



Concepts and Strategies for the Designation and Management of ASM zones

A Contribution to the Formalization of the ASM Sector

Imprint

Commissioned by: Bundesanstalt für Geowissenschaften und Rohstoffe
(Federal Institute for Geosciences and Natural Resources)
Stilleweg 2
30655 Hannover
Germany

Author: Dr. Klaus Steinmüller

Contact: Dr. Klaus Steinmüller
Bundesanstalt für Geowissenschaften und Rohstoffe
Stilleweg 2
30655 Hannover
mineralische-rohstoffe@bgr.de

Date: March 2017

ISBN: 978-3-943566-82-6 (PDF)

Cover

Photographs: © Mine adit, Cooperative Coodmilla, Colombia (left)
© Waste rock disposal, Cooperative Coodmilla, Colombia (middle)
© Mineral processing plant, Cooperative Coodmilla, Colombia (right)

Copyright: © 2017 Bundesanstalt für Geowissenschaften und Rohstoffe

Concepts and Strategies for the Designation and Management of ASM zones

A Contribution to the Formalization of the ASM Sector

By Dr. Klaus Steinmüller

Hannover, March 2017



Content

- 0 Executive Summary 4
- 1 Introduction to ASM..... 5
- 2 ASM zones 8
 - 2.1 Historic review..... 8
 - 2.2 Advantages and challenges of delineating “ASM zones” 9
- 3. Designation and Management of ASM zones 12
- 4. Designation Phase 13
 - 4.1 Identification and delineation of “ASM zones” 13
 - 4.2 Estimation of resources and economics of “ASM zones” 16
 - 4.3 Conceptual environmental/social and health & safety planning..... 21
 - 4.4 Summary, time and costs of the Designation Phase 26
- 5. Implementation Phase 28
 - 5.1 Licensing and permitting 28
 - 5.2 Elaboration of the mine, environmental/social, OHS and closure plans 30
 - 5.3 Summary, time and costs of the Implementation Phase..... 33
- 6. Management Phase 33
 - 6.1 Supervision of ASM 33
 - 6.2 Support to ASM..... 35
 - 6.3 Summary, time and costs of the Management Phase 38
- 7. Conclusions and Recommendations..... 40
- 8. References..... 41

0 Executive Summary

In numerous developing countries, artisanal and small-scale mining (ASM) generates considerable economic and social benefit, not only restricted to the revenues from resource extraction, but also encompassing added value and employment, from the mine through to the export of the products.

At the same time, however, ASM is often accompanied by damage to the environment, large numbers of accidents, risks to health and human rights violations. Against this situation, the way that governments deal with ASM is often reactive.

Nevertheless, for governments there is a range of realistic options for proactive actions that can reduce the risks associated with this type of mining, focusing on the formalization of ASM. One of the options to assist the formalization of ASM is to allocate land with mineral potential, the so called “ASM zones” to the ASM sector.

The idea behind ASM zones, meaning to provide prospective ground to the ASM sector is not new, it appeared first in the early 1990s. To date, numerous countries pursue the idea to establish specific “ASM zones” and in some countries the concept of establishing ASM zones is already prescribed in the mining law.

With the establishment of ASM zones, governments expect to enable a better supervision and administration of ASM and to prevent conflicts with large scale mining (LSM), as their mineral rights often overlap and reduce workable land for ASM.

In theory, the idea of “ASM zones”, which have mineral potential or even established resources for ASM operations, would provide a proper basis for the formalization and regulation of the sector as well as an improved operation, environmental, social and closure planning within that area.

Yet, this kind of zone comes at a cost and governments, industrial mining companies and the donor community have to commit financial and human resources to establish and manage “ASM zones”.

The present document provides a practical way on how to identify, delineate, establish and manage ASM zones, which are amenable for the development of ASM mining operations. Further, the time requirements and financial implications for governments, industrial mining companies as well as the donor and research community will be discussed.

1 Introduction to ASM

Artisanal and Small-Scale Mining (ASM) is a very complex economic phenomenon, which has many facets and is taking place worldwide in a great number of different social and cultural environments, particularly in developing countries (Hruschka & Echavarria, 2011).

Numerous efforts have been made to find an internationally applicable definition for ASM. All attempts to globally define ASM based on common features used to distinguish industrial mining operations such as type of mining, production capacity, level of investment, number of miners etc. have failed to describe ASM adequately. However, on a country basis, mainly for the purpose of regulation, the ASM sector is often defined based on production capacity and/or the size of mining rights. This is, for example, the case in Ghana, Ecuador, Mexico, Mongolia, Peru, Philippines and Zambia.

Generally, ASM comprises all types of mining operations, non-mechanized or mechanized, that do not represent conventional industrial mining enterprises. ASM takes place mostly in rural areas and their operations may be formal or informal. The operations can be described as low-technology and labor-intensive mineral extraction and processing activities, which exploit most existing commodities, including coal and construction materials (Sterbik et al., 2015).

It is estimated that around 20 million people are engaged directly in ASM and that it provides livelihoods for additional 100 million people in at least 70 countries (Hentschel et al., 2003; Hilson & McQuilken, 2014; Sterbik et al., 2015). Therefore, ASM is seen as an activity which contributes substantially to poverty reduction, particularly in rural areas of developing countries (Hentschel et al., 2002).

But very often, the positive impact of ASM on poverty alleviation is undermined by serious health, environmental and social problems which are associated with ASM. Vast degradation of landscapes and deforestation, widespread mercury pollution as well as hazardous working and unhygienic living conditions are the most prominent impacts. In addition, ASM can be associated with child labor, human rights violations and illegal trading and smuggling activities.

The improvement of the livelihoods and purchasing power greatly benefits the miners and their families as well as the local economy, but the costs for the remediation of the resulting environmental and social impacts are a burden for the whole economy of the country where ASM is taking place.

ASM appeared on the development agenda about 40 years ago. As the understanding of ASM increased through time, the perception and the support towards ASM have changed (Hentschel et al., 2003; Garrett, 2013; Hilson & McQuilken, 2014). In Table 1 a summary of the development of ASM and the support approaches during the past 40 years are shown. The information stated in Table 1 is mainly compiled from the above references. Additionally, information was taken from Baumann (1986).

Table 1: Summary of the development stages of ASM sector during the past 40 years

Period	Events	Perception of ASM	Activities related to ASM
1970s	First International Conference on ASM in Mexico		Definition of ASM
1980s	Implementation of Structural Adjustment Programs (SAPs) of the World Bank; number of humans engaged in ASM	ASM mainly considered as entrepreneurship	Technological driven projects by donors and state-sponsored buying schemes

	increased due to bankruptcy of state mining companies and heavy retrenchment		
Early 1990s	Implementation of integrated Rural Development Projects, but ASM not included alongside with agriculture	Emerging livelihood vision of ASM	Technology orientated projects, focusing on improving ASM operations
Mid to late 1990s	Support mainly to the large scale mining (LSM) industry; drafting of new mining legislations; through licensing systems aimed at LSM, unregistered ASM became illegal	Livelihood vision of ASM recognized	Formalization and regulation of ASM, introduction of separate legal categories for ASM into new mining legislation, relation between large scale mining (LSM) and ASM
2000s	ASM more and more included in Poverty Reduction Strategy Papers (PRSP) of countries; number of humans engaged in ASM further increased due to privatization of state mining companies and the financial crises; foundation and demise of the Communities and Small Scale Mining (CASM) initiative; foundation of the Alliance for Responsible Mining (ARM)	ASM regarded as a development issue, considering not only technical matters and economic growth, but also environmental impact, human rights, child labour and sustainable livelihoods	Formalization and regulation of ASM, technical assistance focused on managing environmental and social impacts of ASM, improvement of market access for ASM through supply chain initiatives (Fairtrade/ Fairmined standards for precious metals from ASM, chain of custody control through the OECD Guidance and other standards (LBMA, RJC, etc.))

According to the above table, the assistance for and research on the ASM sector, mainly driven by bilateral and multilateral donors as well as NGOs, have contributed to an increasing awareness of the phenomenon ASM.

Governments have recognized ASM as a generator of rural livelihoods, policymakers have begun to integrate ASM in development plans and mining authorities have recognized the economic potential of ASM and drafted special legislation for this sector. In addition, this support has encouraged some governments to create special units for ASM, which are now able to better plan, control and manage the sector. Lastly, the ASM sector itself has benefited and is slowly improving its technical, economic and social situation.

However, it has to be noted that the assistance given to ASM has often been only stand alone and disconnected from integral development programs, particular in rural areas where ASM is taking place. In addition, through the years it has often been seen that the support for ASM was mainly donor and NGO driven. As long as the donor and/or NGO worked together with the government, the ASM sector received attention. However, as soon as the donor/NGO support ceased, the necessary governmental attention towards ASM was waning. One of the reason that governments are more interested in large scale mining (LSM), is that they tend to be easier to regulate and manage and in addition, bring more royalty income and taxes to the national economy.

Although governments nowadays have accepted that the sector has to be dealt with and have made attempts to provide facilitating environments for ASM, there is still insufficient knowledge on how they should approach and manage the sector. Particularly, the following issues remain to be adequately addressed:

- ✓ Easily understandable legislation and regulations
- ✓ Uncomplicated permitting and licensing
- ✓ Access to prospective land and resources
- ✓ Access to capital
- ✓ Knowledge to organize, start and manage a small mining business
- ✓ Knowledge of health, safety, environmental and social issues in mining
- ✓ Access to sanitation, public health care, power supply and education

In an attempt to guide governments that are confronted with ASM in their countries, the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF)¹, recently developed the “Guidance for Governments on Managing Artisanal and Small-scale Mining”. The ASM guidance complements other guidance tools elaborated in the IGF context, notably the Mining Policy Framework.

