Sustainable Development in the Artisanal and Small-Scale Mining Industry: An Organizational Level Perspective

Abstract

Several researchers and civil society groups working in the Artisanal and Small-Scale Mining (ASM) industry acknowledge the complexity of this economic activity. ASM is described by some as a poverty-driven, economically irrational, and disorganized activity characterised by complex organizational models. Limited progress from several decades of research and civil society interventions in ASM confirms this complexity and hence warrants adoption of a systems thinking approach. In this study we examine possibilities for ASM sustainability using systems science. We use interview data and archival data to model the organizational level system of ASM. Leverage points at the organizational level appear as access to capital, access to technology and education and skills development. Enhanced access to capital enables exploration which can lengthen mine life hance more localised activity. Localised activity results in less spread of negative environmental and social impacts. Successful implementation of appropriate policies further involves several field and societal level factors.

Introduction

The mining industry has abundant leverage points as well as the potential to contribute to all the 17 United Nations Sustainable Development Goals (SDGs) (de Haan, 2021). Significant efforts have been made, to date, to mitigate the negative impacts of mining and enhance its positive contributions, especially by large scale mining (LSM) houses. Nonetheless, a lot remains to be done in areas where ASM operate (Hennessy, 2015). ASM is an economic activity involving millions of people from low-income economies. ASM actors exploit mineral resources in a substantially informal way (Hilson & Hilson, 2015). About 40 million people are directly involved in ASM in over 80 countries while an additional 120 to 280 million people benefit indirectly from ASM for their livelihoods (de Haan, 2021). Since ASM is labor-intensive in nature, the industry employs 80% of the total global mining labor force. ASM also contributes 15 to 20% of total global mineral output (Buxton, 2013). Nevertheless, the ASM industry is responsible for widespread negative environmental, social, and economic impacts (Rustad *et al*., 2016; Smith, 2019; Spiegel, 2012). Poorly managed, ASM often results in environmental degradation, worsening economic and social inequality, population displacement, armed conflicts, gender-based violence, corruption, tax evasion, increased health risks, land and water pollution and human rights violations (Columbia Center on Sustainable Investment, 2016; Hilson & Maconachie, 2020; Spiegel, 2015). Despite a lot of research spanning over two decades, sustainable development is yet to be realized in ASM.

Two decades of research on how to balance the positive and negative impacts of ASM have achieved limited success (Siwale & Siwale, 2017). Past studies show that several approaches have been tried in a bid to make ASM sustainable (Fold *et al*., 2014; Hilson *et al*., 2018; Spiegel, 2012, 2015; Verbrugge & Besmanos, 2016). Most of these approaches follow a path called formalization. Formalization, from a broader view, is the registering, organizing and tracing of mining operations in the field (Heemskerk, 2005). Nonetheless, various formalization approaches created by civil society organizations, government agencies and ASM actors resulted in the emergence of several, conflicting sets of guiding principles in ASM. Extant research on sustainability in the ASM industry now questions the formalization approach. For example, Siwale and Siwale (2017: 191) asks, 'has the promise of formalizing ASM failed?' ASM is also characterized by a paucity of appropriate legal structures and under resourced regulators which negatively affects efforts to make the industry sustainable. Hinton et al. (2003) argue that the success of ASM as a sustainable industry hinge on the adoption of holistic approaches that involve aspects such as technical training and community development initiatives. Merket (2018) further describes ASM as a sector governed by complex organizational models. A holistic approach to the ASM sustainability challenge seems to be outstanding in available ASM literature. We further argue that the complexity of ASM qualifies it to be a wicked problem which requires examination through systems science (Grewatsch et al., 2021). We proceed to fill this gap by applying systems science to answer the question, 'How can sustainability outcomes be achieved in an institutionally complex environment?' We limit our study to the organizational or actor level of the ASM industry.

First, we highlight the complexity of the ASM industry using the Zimbabwean ASM case and develop respective hypotheses. Second, we develop systems thinking models informed by interview and archival data. Our research yields systems thinking models that show leverage points for sustainable development in ASM. Finally, we discuss how our study results can be implemented to promote sustainability in ASM.

