportunities, and sustainable solutions. *Front Environ Sci* 13(1505202):1–16
- Teschner B, Smith NM, Borrillo-Hutter T et al (2017) How efficient are they really? A simple testing method of small-scale gold miners' gravity separation systems. *Min Eng* 105(1):44–51
- Transparency International (2025) CPI 2024 for sub-Saharan Africa. Transparency International, Brussels
- Traoré M, Hilson G, Hilson A (2024) Reimagining entrepreneurship in the artisanal and small-scale mining sector: fresh insights from sub-Saharan Africa. *Africa Journal of Management* 10(2):176–207
- Tschakert P (2009) Digging deep for justice: a radical re-imagination of the artisanal gold mining sector in Ghana. *Antipode* 41(4):706–740
- United Nations Economic Commission for Africa (2002) Compendium in bestpractices in small-scale mining in Africa. United Nations Economic Commission for Africa, Ethiopia
- United Nations Environmental Program (2020) Sustainability reporting in the mining sector. United Nations, Washington
- United Nations Environmental Programme (2012) Analysis of formalization approaches in the artisanal and small-scale gold mining sector based on experiences in Ecuador, Mongolia, Peru, Tanzania and Uganda. United Nations, Geneva
- Van Bockstael S (2014) The persistence of informality: perspectives on the future of artisanal mining in Liberia. *Futures* 62(Feb):10–20
- Veiga MM, Marshall BG (2019) The Colombian artisanal mining sector: formalization is a heavy burden. *Extr Ind Soc* 6:223–228
- Verbrugge B, Besmanos B (2016) Formalizing artisanal and small-scale mining: whither the workforce? *Resour Policy* 47(March):134–141
- World Bank (2023) State of the artisanal and small-scale mining sector. World Bank Group, Washington, D.C
- World Bank (2020) Building centers of excellence in Africa to address regional development challenges. World Bank Group, Washington, D.C.
- World Bank (2024) Achieving sustainable and inclusive artisanal and small-scale mining (ASM): a renewed framework for world bank engagement. World Bank Group, Washington, D.C.
- Yingi E, Chitongo L (2021) Governance and politics of small-scale artisanal gold mining in Zimbabwe. *J Public Admin Dev Alt* 6(1):28–42
- Yu M, Wang Y, Umair M (2024) Minor mining, major influence: economic implications and policy challenges of artisanal gold mining. *Resour Policy* 91(September):1–11
- Zvarivadza T (2018) Artisanal and small-scale mining as a challenge and possible contributor to sustainable development. *Resour Policy* 56(1):48–58

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.