Although the guidance is regarded by some ASM experts as very general and too simplistic, this document delivers for the first time a holistic methodology for governments on how to develop and implement a management strategy for the ASM sector. Most of the document contents are not new, but the concepts presented therein integrate the ASM strategies and management fragments available from selected locations.

Particularly interesting is that the document advises governments to specifically allocate areas of land, the so called “ASM zones”, to ASM. These zones should be delineated by means of geological and prospectivity mapping and land use planning. According to the guidance, the necessary actions to formalize and better manage the ASM sector would become easier if such “ASM zones” were made available to the ASM sector.

In theory, the idea of “ASM zones”, which have mineral potential or even established resources for ASM operations, would provide a proper basis for the formalization and regulation of the sector as well as an improved operation, environmental, social and closure planning within that area.

Yet, this kind of zones does not come for free and governments, industrial mining companies and the donor community have to commit financial and human resources to delineate, establish, administer and manage “ASM zones”, at least during the initial phases.

A pertinent question in this regard is “what are reasonable costs to manage ASM within a given zone compared to its underlying socioeconomic benefits for the local population and the government”. In addition, one should evaluate the scalability of the approach when considering sector-wide application for a given country.

In the next chapter the term “ASM zones” will be described, giving a short historic review and analyzing their advantages, challenges and requirements. Subsequently, guidance will be given, on how to delineate, establish, administer and manage these zones. Further, the time and financial implications for governments, industrial mining companies as well as the donor and research community will be discussed.

¹ IGF was founded in 2005 and consists currently of 57 member countries in Africa, Asia, Europe and North and South America

2 ASM zones

2.1 Historic review

The idea behind ASM zones, meaning to provide appropriate land with mineral potential to the ASM sector in order to allow its proper development and management, is not new. The idea appeared first in the early 1990s, when Jeffrey Davidson (1993), at that time Managing Director of Small Mining International (SMI) based in Montreal, wrote in his paper:

“Guarantees for the access of prospective grounds are a crucial concern for the rationalization and orderly development of artisanal mining activity. Without reasonable opportunities to mine, artisanal miners will feel compelled to disregard the law and preexisting rights in order to secure their own livelihoods, even in countries where artisanal mining has been legalized” and “Governments must be prepared to move beyond the establishment of legal frameworks, to identify deposits and areas amenable to small-scale development, including the preliminary evaluation of their technical and economic viability at different levels of operation”.

Later, from 1996 to 1998, BGR implemented a technical cooperation project called “Assistance to the Small Scale Mining” in Ghana, which, amongst other components, already supported the prospecting and delineation of “ASM zones” for the gold mining sector.

Then in 2000, the study on the “Design and Pilot Implementation of a Model Scheme of Assistance to Small Scale Miners (Phase I) commissioned by DFID and elaborated by a consulting firm, recognized the outlining of mineral potential as one of the priority issues for improving the successful management of ASM. The study notes:

“The fundamental concern for any SSM venture is the accessibility and recoverability of the mineral deposit. Without an accessible mineral worthy of exploitation by primitive non-mechanized means there would be no SSM sector” and “There is a requirement to define the criteria for mineral exploitation for all types of mining enterprises and delimit areas for SSM, for all commodities on existing geological information.”

This comprehensive study on a scheme of assistance to small scale mining prepared in the year 2000 may be considered as the forerunner of the recent IGF “Guidance for Governments on Managing Artisanal and Small-scale Mining”.

Then, Hinton et al. (2003) mention in their review on mining and beneficiation methods for artisanal gold mining the following:

“Establishing mineable reserves is vital to creating a sustainable operation as it: enhances the link between miners and the land they work; promotes planning that may be accompanied by an extended mine life; and it can be used to obtain funding from formal financial institutions, and therefore may encourage operation within a regulatory framework.”

In more recent times, the idea of delineating “ASM zones” for supporting a better management of ASM is appearing in studies and newspaper articles in several countries. Examples are Cambodia (Spiegel, 2013), Colombia (Dinero, 2013; OpinionCaribe, 2015), DR Congo (Bafilemba & Lezhnev, 2015), Ecuador (Upsidedownworld, 2010), Ethiopia (Meaza, 2011), Ghana (Amankwah & Anim-Sackey, 2003; Aryee et al., 2003; Eshun, 2005), Indonesia (Leks & Co lawyers, 2012), Mozambique (CfC, 2008; Fundo de Fomento Mineiro, 2012), the Philippines (AGHAM, 2005; The Philippine Star, 2014) and Tanzania (UNEP, 2012; Ministry of Energy and Minerals, 2015).

In some of the above mentioned countries, namely DR Congo, Ghana, Indonesia, the Philippines, Tanzania and Colombia, “ASM zones” already have become part of the mining law.

Through the years, the main reason for creating “ASM zones” had been the idea to allocate land with mineral potential or even known mineral resources to the ASM sector and facilitating through this the formalization of the ASM sector. So far this concept is being implemented only in few ASM countries. Most known examples are the DR Congo, Colombia and Indonesia, where “zones d’exploitation artisanale (ZEA)”, “Áreas de Reserva Especial (AREs)” and “Wilayah Pertambangan Rakyat (WPR)” are being established. Other examples where the concept of delineating “ASM zones” was/is being tried are Ghana, Mozambique, Suriname, Tanzania and Zambia (CfC, 2008, Dompig, 2013).

But the success of the establishment of “ASM zones” leaves much to be desired, as the zones are not always chosen based on sound geological assessment and ASM requirements. Therefore the delineated zones often do not have enough mineral resources and are not appropriate for longer-term ASM mining (CfC, 2008; MERG, 2011).

However, more recently, a stronger reason appeared in many countries to push the establishment of “ASM zones” forward. The new driver to implement such zones are the frequent conflicts between LSM and ASM. These conflicts are resulting from the promotion of LSM and the exploration and mining licenses of this sector, which frequently produce overlapping of concessions and reduction of workable land for ASM (Siegel & Veiga, 2009). Awakened by these conflicts, some governments now opt for land use planning, which includes also the designation of special land for the ASM sector.

2.2 Advantages and challenges of delineating “ASM zones”

Advantages

As Davidson (1993) already stated, the accessibility to land with known mineral resources is vital for the sustainable development of the ASM sector. Possessing the right to mine a known mineral resource, makes the ASM sector predictable and manageable. This is beneficial both for the miners and the government concerned.

Just like in medium and large scale mining, where the clarification of the mineral resources in the ground is of utmost importance and determines the economic viability of the future mine, the same applies for ASM. Without a viable mineral resource, neither miners nor the governmental mining agencies can plan and regulate the mining operations in regard to their economic, environmental and social viability.

Based on a known mineral resource, the value of the material in the ground and the life of the future mining operation may be estimated. The ore value indicates the revenue of the mine, the life of mine indicates for how long mining can initially be sustained. The life of mine allows the estimation of the mine capacity, the investment amount for development and the operation costs to run the mine. Having such kind of information on hand, a mine business plan, including a cash flow model, can be developed, that allows predicting the economics of the future mine.

If the economic estimations are indicating a profit, parts of it can be used to manage the environmental and social matters during operation and to explore the property further to increase mineable reserves. In addition, knowing the economics of the ASM operations, governments could decide on fair taxes and ask for payments into a governmental ASM fund, used for regional exploration and environmental remediation.

Currently, due to the largely unknown quantity and quality of mineral resources in areas where ASM is taking place, mining activities often show a chaotic and haphazard character. The miners destroy forests and degrade land by wild digging into the ground in order to find and extract material, whose mineral content they do not know. If they finish mining in one place, with finding or without finding mineralization, they create a visual impact such as a devastated landscape with open holes and shafts, waste rock piles and disturbing substances like industrial and domestic wastes.

However, if there was an adequately known and delineated mineral resource, this would reduce the land degradation caused by unplanned searches for mineralized areas as well as the physical efforts and financial risks of the miners. In addition, both the miners and the relevant governmental agency benefit as the ASM operation could be better planned and managed in regard to its operation and the accompanying environmental, social and mine closure issues.

Challenges

Based on the aforementioned, it is highly recommendable to establish “ASM zones”, in countries which have an ASM sector. Nevertheless, the creation of such kind of special lands for ASM is very challenging, as it is not an easy task and requires a strong commitment of both the government concerned and the ASM sector itself.

First, many countries lack relevant geological information to be used for identifying and assessing potential “ASM zones”. Regarding this Hilson & Maponga (2004) state:

“Few developing-world governments possess detailed geological maps in forms easily understood and suitable as reference points for determining areas appropriate for ASM. This can lead to the demarcation of poorly-mineralized concessions”.

Secondly, the creation of the “ASM zones” has to be closely coordinated and agreed with all stakeholders affected by the establishment of “ASM zones”. Depending on the political, economic and social landscape of a country’s region, representatives of the local and regional government, communities, land owners, large scale mining, other land users (agriculture, tourism sector), infrastructure providers and of course the ASM sector have to be involved in the planning and establishment process to prevent unintended activities such as massive migration towards such zones.

Thirdly, the government has to allocate enough human and financial resources for the identification and delineation, the subsequent establishment and the future administration and management of these zones. Also, the miners who will work in these zones, have to participate actively in managing the zones, particularly in mine based exploration, environmental management and closure of operations.

Probably, the identification and delineation of “ASM zones” is the easiest and a relatively straight forward undertaking. However, the incorporation of the delineated zones into a spatial planning process to physically establish the zones, will need a huge coordination effort and some time to see if the planning results will achieve a balance between the different stakeholder interests. Finally, the future administration and management of the “ASM zones” demand constant availability of human and financial resources to supervise and monitor the development, operation and closure of the mines.