Background and Literature Review

Different countries have different definitions for ASM. Zvarivadza (2018: 50) defines ASM as 'the exploitation of marginal ore deposits, which are not profitable to mine on a large scale, through both informal and formal channels using rudimentary tools. Many countries consider ASM to be a combination of two categories namely artisanal mining and small-scale mining. Artisanal mining is informal, labor intensive and low tech while small-scale mining is formal but still low tech and labor intensive (Chakravorty, 2001). Commodities with a ready market, high value, portability and low cost transportation such as gold and diamonds are the most mined in ASM (Zvarivadza, 2018). ASM actors normally work in pairs or small groups of up to twenty individuals who could be from the same family. Women comprise a sizable portion of ASM actors even though they might not go underground into the mines. Women are usually involved in the processing of mined ore as well as service provision such as retailing of food and clothes.

ASM actors individually acquire mining rights or informally engage in mining with an individual income generating objective. These actors have less interest in social or environmental sustainability (Bansah, 2019). ASM practices involve targeting of easy to mine, high value minerals such that actors shift from one area to another leaving behind a trail of environmental damage (O'Faircheallaigh & Corbett, 2016). In addition, several social ills such as poor sanitation, substance abuse, child labor and sexual violence against women are associated with ASM activities (Buxton, 2013b; Rustad et al., 2016).

Informal ASM often poses the greatest threat to environmental and social sustainability. Informal ASM does not consider mine planning activities such as excavation of access ways, rock breakage, material handling, ventilation, water management and general safety considerations (Rupprecht, 2015). However, formal ASM also becomes a threat to sustainability when weak regulation is in place. Weak regulation often arises through the conversion of ASM into a political establishment in which political figures allow informal behavior in exchange for personal gain. Politicians and regulators often collect bribes or allow environmental damage and social ills in exchange for wider access to mineral resources (Zvarivadza, 2018).

A few leverage points on how to make ASM sustainable are documented. Opportunities related to the organizational or actor level of ASM include improved access to finance, technical training and education and access to technology. Access to finance is critical for ASM since this industry is poverty driven (Verbrugge, 2014). Rupprecht (2015) indicates that provision of technical capacity to ASM is imperative for efficiency through elimination of wasteful extraction and processing methods. Improvement of mining methods also minimizes environmental damage. ASM centers with facilities such as schools, hospitals and social structures can be established to promote education and training as well as improved social well-being of ASM communities. A well-documented example is the Shamva mining center in Zimbabwe which however, later collapsed due to mismanagement (Dreschler, 2001).

Field level opportunities include formation of cooperatives or joint ventures among ASM actors. Joint ventures improve ASM level of organization and eases the pooling together of resources thereby enabling miners to acquire necessary equipment (Zvarivadza & Neingo, 2015). Collaboration between ASM and LSM is a viable opportunity for a more sustainable ASM industry. An example is the tribute system between ASM and LSM in the chrome industry in Zimbabwe. Sharing of experiences through networking among ASM members is a possible opportunity that can be harnessed at the field level. Centers of excellence are a possible means for economic development in ASM. Through centers of excellence ASM actors are able to receive training, acquire geological information, access loans, rent equipment but these centers must be financially sustainable (Kinyondo & Huggins, 2020).

Societal level opportunities involve first, recognizing the ASM sector as a livelihood and subsequent liberalization of ASM (Hentschel et al., 2002). The bureaucratic and cumbersome nature of ASM registration is a huge hindrance to formal ASM operation (Mohammed Banchirigah, 2006; Nyame & Blocher, 2010; Rupprecht, 2015). Hence adopting a non-bureaucratic and decentralized registration process can promote formal operation of ASM. Second, access to competitive markets and legally protected free trade is a necessity (Pedro, 2006). Third, further beneficiation and value addition of minerals through downstream industrial processes such as jewelry manufacture are key for overall societal prosperity. Fourth, stamping out corruption in governments is critical for sustainability in ASM. For example, Kelly et al., (2014) highlight how corruption and nepotism are key social ills driving informality and discrimination against women in Kivu, DRC.