But such proactive efforts, including proper planning, administration and management of the ASM sector, are more rewarding and more economic than the often too late reactive actions such as police and military intervention or costly environmental remediation. In addition, the proactive actions help to preserve an economic sector which represents one of the few viable sources of income in rural areas.

A good discussion of the pros and cons of establishing “ASM zones” is given in the “Legalization guide for artisanal and small scale mining” prepared by MERG (2011).

3. Designation and Management of ASM zones

The following provides a practical way for governments on how to identify, delineate, establish and manage ASM zones, which are amenable for the development of ASM mining operations.

The present work proposal is thought to be an addition to the IGF “Guidance for Governments on Managing Artisanal and Small-scale Mining”. In contrast to the IGF guidance, which mention “ASM zones” in a broader frame of developing and implementing a management strategy for ASM, this document focuses exclusively on the topic “ASM zones” and gives advice towards the finding, evaluation, establishment and management of such kind of zones. As does the IGF guidance, also an industry approach is taken towards the ASM sector. That means, the ASM operations are not regarded individually, but collectively, as an industry.

The process of identifying, delineating, establishing and managing “ASM zones” is seen as a phased process and will be explained by the following steps:

Designation Phase

1. Identification and delineation of “ASM zones”
2. Estimation of resources and economics of “ASM zones”
3. Conceptual environmental/social and health and safety management plans

Implementation Phase

4. Licensing and permitting
5. Elaboration of the mine, environmental/social/OHS and closure plans

Management Phase

6. Supervision of ASM
7. Support to ASM

Although information is very scarce on the costs and the time for planning and implementing the above steps, an indicative cost range and a time span will be given, whenever it is possible.

In order to establish and manage “ASM zone” it is a prerequisite to have an appropriate legal system in place which aims at formalizing and regulating the ASM sector. In addition, the mining authority of the country should have a special department for ASM, which has also offices in regional/district mining authorities, equipped with enough financial resources and employing well-trained staff.

Examples for countries already having such adequate conditions are Ghana, Tanzania, DR Congo, Indonesia, Mongolia, Peru and Colombia (Peru Support Group, 2012; Mahobe & Magayane, 2013; Macdonald et al., 2014; MinMinas, 2014; SDC, 2015; Amnesty International, 2016).

In the following chapters, the activities to designate and manage “ASM zones”, with the related economic, environmental and social issues will be described in detail.

4. Designation Phase

4.1 Identification and delineation of “ASM zones”

The identification and delineation of “ASM zones” comprises the following steps, described under a), b) and c):

a) Consulting mineral resource maps and databases

A country’s mineral endowment is commonly studied by its mining authority, particularly by the National Geological Survey. Basis for such study are geological reports and maps, satellite images, inventories of known mineral occurrences and deposits as well as results of regional geochemical and aerial geophysical surveys.

Depending on the progress of assessing its mineral resources, a country may have maps at different scales and databases showing and describing its mineral occurrences and mineral deposits.

Mineral resource maps show the rock types, the geological structures and the mineral resources of a country according to different commodities and possibly deposit types. Depending on the country, mineral resource maps may be available either on paper down to a scale of 1:50:000 or in digital form based on GIS. The accompanying mineral resource databases, whose content depends on the extent of the exploration and mining history of a country may contain information on the location of mineral occurrences and deposits, deposit type, commodities, geology, mineralogy, type of mining and beneficiation, resources/reserve and past production.

The availability of information on ASM, regarding its location, size and type of operations, deposit type worked etc. is largely determined by the history, extent and importance of ASM activities in a country. Countries which do have a significant ASM sector will probably have gathered this information. However, many countries which do not have a significant ASM sector will not have this kind of information on hand.

The information on mineral resources, particularly the geology, the deposit types and their location as well as the size and type of mining operations assists to identify areas which could potentially be interesting for the ASM sector. In the case that a country already has a (significant) ASM sector, these areas are most probably already known from past or present exploitation activities and hence this identification stage is not necessary, unless new areas have to be found to accommodate an increasing ASM sector or ASM miners have to be diverted to new established “ASM zones”.

To assist with the determination of areas, which are amenable to ASM development, the following table presents the commodities and their mineral deposits, which are mostly worked by the ASM sector. These are all high value commodities, low value commodities such as coal and construction materials are not considered.

The characteristics of the deposits are taken from the “Descriptive Mineral Deposit Models” of USGS, which were started to be developed by the USGS in the 1980s (Cox & Singer, 1986). Such a model is a systematic description of the essential characteristics of a certain mineral deposit type, including grade and tonnage information. Nowadays there are more than 100 “Descriptive Mineral Deposit Models” available, based on thousands of well-explored mineral deposits world-wide.

Table 2: Commodities and their mineral deposits mostly mined by ASM

Commodity	Deposit Type	Regional Expression	Host rock Types
Gold	Low-sulphide Au-quartz veins (models 36a, 36a.1)	Veins are along regional high-angle faults and joint systems	Regionally metamorphosed mafic volcanic rocks, graywackes, cherts, shales, and quartzites, granodioritic-granitic batholiths
	Placer Au-PGE (model 39a)	River environments, moraine environments	Alluvial gravel and conglomerate, sand is of secondary importance
Gemstones	Placer, veins, pegmatites (no models available)		Alluvial sand and gravel, volcanic, plutonic and metamorphic rocks
Diamonds	Diamond Placer (model 39d)	River and beach environments	Alluvial and beach deposit sand and gravel
Tantalum	Lithium-Cesium-Tantalum (LCT) Pegmatites	Occur in clusters	Schists and gneiss, marble, quartzite, igneous rocks
Tin	Alluvial Placer Sn (model 39e)	River and beach environments	Alluvial sand, gravel, and conglomerate indicative of rock types that host lode tin deposits
	Sn Veins (model 15b)	Plutons, dikes and dike swarms	Close spatial relation to granitoids, pelitic sediments are generally present
Chromium	Podiform chromite (model 8a)	Ophiolite complexes	Highly deformed ultramafic rocks, commonly serpentized
Cobalt	Sediment-hosted Cu (model 30b)		Red-bed sequences with shale, siltstone, and sandstone. Carbonate and evaporite beds are present

b) Consulting the mining cadastre

The above mentioned mineral resource maps and databases are not enough to identify potential areas for ASM, as mineral rights (for exploration and mining) commonly determine the access to areas with potential mineral resources. Therefore, the mining cadastre has to be consulted also, to find out if potential ASM areas are already covered by mineral rights or not.

If potential ASM areas are already covered by mineral rights of other mining companies, a consultation process has to be started, in order to learn if the LSM enterprise is willing to let land to the ASM sector. As the overlapping of LSM mineral rights with active ASM areas is already the case in many mining countries, the consultation process has to find out, if companies are prepared to accept ASM activities on their land or even cooperate with it, in order to avoid or to stop conflicts.

In regard to the consultation process advice is given in “Working Together” (ICMM, 2013), showing how LSM can engage with ASM. This document was developed through a partnership between Communities and Small-Scale Mining (CASM), the International

Finance Corporation's Oil, Gas and Mining Sustainable Community Development Fund (IFC CommDev) and the International Council on Mining and Metals (ICMM).

c) Checking for other land uses

Having consulted the mineral resource information and the mining cadastre, it has to be checked if other possible land uses are in conflict with the identified ASM areas. Other land uses may be areas reserved for natural parks and other protected lands, agriculture, forestry, fishery, tourism etc. Depending on the country, the availability of such kind of information may greatly vary.

The existence of nearby settlements have also to be taken into account during this step. Communities could either oppose ASM areas, as they fear that they are negatively affected by them or could be highly attracted, which eventually would trigger an unintended rush into these areas.

The following figure shows the steps for initially identifying areas that could be interesting for ASM.

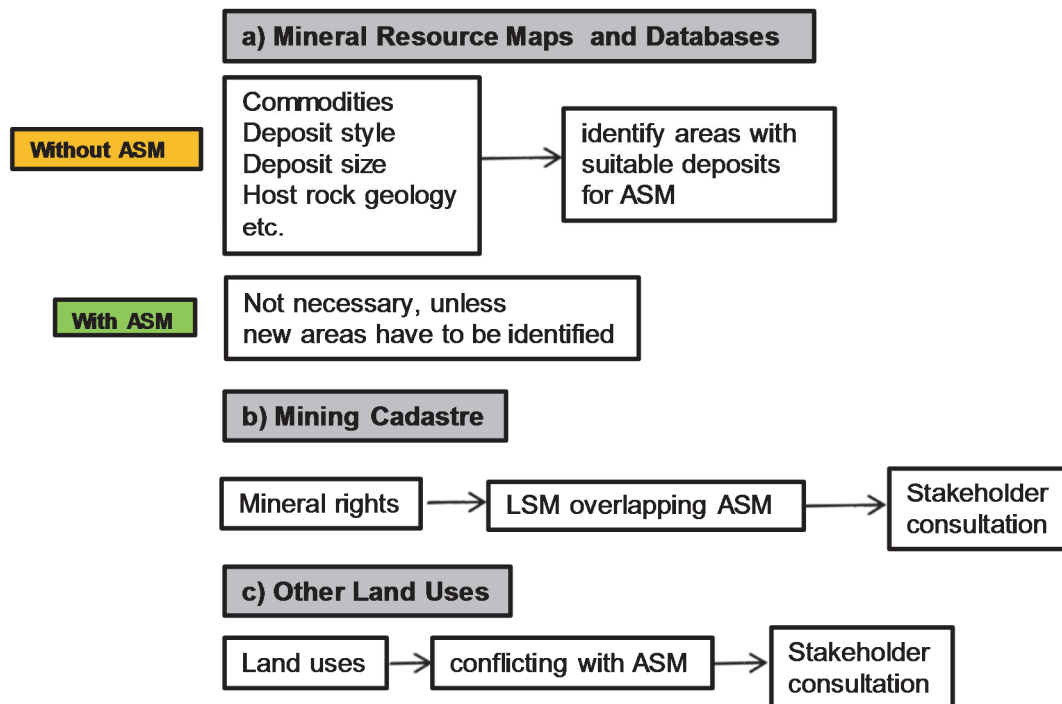


Figure 1: Initial identification of ASM areas

The above tasks and activities should be conducted by staff of the National Geology and Mines Authority and the Mining Cadastre, possibly with the assistance of other institutions, which are involved in spatial planning.

The information on mineral resources, mineral rights and other land uses normally is available in form of maps. These maps can be used to show areas for ASM, which do reveal the right geology and deposit types and to see which areas may be in conflict with LSM mineral rights and/or other land uses or not. Many countries do have already a GIS based Mineral Resource and Mining Cadastre Information System, which also shows other land uses. Examples are Tanzania, Mozambique, Zambia, Uganda and Kenya which have mining cadastre portals based on GIS (Feast et al., 2006).

4.2 Estimation of resources and economics of “ASM zones”

Having successfully identified “ASM zones” and agreed with the LSM sector and/or other land users to allocate these zones to the ASM sector, the next step is to estimate the mineral resources contained in these zones and to get some idea on the economics of the future ASM operations. The necessary activities are described under a), b) and c).

a) Grade, tonnage and mineral deposit density

From Table 2 it can be seen that the commodities, which are interesting for the ASM sector are mainly gold, gemstones, diamonds, tantalum, tin, chromium and cobalt. These commodities are mainly hosted by placer, vein, pegmatite and podiform deposits. The same Table 2 shows also the “Descriptive Mineral Deposit Models”, by which the placer, vein, pegmatite and podiform deposits may be described. Furthermore, for the majority of these models, grade and tonnage information is available (Cox & Singer, 1986).

In addition to the grade and tonnage information, the mineral deposit density per area for some of the ASM target deposits are available (Singer, 2008; Singer et al., 2013). The deposit densities can be used to provide an estimate of the number of deposits in a potential “ASM zone”.

Table 3 presents the grade and tonnage information, as median and 90th percentile values, and available mineral deposit densities of some ASM deposit types.

Table 3: Grade, tonnage and deposit density for ASM mineral deposits

Commodity	Deposit Type	Grade	Tonnage	Density (deposits/km ²)
Gold	Low-sulphide Au-quartz veins (models 36a, 36a.1)	Median: 8.8 g/t, 90 th P: 4.3 g/t	Median: 1,000,000 t, 90 th P: 89,000 t	0.005
	Placer Au-PGE (model 39a)	Median: 0.2 g/t, 90 th P: 0.08 g/t	Median: 1,100,000 t, 90 th P: 22,000 t	0.006
Diamonds	Diamond Placer (model 39d)	Median: 0.37 ct, 90 th P: 0.03 ct	Median: 970,000 t, 90 th P: 39,000 t	
Tantalum	Lithium-Cesium-Tantalum (LCT) Pegmatites (model 13)	Median: 0.02 % (Ta ₂ O ₅)	Median: 1,000,000 t, 90 th P: 49,000 t	
Tin	Alluvial Placer Sn (model 39e)	Median: 0.06 %, 90 th P: 0.015 %	Median: 2,000,000 t, 90 th P: 15,000 t	
	Sn Veins (model 15b)	Median: 1.3 %, 90 th P: 0.7 %	Median: 240,000 t, 90 th P: 12,000 t	
Chromium	Podiform chromite (model 8a)	Median: 46 %, 90 th P: 33 % (Cr ₂ O ₃)	Median: 20,000 t, 90 th P: 2,200 t	0.12

It should be mentioned that the above described information is rather indicative. Therefore, the information in Table 3 should be complemented by available exploration results and mining production data in the given country in order to refine the grade and tonnage

information. Particularly, if an ASM area is located within a LSM concession, exploration data of the LSM company could be of great assistance.

b) Economic estimations

Having the grades and tonnages on hand of the deposits which are likely to occur in the ASM areas, indicative estimations on the commercial viability of future ASM operations may be conducted. This should comprise at least the calculation of the Operating Profit (OP) and the Net Present Value (NPV).

For the estimations the following input is necessary:

- ✓ The median grade of the deposit
- ✓ The median tonnage of the deposit
- ✓ Operation costs (Opex)
- ✓ Investment amount (Capex)

In the case of being very conservative, it could also be necessary to conduct estimations using the 90th percentile of the grades and tonnages. This means that the grades and tonnages are taken, which 90 % of the deposits of a given type at least have.

The most likely scenario needs to be identified by comparing the model information with local existing information.

With the grade of the deposit, the ore value of the mineral resource can be estimated, taking into account a conservative average commodity price, the recovery of the mineral concentrate and, if applicable, the percentage of the mineral value for the mine operator. The tonnage allows estimating the life of mine and the mine capacity.

Several scenarios should be calculated in order to get a range of possible operation sizes and economic values. The scenarios should include a minimum, average and maximum production capacity of ASM operations and the life of mine should be at least 10 years.

The following commercial viability estimation is illustrated through several steps, utilizing the method described in Wellmer et al. (2007) and using cost models of Camm (1991).

For the illustration of the estimation process examples for a hard rock vein deposit and a placer deposit type are given below.

Example 1

In an identified prospective ASM area low sulphide Au-Quartz veins occur. According to the "Descriptive Mineral Deposit Model", the gold veins have a median tonnage of 1 Million tons and a median grade of 8.8 g/t Au.

To estimate the economic viability of an operation working such veins, production capacities of 10 t/d, 20 t/d and 50 t/d are assumed, which are typical production sizes for ASM operations. Further, it is assumed that the operation works 300 days annually. The veins are mined underground and the ore is processed by a gravity plant.

1. Taking into account the daily production capacity and the mineral resources, the life of mine is estimated:

Capacity and Life of Mine

Production (t/d)	Production (t/a)	Life of Mine (years)
10	3,000	333
20	7,500	133
50	15,000	67

2. Considering the ore grade and a dilution of 10 %, a recovery of 60%, a share of 95 % for the mine and a long-term average gold price (1073 US\$/oz), the ore value (US\$/t) is estimated:

Ore value (US\$/t)

Commodity	Grade (oz/t)	Recovery	% for mine	Price (US\$/oz)	Ore value (US\$/t)
Au	0.26	0.6	0.95	1073	157

3. Based on the production capacity, the operation costs and the investment amount are estimated:

Operation Costs (Opex)

Production (t/d)	Mining (US\$/t)	Beneficiation (US\$/t)
10	93	52
25	81	38
50	72	29

Investment (Capex)

Production (t/d)	Mining (US\$)	Beneficiation (US\$)
10	1,342,000	805,000
25	2,327,000	1,342,500
50	3,580,000	1,790,000

4. Having the ore value and the Opex, the Operating Profit can be estimated:

Operating Profit (OP) (US\$/t)

Production (t/d)	Ore value (US\$/t)	Opex (US\$/t)	Operation Profit (US\$/t)
10	157	145	12
25	157	118	39
50	157	100	57

5. With the Operating Profit per ton and the annual production capacity, the annual Operating Profit and the Net Present Values (NPV) can be estimated:

Annual Operation Profit and Net Present Value (NPV) (US\$)

Production (t/d)	Annual Operation Profit (US\$)	Capex (US\$)	Present Annual Value Factor	NPV (US\$)
10	36,000	2,148,000	10.0000	-1,788,000
25	292,500	3,669,500	10.0000	-744,500
50	855,000	5,370,000	9.9831	3,165,551

The above numbers indicate that, by considering a conservative gold price, only scenario 3 is economically viable. Therefore, it is recommended that a government should opt for a 50 t/d operation, which could sustain more than 50 years of mining.

Example 2

In an identified prospective ASM area alluvial placer Sn deposits occur. The “Descriptive Mineral Deposit Model” shows that the placers have a median tonnage of 2 Million tons and a median grade of 0.06 % Sn.

To estimate the economic viability of an operation working such placers, production capacities of 50 t/d, 100 t/d and 200 t/d are assumed, which are typical production sizes for ASM operations. Further it is assumed that the operation works 300 days annually. The Sn placer is processed by a gravity plant.