Method

We collected views of ASM stakeholders through 6 focus group discussions and 13 key informant interviews done with ASM actors, government agents and civil society representatives between the years 2018 and 2019. To supplement the interview data, we used archival data from 5 databases namely Delve, MapX, EITI Data, artisanalmining.org and the African Minerals Geoscience Initiative. The study also involved review of policy documents and reports by developmental organizations as well as insights from academic papers. Using this information, we proceeded to develop a systems dynamics model in Vensim software. We ran the model and tested the behavior of sustainability outcomes under ideal organizational level factors. We followed the Problem Hypothesis Analysis Policy and Implementation approach in designing our study.

Problem

The problem that ASM policy makers, civil society groups and researchers face is how to balance the positive and negative impacts of ASM. How can the negative impacts be minimized while enhancing the positive impacts? Since the positive impacts revolve around economic benefits such as poverty alleviation, we took financial performance as the outcome variable to be enhanced. Second, since the negative impacts are concentrated on the society and the environment, we took societal ills and environmental damage as two outcome variables to be minimized. We then proceeded to model the activities of a single formal ASM actor and link their resultant effects on the three variables of financial performance, social ills, and environmental damage.

We limited our investigation to the organizational or actor level of ASM. Thus, our model boundary excludes prevailing legal, regulatory, and social contextual factors that may affect the operations of an ASM actor. In addition, we modelled the life of a formal ASM actor leaving out the informal component of ASM. Our model includes, however, the economic and technical needs that an ASM actor faces to operate. The economic need is access to capital which determines many other aspects like ability to explore for mineral resources and ability to employ skilled labor. The technical aspects include the rate of finding mineral reserves, and access to technology and equipment.

Hypotheses

Our hypothesis (Figure 1) reflects the relationship between the outcome sustainability variables (financial performance, social ills, and environmental damage) and the operating factors at ASM organizational level (access to capital, access to equipment and technology, employee education and skills level).

Dynamic hypothesis: ASM access to capital is positively related to increased rate of finding new mineral reserves. The rate of finding new mineral reserves and workforce skills and education both contribute to ASM increased financial performance, decreased social ills, and decreased environmental damage.

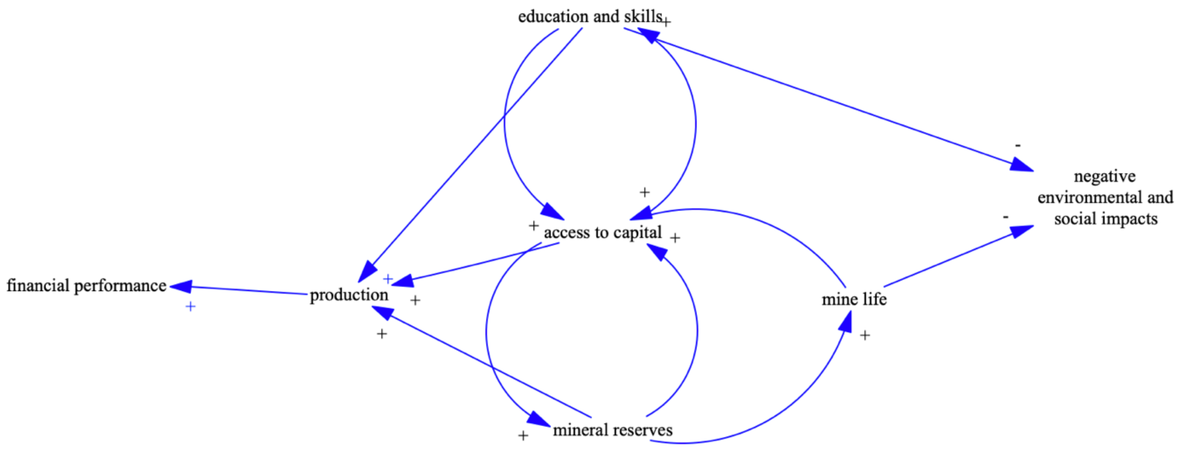

Figure 1: Dynamic hypothesis showing the relationship between organizational level ASM factors and outcome sustainability variables

Analysis

The pivotal point of activity in the operations of an ASM actor is production. From production several interconnections with various other system elements develop until we finally have resultant impacts on economic (financial performance), environmental (environmental damage) and social (social ills) dimensions of sustainability. Changes in ASM production can either increase or decrease financial, environmental, and social impacts of ASM. The analysis done in this section explains all the relationships depicted in Figure 2.