1. Taking into account the daily production capacity and the mineral resources, the life of mine is estimated.

Capacity and Life of Mine

Production (t/d)	Production (t/a)	Life of Mine (years)
50	15,000	133
100	30,000	67
200	60,000	33

2. Considering the ore grade, a recovery of 60%, a share of 95 % for the mine and a long-term average tin price (7,9 US\$/lb), the ore value (US\$/t) is estimated

Ore value (US\$/t)

Commodity	Grade (%)	Recovery	% for mine	Price (US\$/%)	Ore value (US\$/t)
Sn	0.06	0.6	0.95	174	6

3. Based on the production capacity, the operation costs and the investment amount are estimated:

Operation Costs (Opex)

Production (t/d)	Plant (US\$/t)
50	29
100	23
200	18

Investment (Capex)

Production (t/d)	Plant (US\$)
50	1,790,000
100	2,774,500
200	3,938,000

4. Having the ore value and the Opex, the Operating Profit can be estimated:

Operating Profit (OP) (US\$/t)

Production (t/d)	Ore value (US\$/t)	Opex (US\$/t)	Operation Profit (US\$/t)
50	6	29	-23
100	6	23	-17
200	6	18	-12

5. With the Operating Profit per ton and the annual production capacity, the annual Operating Profit and the Net Present Values (NPV) can be estimated:

Annual Operation Profit and Net Present Value (NPV) (US\$)

Production (t/d)	Annual Operation Profit (US\$)	Capex (US\$)	Present Annual Value Factor	NPV (US\$)
50	-345,000	1,790,000	10.000	-5,240,000
100	-510,000	2,774,500	9.9831	-7,865,881
200	-720,000	3,938,000	8.7715	-10,827,968

In example 2 none of the production capacity scenarios of tin placer mining, considering an average tin grade of 0,06 % and a conservative long-term average tin price of 7,9 US\$/lb, is economically viable. For mining such kind of placer deposits, tin prices must be much higher, but price peaks commonly last only briefly (ITRI, 2011).

It can be concluded that despite of the preliminary character of the above calculations, they represent a valuable planning tool for the further implementation and management phase of the "ASM zones". Therefore, it is recommended to check the economic viability of mining a certain type of deposit in a potential area, before these deposits are given to the ASM sector. This is particular true in regard to the above tin placer case. If these placers were given to the ASM sector, the likelihood exist that they are mined only when tin prices peak. With a price decrease, tin placer mining becomes uneconomic and the area will probably be abandoned without any reclamation measures. In the case of a future price peak there will be again uncontrolled rush-type mining activities.

c) Field exploration activities

In order to verify the grade and tonnage assumptions for the above desk studies, additional exploration and evaluation work is highly recommended. The work should comprise:

- ✓ Mapping and measuring of mineralization in outcrops and old workings
- ✓ Sampling of available outcrops and workings, including limited drilling
- ✓ Taking bulk samples
- ✓ Chemical assays for grade determination
- ✓ Mineral processing tests for determining recovery
- ✓ Estimation of mineral resources, utilizing basic methods and taking into account the maximum depth of ASM operations, which is around 30 m.

The following figure illustrates the steps to estimate the resources and the economics of “ASM zones”.

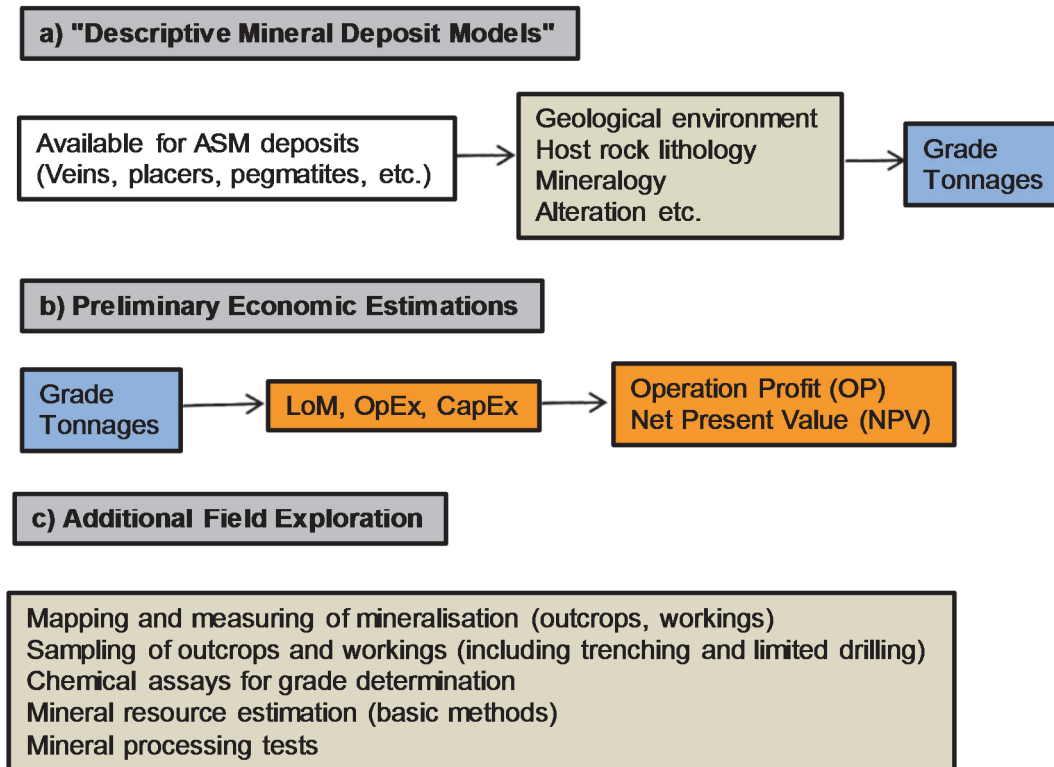


Figure 2: Estimation of resources and the economic viability of “ASM zones”

The required tasks and activities should be conducted by staff of the National Geology and Mines Authority and the regional/district ASM office with possible assistance by outside local professionals. In addition it is recommended, to involve members of the local community or ASM miners in the exploration activities.

As exploration work is often not successful the first time, governments must be prepared to evaluate several potential “ASM zones”, before finding suitable land to allocate to the ASM sector.

4.3 Conceptual environmental/social and health & safety planning

Once potential “ASM zones” of certain types of mineral deposits have been selected and the likely economic viability of mining these deposits has been estimated, the next step would be to deal with the environmental/social and occupational health and safety issues that would result from the development and the operation of mines working such deposits.

At this stage it is only necessary to conduct a conceptual analysis of the environmental/social and occupational health and safety (OHS) issues of the mining cycle in order to understand which impacts and hazards have to be expected and which kind of mitigation measures should be implemented. The required work is detailed under a), b) and c).

a) Environmental impacts and OHS hazards

“Geoenvironmental Models of Mineral Deposits” developed by USGS is a helpful tool (Plumlee & Nash, 1994 to predict the adverse environmental impacts of developing and operating mines and to plan mitigation measures, the). These models are natural extensions

of “Descriptive Mineral Deposit Models”, considering that mineral deposits of a given type with similar geological and geochemical characteristics have similar environmental signatures. Such signatures allow predicting the environmental effects to be taken into account when this kind of deposit type is developed, operated and closed. In addition, based on the predicted impacts appropriate measures to mitigate these impacts may be planned.

Table 4 summarizes the main environmental concerns and occupational health and safety risks which should be taken into account, when dealing with ASM mining and mineral processing activities. The information on environmental matters is compiled with the help of the Geoenvironmental Models of USGS. Occupational health and safety issues are taken from Walle & Jennings (2001) and Walle (2007).

Table 4: Environmental concerns and health and safety risks of mining ASM deposits

Commodity	Deposit Type	Main environmental effects of mining	Main environmental effects of mineral processing	Main health and safety risks
Gold	Low-sulphide Au-quartz veins (models 36a, 36a.1), geoenv. model available	Sulphides in gold ore and low acid-buffering capacity of host rocks may produce acid rock drainage (ARD) in the mine, waste rocks and tailings; increased concentrations of Fe, SO ₄ , As, Sb etc. may be present in waterways downstream and groundwater; erosion of waste rocks and tailings may cause siltation of waterways and dust problems.	Mercury used in the amalgamation process could be released into waterways causing water and fish pollution. Volatilized mercury generated by decomposing mercury could contaminate the air. In the case of using cyanide for gold ore processing, any loss of cyanide to the environment is a major concern because it is highly toxic to organisms.	Underground mining: rockfall, dust, gases, noise, poor ventilation; Mineral processing: volatilized mercury could cause health risks, use of cyanid poses toxicity problems.
	Placer Au-PGE (model 39a), no geoenv. model available	Land clearance causes deforestation, soil loss and erosion; mining causes land degradation resulting from excavations and waste rock piles; fuels and lubricants used for machinery could contaminate surface and ground water.	Concentration process could cause siltation of waterways, concerns related to the use of mercury and cyanide see Low-sulphide Au-quartz veins.	Surface mining: pit wall collapse, noise, mosquito propagation in pit ponds; mineral processing: hazards related to mercury and cyanide handling see Low-sulphide Au-quartz veins.
Gemstones	Placer, veins, pegmatites (no models available)	See models 39a, 39d and 39e, also 13 and 15b		
Diamonds	Diamond Placer (model 39d), no geoenv. model available	Land clearance causes deforestation, soil loss and erosion; mining causes land degradation resulting from excavations and waste rock piles; fuels and lubricants used for machinery could contaminate surface and ground water.	Concentration process could cause siltation of waterways.	Underground mining: rockfall, dust, gases, noise, poor ventilation; Surface mining: pit wall collapse, noise, dust, mosquito propagation in pit ponds.
Tantalum	Lithium-Cesium-Tantalum (LCT) Pegmatites (model 13), no geoenv. model available	Land clearance causes loss of vegetation and soil as well as erosion; erosion of waste rocks and tailings may cause siltation of waterways and dust problems.	Concentration process could cause siltation of waterways.	Underground mining: rockfall, dust, gases, noise, poor ventilation; Surface mining: pit wall collapse, noise, dust, mosquito propagation in pit ponds.
Tin	Alluvial Placer Sn (model 39e), no geoenv. model available	Land clearance causes deforestation, soil loss and erosion; mining causes land degradation resulting from excavations and waste rock piles; fuels and lubricants used for machinery could contaminate surface and ground water.	Concentration process could cause siltation of waterways.	Surface mining: pit wall collapse, noise, mosquito propagation in pit ponds.
	Sn Veins (model 15b)	Sulphides in tin ore and low acid-buffering capacity of host rocks may produce acid rock drainage (ARD) in the mine, waste rocks and tailings; increased concentrations of Fe, SO ₄ , As etc. may be present in waterways downstream and groundwater; erosion of waste rocks and tailings may cause siltation of waterways and dust problems.	Concentration process could cause siltation of waterways.	Underground mining: rockfall, dust, gases, noise, poor ventilation.
Chromium	Podiform chromite (model 8a), no geoenv. model available	Land clearance causes loss of vegetation and soil as well as erosion; erosion of waste rocks and tailings may cause siltation of waterways and dust problems; hexavalent chromium Cr (VI) may be present in waterways downstream and groundwater.	Concentration process could cause siltation of waterways.	Underground mining: rockfall, dust, gases, noise, poor ventilation; Surface mining: pit wall collapse, noise, dust, mosquito propagation in pit ponds.
Cobalt	Sediment-hosted Cu (model 30b)	Sulphides in copper-cobalt ore and low acid-buffering capacity of host rocks may produce acid rock drainage (ARD) in the mine, waste rocks and tailings; increased concentrations of Cu, Pb, As etc. may be present in waterways downstream and groundwater; erosion of waste rocks and tailings may cause siltation of waterways and dust problems.	Only hand sorting, no environmental effect	Underground mining: rockfall, dust, gases, noise, poor ventilation.