An increase in ASM production results in an increase in demand for mining equipment fixed costs. Coupled with mining equipment per tonne of production, a higher demand for mining equipment fixed cost increases available fixed cost for mining equipment. This combination increases overall fixed costs which in turn lowers financial performance. On the other hand, increased ASM production increases revenue which in turn directly increases financial performance while simultaneously increasing the effect of revenue on access to capital. An increase in revenue results from a concurrent increase in both production and mineral price. The effect of revenue on access to capital is however, also influenced by the elasticity of revenue on access to capital and baseline revenue. Baseline revenue increases depending on the initial ASM production and baseline mineral price. Baseline mineral price also affects mineral price.

Mineral price is influenced by the effect of supply on mineral price. A higher effect of supply on mineral price results in a higher mineral price. In turn an increase in the effect of supply on mineral price follows an increased initial ASM production. However, an increase in ASM production results in a decrease in the effect of supply on mineral price.

Higher access to capital results in higher available fixed costs for mineral exploration. Though a higher available fixed cost for mineral exploration increases overall fixed costs, it also increases the rate of finding mineral reserves. An increased the rate of finding mineral reserves results in a change in available mineral reserves. When mineral reserves are low, there is an increase in demand for mineral exploration. This demand for mineral exploration also increases as expected mineral exploration rate and initial mineral reserves increase. Higher demand for mineral exploration and higher exploration cost per tonne increase available fixed cost for mineral exploration.

Amount of mineral reserves affects access to capital and mine life. An increase in mineral reserves increases the effect of mineral reserves on access to capital. At the same time a higher initial amount of mineral reserves reduces the effect of mineral reserves on access to capital. A higher effect of mineral reserves on access to capital results in increased access to capital. Increased access to capital also increases available fixed cost for mining equipment.

A higher amount of mineral reserves cause ASM actors to remain fixed on a particular location thereby minimizing the spread of negative social and environmental impacts. Mineral reserves achieve this positive development by extending mine life. Hence a higher amount of mineral reserves results in a lower effect of mine life on environmental damage and social ills. Initial mineral reserves also affect mine life such that a higher amount of initial mineral reserves results in a lower effect of mine life on both environmental damage and social ills.

Higher wage per person per month increases variable costs. At the same time an increase in ASM production increases variable costs. However, higher production per person decreases variable costs. In the end an increase in variable costs results in a decrease in financial performance. Higher wage per person on the other hand attracts higher workforce skills and educational level. However, a higher baseline wage per person per month results in a low incentive for workers to invest in education and skills development. Higher workforce skills level results in a decrease in social ills. At the same time a higher effect of mine life on social ills results in increased social ills. Increased social ills are also a result of an increase in the expected social ills. Expected social ills increase when there is an increase in social ills per environmental damage as well as an increase in environmental damage.

Environmental damage is a result of ASM production, impact per tonne and the effect of mine life on environmental damage. As the effect of mine life on environmental damage increases, environmental damage also increases. This happens since reduced mine life means nomadic ASM behavior which results in the spread of environmental damage. Increased production results in increased environmental damage due to enlargement of mining footprint. In the same way, a higher impact per tonne results in increased environmental damage. However, higher impact per tonne is a result of higher baseline impact per tonne and higher initial ASM production.

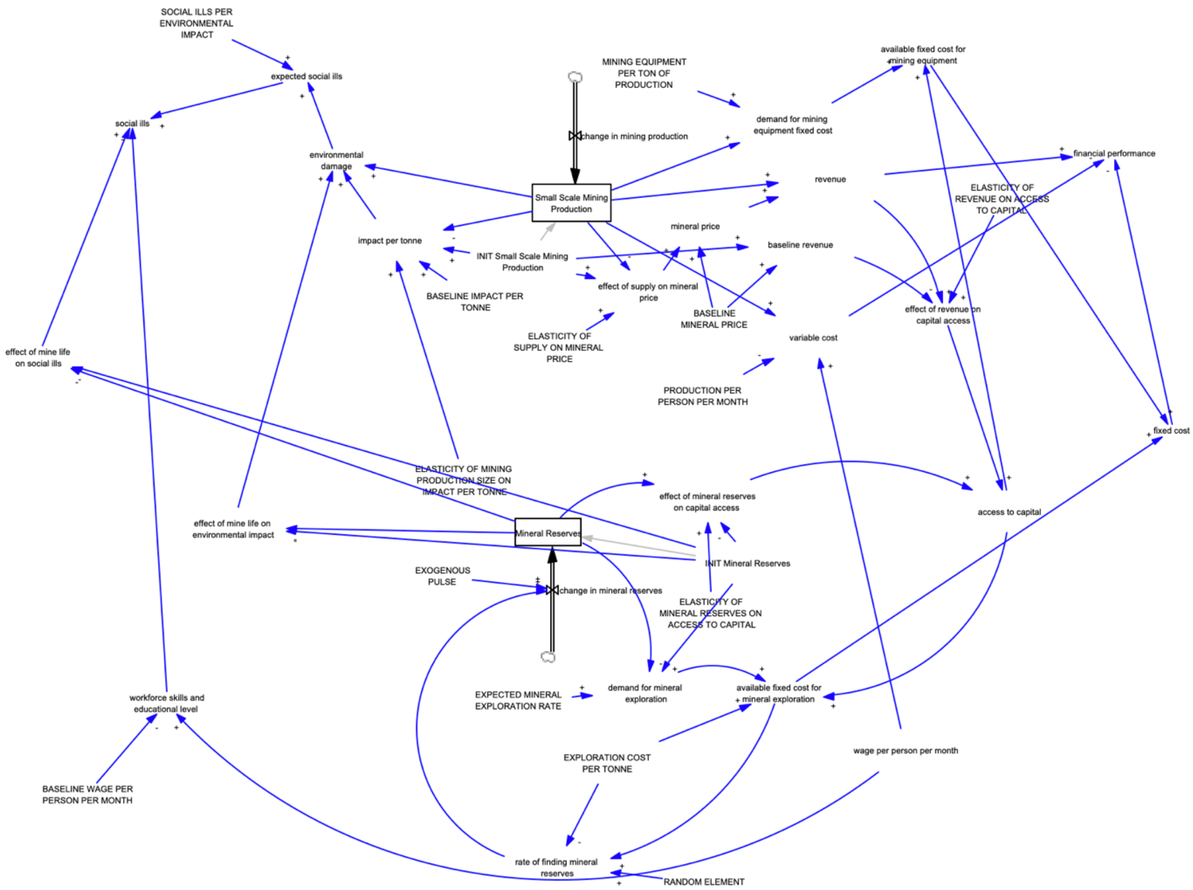

Figure 2: Analysis of the organizational level factors that make up the ASM operation. Elements shown are based on interview and archival data. Analysis excludes field and societal level factors.

Policy

According to Figure 3, the ASM sector has potential for sustainable development. In an ideal situation, following up to at least 20 months of initial ASM production, financial performance can start to increase while environmental and social damage decrease. Hence, the three outcome variables that we were testing have potential for positive response to sustainability efforts given an enabling set of factors. As shown in Figure 4, a higher workforce skills level and an improving rate of finding mineral reserves is the condition necessary for the desired behavior of Figure 3 to be realized. In addition, Hidrón and Koepke (2014) highlight that several social ills such as women abuse, and child labor are better addressed through education and training. Hence education and training are not only necessary for mineral extraction efficiency but also to reduce social ills. However, both the higher skills and educational level as well as the higher rate of finding mineral reserves depend on access to capital.

Since availability of capital is an inherent problem in ASM, policy interventions for ASM should aim at improving access to capital. Capital for ASM can be accessible through government loans, private business loans or various schemes from civil society groups (Verbrugge, 2014). Alternatively, policy measures aimed at directly addressing mineral exploration and education and training can achieve the same results. Governments in ASM countries can conduct state funded exploration and then release explored mineral reserves to ASM actors who can then pay back over the production period. Governments can also use existing educational infrastructure to train ASM actors at subsidized fees.