By analyzing Table 4 it becomes clear that the adverse environmental impacts of ASM mining and processing are quite variable and are depending on the type of deposit worked.

In contrary, OHS hazards are not depending on the type of mineral deposit, but on the type of mining and mineral processing applied.

- ✓ Mining of gold veins and placers is of most environmental concern. Sulphides in gold ore may create acid rock drainage (ARD), contaminating surface and ground waters. In addition, gold ore may be processed by using mercury or cyanide, which are impacting on the biophysical environment and the human health. Finally, gold placer mining may be accompanied by vast land degradation.
- ✓ Mining of tin veins and cobalt ores could produce acid rock drainage, which may impact on water resources.
- ✓ Mining of tin and diamond placers, tantalum pegmatites and chromite ore could vastly devastate landscapes, but does not create chemical impacts, as only water is used in mineral processing. However, hexavalent chromium related to chromite mining may be of concern.

b) Environmental and OHS management plan

Based on the predicted environmental impacts and occupational health and safety (OHS) hazards of ASM mining shown in Table 4, a conceptual environmental/OHS management plan should be developed in advance of allocating prospective land to the ASM sector. Such a plan is aimed to assist the governmental authority with the environmental and OHS management during operation and after closure in the whole “ASM zone”. It is not meant for managing environmental and OHS issues at an individual mine site.

In the following table control and monitoring measures are shown which aim at mitigating the environmental impacts and OHS hazards in a potential “ASM zone”.

Table 5: Measures to mitigate environmental impacts and OHS hazards of ASM operations

Commodity	Deposit Type	Environmental measures	Health and safety measures	Post closure measures
Gold	Low-sulphide Au-quartz veins (models 36a, 36a.1)	Communal processing plants, which use environmentally sound methods; proper (communal) waste rock and tailings facilities, based on resource availability and mine planning; monitoring systems for ARD, mercury etc.	Proper underground operations, providing technical and financial assistance in mine safety issues (ground support, lightning, ventilation, PPE), basic sanitary and health services (drinking water, medical posts, sewage and waste management etc).	Capping waste rock piles and tailings facilities; monitoring ARD; passive water treatment if necessary; securing shafts and adits; help to create new employment basis.
	Placer Au-PGE (model 39a)	Proper stripping measures, utilizing felled trees and storing top soil; communal processing plants, which use environmentally sound methods; proper (communal) waste rock and tailings facilities, based on resource availability and mine planning.	Proper open pit operations, providing technical and financial assistance in mine safety issues (PPE), basic sanitary and health services (drinking water, medical posts, sewage and waste management etc).	Reclamation and revegetation of land; capping waste rock piles and tailings facilities; help to create new employment basis.
Gemstones	Placer, veins, pegmatites (no models available)	See models 39a, 39d and 39e, also 13 and 15b		
Diamonds	Diamond Placer (model 39d)	Proper stripping measures, utilizing felled trees and storing top soil; communal processing plants; proper (communal) waste rock and tailings facilities, based on resource availability and mine planning.	Proper open pit and underground operations, providing technical and financial assistance in mine safety issues (ground support, lightning, ventilation, PPE), basic sanitary and health services (drinking water, medical posts, sewage and waste management etc).	Reclamation and revegetation of land; capping waste rock piles and tailings facilities; securing shafts and adits; help to create new employment basis.
Tantalum	Lithium-Cesium-Tantalum (LCT) Pegmatites (model 13)			
Tin	Alluvial Placer Sn (model 39e), no geoenvironmental model available			
	Sn Veins (model 15b)	Communal processing plants; proper (communal) waste rock and tailings facilities, based on resource availability and mine planning; monitoring systems for ARD etc.	Proper underground operations, technical and financial assistance in mine safety issues (ground support, lightning, ventilation, PPE), basic sanitary and health services (drinking water, medical posts, sewage and waste management etc).	Capping waste rock piles and tailings facilities; monitoring ARD; passive water treatment if necessary; securing shafts and adits; help to create new employment basis.
Chromium	Podiform chromite (model 8a)	Eventually proper stripping measures, utilizing felled trees and storing top soil; communal processing plants; sound (communal) waste rock and tailings facilities, based on resource availability and mine planning.	Proper open pit and underground operations, providing technical and financial assistance in mine safety issues (ground support, lightning, ventilation, PPE), basic sanitary and health services (drinking water, medical posts, sewage and waste management etc).	Reclamation and revegetation of land; capping waste rock piles and tailings facilities; securing shafts and adits; help to create new employment basis.
Cobalt	Sediment-hosted Cu (model 30b)	Eventually proper (communal) waste rock and tailings facilities, based on resource availability and mine planning; monitoring systems for ARD etc.	Proper underground operations, providing technical and financial assistance in mine safety issues (ground support, lightning, ventilation, PPE), basic sanitary and health services (drinking water, medical posts, sewage and waste management etc).	Capping waste rock piles and tailings facilities; securing shafts and adits; monitoring ARD; help to create new employment basis.

c) *Field activities*

The desk-based assessment of the environmental impacts and OHS hazards and the development of an environmental and OHS management plan for a potential “ASM zone” should be accompanied by a field-based baseline study.

Apart from the environmental and OHS issues, such a baseline study has to analyze also the socio-cultural context of a potential “ASM zone”, a task which cannot be done adequately during the desk-based work. The socio-cultural analysis recognizes likely social impacts triggered by ASM operations and helps to plan social mitigation measures at an early stage.

The baseline study could already be undertaken together with the field exploration work and should focus especially on the mitigation of possible environmental and social impacts. To capture the cultural and biophysical framework of a potential “ASM zone”, the following should at least be analyzed:

- ✓ Community issues and land ownership
Whose land is it? Does the community accept a land allocation to ASM? Is the community interested working in the ASM sector or does it already work in it? Are there problems with LSM?
- ✓ Land use
Is the land used for agriculture, animal husbandry etc?
- ✓ Geomorphology
Are there adequate sites for a processing plant, waste rock and tailings facilities and human settlement with infrastructure?
- ✓ Soil and vegetation
Is the potential “ASM zone” densely vegetated or in savanna or desert type environment? This is important in regard to land clearing and stripping for mining as well as top soil storage.
- ✓ Rock types
Are there rocks with acid-buffering capacity for possible ARD? Is there low permeability material available which could be used as lining material for the waste rock and tailings facilities as well as sanitary landfill for domestic waste?
- ✓ Surface and ground water
Is there water for drinking and industrial water supply? How deep is the groundwater level? This is important for mine and infrastructure planning.
- ✓ Power and accessibility
Is there a rural power grid nearby or not? Through which kind of traffic infrastructure is the area accessible? Road? This is important for mine and infrastructure planning.

According to the special circumstances of a country or region, the above selection of issues to be assessed should be amended or extended.

The figure below presents the steps to initially predict and mitigate the environmental and social effects and OHS hazards in “ASM zones”.