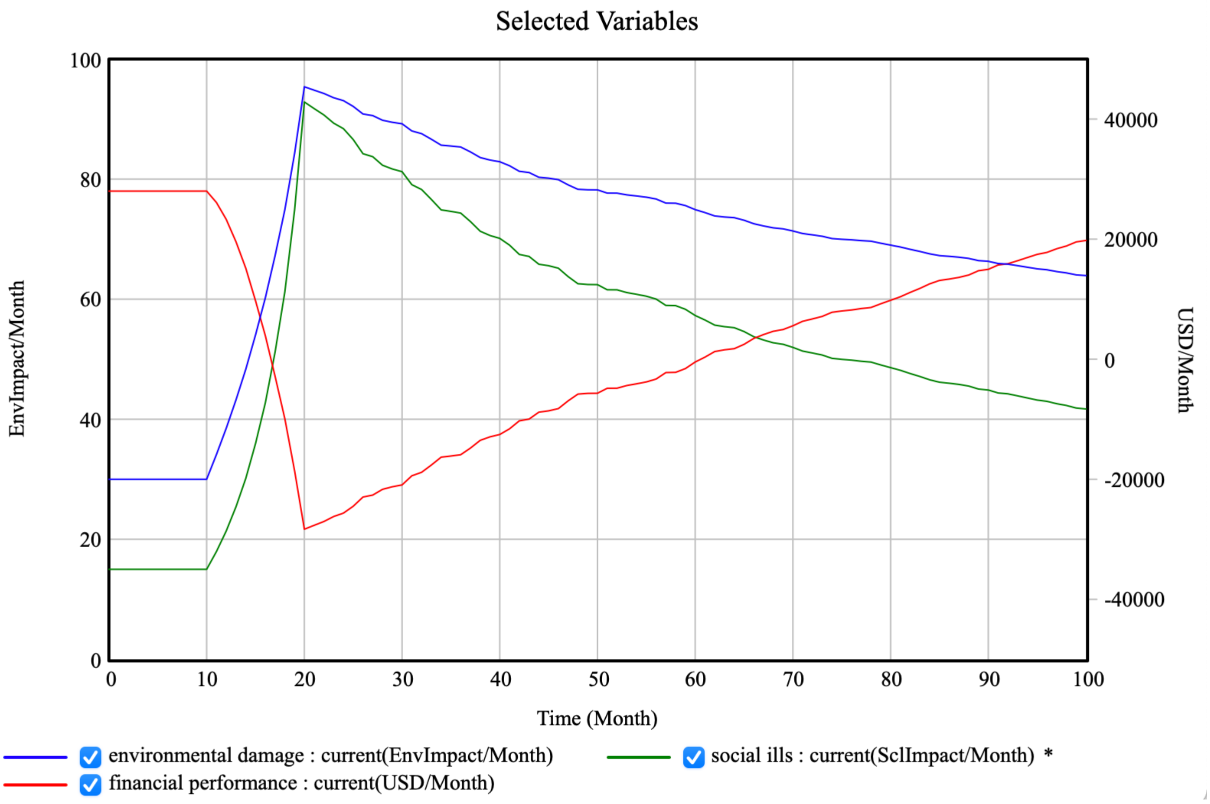

Figure 3: Outcome ASM sustainability variables showing the potential that ASM possesses to operate sustainably given the conducive environment and enabling factors indicated in Figure 4.