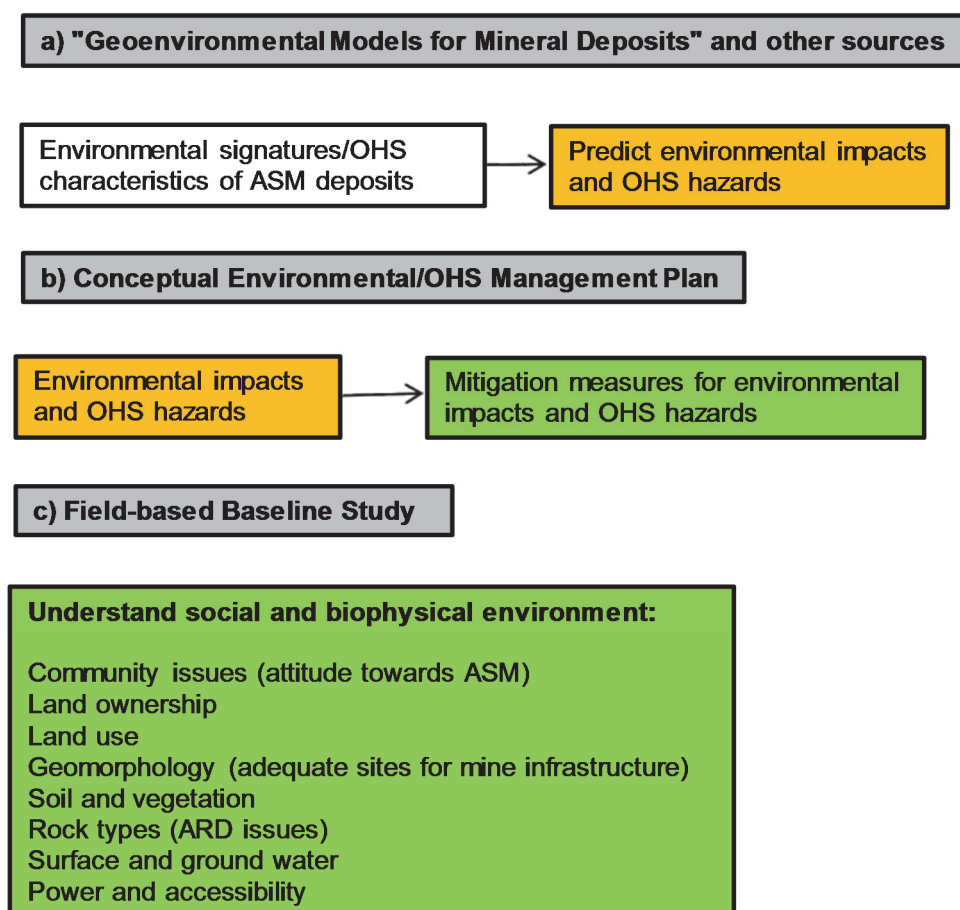


Figure 3: Prediction and mitigation of environmental/social effects and OHS hazards in “ASM zones”

The required tasks and activities should be conducted by staff of the regional/district ASM office with possible assistance by professionals of the National Geology and Mines Authority and the relevant environmental agency.

4.4 Summary, time and costs of the Designation Phase

Having a relevant framework for the ASM sector in place, meaning the country has an appropriate legislation and decentralized offices for managing the ASM sector, the above activities allow selecting zones with mineral potential for ASM. Furthermore, it allows an indicative assessment of the economic viability of future ASM operations. Lastly, the activities are resulting in a conceptual plan for managing adverse environmental and social impacts and OHS hazards in a potential “ASM zone”, during mine operation and after closure.

As described above, the necessary activities should be directed by the mining sector of a country, but coordinated very closely with other stakeholders affected by the implementation of “ASM zones”. These may be authorities in charge of forestry, agriculture, fishery etc., nearby communities, land owners and large scale mining companies.

The approximate timeframe and cost range for the aforementioned steps are:

✓ *Identification and delineation*

It is assumed that, depending on the availability of the information, this step could be a matter of 6 months to identify potential “ASM zones” in a country. As the work is principally desk-based it does not need a large additional budget. It is recommended

to establish a special task force comprising a mineral resource geologist, an expert in cadastre and another expert in land use planning. These three with the support of the GIS department shall identify the areas and make it available to the relevant stakeholders. Considering the human and material input it is presumed that the identification process may need a budget of around 50,000 US\$. The work, however, does not include a possible stakeholder consultation process with LSM, other land users and communities.

✓ *Estimation of resources and economics*

It is assumed that this step, including field exploration work, may take around 1 year, for assessing some potential “ASM zones”. Here it is also recommended to establish a special task force comprising a mineral resource geologist and a mining engineer. Considering the human and material input it is presumed that the desk work may need a budget of around 30,000 US\$. Nevertheless, the recommended field exploration stage with sampling, chemical analysis and mineral processing tests may need financial resources of up to 1 Million US\$.

✓ *Conceptual environmental/social and health and safety management plans*

This step may take around 2 months for the commercially viable “ASM zones”. Here it is also recommended to establish a special task force comprising a geographer, geologist, biologist and social scientist. Considering the human and material input, including the baseline study, it is estimated that the whole work may need a budget of around 50,000 US\$.

Adding together the time for the above steps, the identification and delineation of “ASM zones” in a country, with the relevant economic and environmental assessments, could take up to 2 years. The costs of the various desk studies could amount to 150,000 US\$ and the additional field base exploration work and baseline studies could cost another 1 Million US\$.

The necessary financing for the above activities should be provided by the mining sector of a country, with or without the assistance of international donor money. In case the “ASM zone” is situated within the mineral right zone of a large scale mining entity, the very company could bear a share of the costs.

5. Implementation Phase

After the identification and delineation of a potential “ASM zone”, with the necessary economic and environmental and social assessments as well as the availability of all agreements of the relevant stakeholders, the mining authority has to issue mining rights to the ASM sector. It is important to note that the issuing of a mining right should be uncomplicated and at low cost.

Subsequently, the task of the regional/district ASM office is to supervise and manage the mining operations in the “ASM zone”. Through the life of the mine, the governmental ASM office has to provide assistance in regard to the development of a business plan and an environmental/OHS management system, mine based exploration and the final closure planning.

In addition, depending on the development goals of the ASM sector, the regional/district ASM office may have to arrange possibilities for ASM miners to get access to capital, equipment and to markets.

In the following chapters, the necessary activities to successfully implement, administer and manage “ASM zones” will be described in detail.

5.1 Licensing and permitting

a) Issuing mineral rights

The issuance of mining rights for an “ASM zone” should be done at local level, meaning the national mining authority should delegate this task to a regional/district ASM office. Through the economic assessment of the mineral resources during the Designation Phase, which allowed estimating the deposit size and the life of mine, the tailoring of the mining rights in regard to their size and duration will become easier.

Furthermore, the assessment of the environmental and social matters during the initial phase facilitates the environmental permitting in the process of issuing a mining right. The analysis of the environmental and social effects caused by mining a given type of mineral deposit and the development of a conceptual environmental/social management plan to mitigate the effects should be the basis for the environmental permitting.

It is suggested that mining rights are issued only to mining co-operative and/or small enterprises and not to individual miners. The reason for this is that larger entities are easier to be controlled and managed by the governmental authorities. Co-operatives and small enterprises possess a certain structure and may appoint responsible persons, who could be addressed in regard to technical, environmental, social and OHS issues. If people from nearby communities are already working as miners in the recently delineated “ASM zone”, the mining rights should be issued with preference to them. But they should also be required to establish a co-operative or a small enterprise.

It is suggested that after the constitution of the mining co-operative or small enterprise, the entity could obtain a mining right by filling in a template application letter directed to the head of the regional/district ASM office. If necessary, the completion of the application should be assisted by the personnel of the ASM office. An example of such a template is shown below.

Details of Applicant

- a. Name and contact details of the co-operative or small enterprise
- b. Registration Certificate No.
- c. Date and place of registration
- d. Share capital (nominal and paid-up)

- e. Full names of members, ID No., residential address
- f. Full names of Chairman
- g. Full names of secretary

Particulars of Application

- a. Area required in hectares
- b. Location of area
- c. Mineral(s)

Brief Technological Information on Mining and Processing

Sketch Plan

Show the following details on the plan:

- a. The position of the areas (coordinates)
- b. The dimensions of the area
- c. The position of any area in the vicinity already held under a mining right

I, do hereby declare that the information given above is true and correct and I make this declaration conscientiously believing the same to be true.

Signature (of the Chairman)

Date:

Modified after section 108 – The Mines and Minerals (Application for Mining Rights) Regulation of Zambia, 1996

b) Environmental permitting

The required environmental permitting for obtaining the mining right could be done through an induction training course conducted in the regional/district ASM office. The basis for the training course is the environmental, social and OHS assessment conducted during the Designation Phase. Based on this assessment, training material should be developed, which illustrates the negative environmental and social effects and OHS hazards of an ASM mine working a certain type of mineral deposit and the relevant measures to reduce these effects. Such training materials or guides have already been developed by several institutions, which are working with ASM and could be serving as examples for deposit specific guidelines (UNEP, 2012; ARMA, 2014a, b, c). In addition, guidelines on OHS issues of different ASM mining types have been elaborated by Walle & Jennings (2001) and Walle (2007).

In the training course all co-operative or small enterprise miners are trained in understanding and managing the environmental and social impacts and OHS hazards of their operation, which will work a given type of deposit. The training should include legal aspects such as current norms and standards as well as methods to control and monitoring the anticipated impacts and hazards. The course should be as much didactic as possible, teaching the content by videos and case studies.

The attendance in the course has to be mandatory and there should be a final examination in order to control if the participants understood the content of the training course. In the same event the co-operative or small enterprise has to elect a person, who will be responsible for environmental/social and OHS issues in the future mine and who serves as contact person for the regional/district ASM office.

With the above letter and the mandatory participation in the environmental/social and OHS training course the mining right to operate the deposit should be awarded to the co-operative or small enterprise.

The following figure illustrates the proposed licensing and permitting procedure in “ASM zones”.