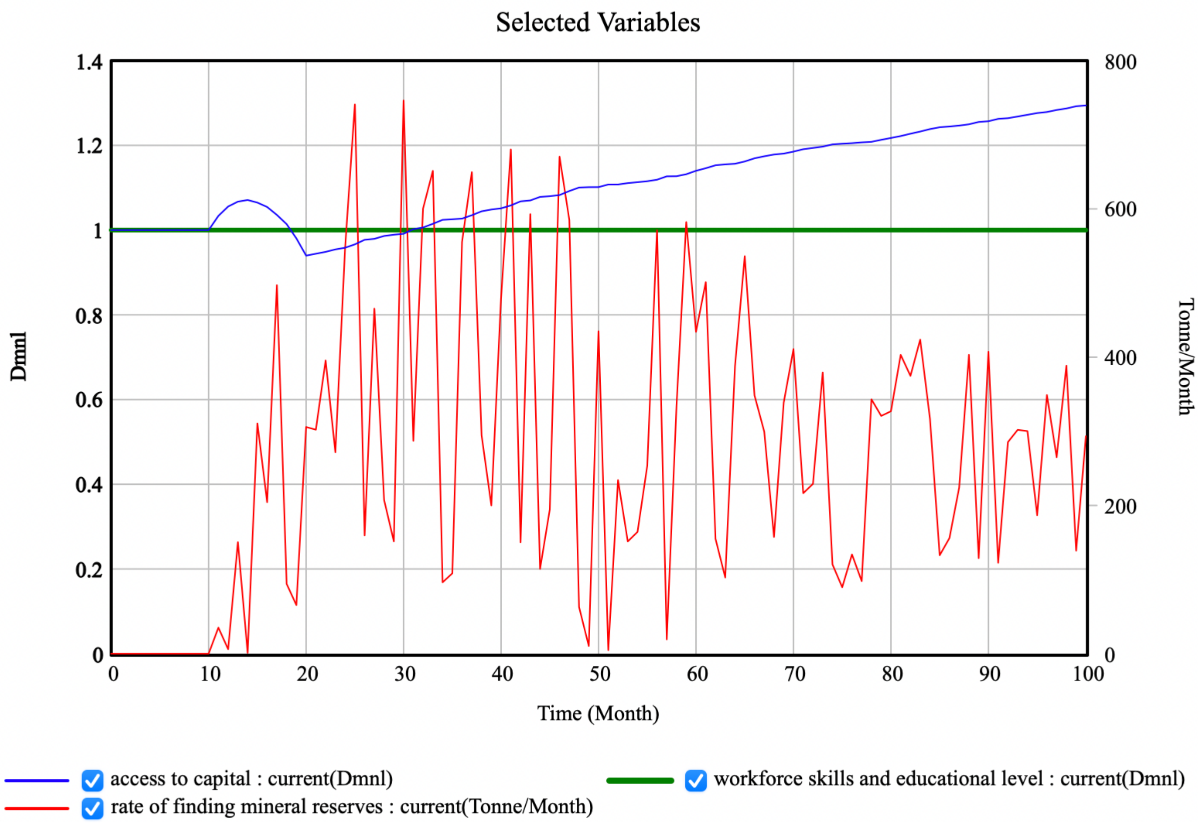

Figure 4: Requirements for a sustainable ASM scenario with outcomes shown in Figure 3. Access to capital, high level of skills and education resulting in an improving rate of finding mineral reserves.

Implementation

The approaches discussed in this paper can be successfully implemented alongside an array of enabling factors such as stable policies, government capacity building, a peaceful political environment and organized ASM actors. The institutional environment must not allow for social ills that might impede implementation of recommended policy actions. Most common challenges that interfere with implementation include corruption, nepotism and many underhand dealings (Kelly et al., 2014). Field level opportunities necessary for successful implementation include formation of ASM joint ventures, collaborations between ASM and

LSM and establishment of centres of excellence (Zvarivadza, 2018). Societal level opportunities to be exploited for a successful ASM sustainability agenda include recognition of ASM by both governments and civil society, easing registration procedures, promoting beneficiation and value addition, and stamping out corruption.

Conclusion

Converting ASM into a sustainable economic sector is possible through a few leverage points at the organizational level. Leverage points include access to capital, access to equipment, and education and training. The three leverage points result in increased rate of finding mineral reserves. Once mineral reserves are ascertained, ASM actors stop moving from place to place leaving a trail of environmental and social damage. In other words, more mineral reserves result in a longer mine life. A longer mine life and improved skills and education result in less environmental damage and social ills. Successful implementation of appropriate policies depends on a conducive political, economic, and social environment. The analysis done in this paper however, remained at the organizational or ASM actor level thereby leaving room for further research that tackles multiple levels of the ASM sustainability case.

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