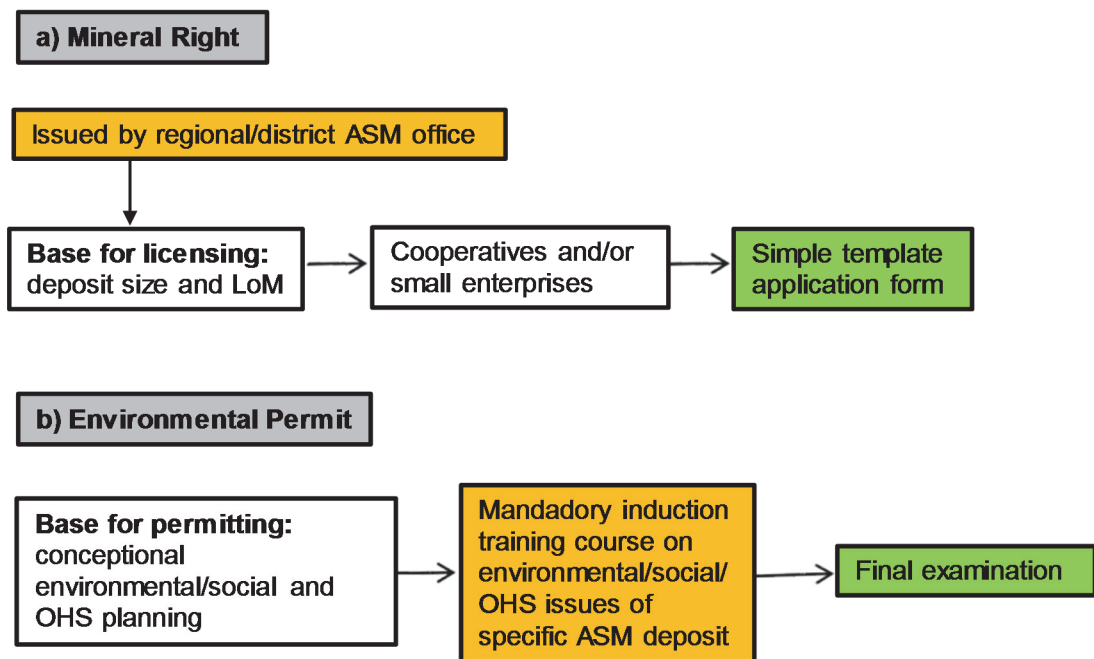


Figure 4: Licensing and permitting procedure in “ASM zones”

5.2 Elaboration of the mine, environmental/social, OHS and closure plans

After a mining right has been issued to the co-operative or small enterprise, the mine plan as well as the environmental/social/ OHS management and closure plans for the future mine have to be developed. This has also to be an uncomplicated and straightforward process. It is advised that the above plans are elaborated with the technical and financial assistance of the regional/district ASM office.

a) Mine plan

The mine plan has to be based on the deposit type worked, the estimated mineral resources and the initial economic assessment. This information has been generated in the prior Designation Phase and is summarized and explained in Table 3 as well as by Examples 1 and 2.

The mine plan should cover the following topics at a minimum:

Mining right

- ✓ Location of area and size of area

Topography and Geology

- ✓ Description of the topography and local geology of the mineral deposit within the mining right, including a topographical/geological plan at an appropriate scale

Resources and Reserves

- ✓ Estimates of resources and reserves along with grade, stating method of estimation supported by analytical reports

Development and Mining Program over the life of mine

- ✓ Description of the mining method (underground or open pit), including the statement of equipment
- ✓ If no communal processing plant is available, description of the mineral treatment method (gravimetric, flotation, leaching etc.), including the statement of equipment
- ✓ Description of the infrastructure (offices, waste rock and tailings storage, water management etc). If communal waste rock and tailings storage facilities are available, their description is not necessary
- ✓ Description of water and power supply
- ✓ Description of access roads
- ✓ Statement of the daily and annual capacity and annual work days
- ✓ A surface plan should be included showing the mine, (processing plant) and the necessary infrastructure at an appropriate scale

Manpower

- ✓ Statement of the number of employees and their positions in the operation (mine and mill manager, environmental and OHS manager, bookkeeper, miners etc.)

Marketing

- ✓ Description of the utilization of the mineral product and to whom it will be sold

Financial Planning over the life of mine

- ✓ Capital expenditures (Capex) for the development and operation of the mine (mining, mineral processing, infrastructure)
- ✓ Operation expenditures (Opex) for mining and mineral processing
- ✓ Cash flow calculation, including royalties and other taxes
- ✓ Net Present Value (NPV)
- ✓ Internal Rate of Return (IRR)

Modified after Mining Plan Format (very small B category mines), Indian Bureau of Mines (2016)

b) Environmental/social/OHS and closure plan

The environmental/social/OHS management and closure issues could be an integral part of the mine plan or a standalone product. These plans should at least cover the following:

Environmental Management

Description of the arrangements made for:

Technical

- ✓ Top soil storage
- ✓ Waste rock and tailings disposal, including ARD treatment (if applicable)
- ✓ Erosion control, including retention walls etc. (if applicable)
- ✓ Water management, including settling ponds, diversion ditches, recycling etc.
- ✓ Dust suppression
- ✓ Noise and vibration control
- ✓ Adequate measures for the risk free utilization of mercury and cyanide (if applicable)

Administrative

- ✓ Auditing requirements
- ✓ Reporting structures

Social Management

Description of the arrangements made for:

- ✓ Information, communication, participation and reporting
- ✓ Employment issues
- ✓ Training
- ✓ Sharing of profits
- ✓ Community development (e.g. investment in social infrastructure)

OHS Management

Description of the implementation of OHS measures:

Technical

- ✓ Ground support
- ✓ Personal Protection Equipment (PPE)
- ✓ Proper lightning (mine lamps)
- ✓ Ventilation
- ✓ First Aid equipment and mine rescue options
- ✓ Sign posts with safety warnings
- ✓ Safe storage for explosives (if applicable)

Administrative

- ✓ Auditing requirements
- ✓ Reporting structures

Closure

Description of the anticipated closure measures:

Technical

- ✓ Dismantling of buildings
- ✓ Fencing of open shafts and adits
- ✓ Leveling and revegetation of land
- ✓ Capping of waste rock and tailings facilities
- ✓ ARD monitoring
- ✓ ARD treatment, if necessary etc.

Social

- ✓ Creation of alternative livelihood
- ✓ Resettlement

Compiled from Wotruba et al (2005), BGR (2010) and Mining Plan Format (very small B category mines), Indian Bureau of Mines (2016)

The figure below gives a summary of the information needed for and the content of the mine plan, environmental/social/OHS and closure plans in “ASM zones”.

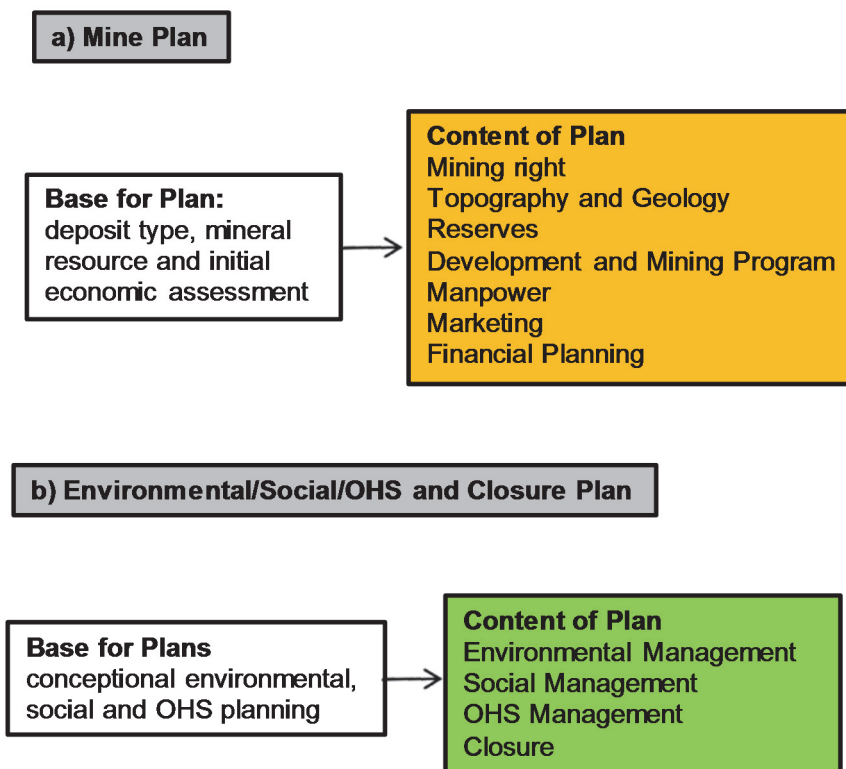


Figure 5: Information for and content of the mine, environmental/social/OHS and closure plans in “ASM zones”

5.3 Summary, time and costs of the Implementation Phase

The proposed issuance of mining rights and the accompanying environmental permitting is quite straightforward and does not pose an administrative burden on the ASM sector. As stressed above, the steady participation and accompaniment by the government in this Implementation Phase is pivotal.

It is estimated that the issuance of a mining rights to mining co-operative or small enterprise with the required permitting within an “ASM zone” could take around 1 month. The support for the elaboration of the mining, environmental management/social/OHS and closure plans could last another 2 months.

In regard to the costs of the Implementation Phase it has to be stated that the support to the ASM sector has to come entirely from the regular staff in the regional/district ASM office. Therefore, apart from their monthly wages, no further costs should occur, may be with the exception of the cost for conducting the induction training courses. Assuming three persons, a mining engineer, an environmental/social and an OHS expert, the three months duration for participative licensing, permitting and planning of mining operations in an “ASM zone” should not cost more than 20,000 US\$.

The required financing for the above activities should be provided by the mining sector of a country, with or without the assistance of international donor project.

6. Management Phase

After the co-operative or small enterprise obtained a mining right and received support by the regional/district ASM office in planning its future mine, the basis for improved management and sustainability of the ASM operation has been established.

The mine plan, the environmental/social/OHS management plan and the closure plan now constitute an “ASM Feasibility Study”, which provides all the technical, economic and environmental details for considering the ASM project as an industrial venture. This facilitates that governmental or even private financing agencies may loan capital for developing the ASM mine or even become a partner in the future mining operation. The required investment (Capex) for developing an ASM mine depends on the type of mining and the capacity of the operation. In comparison with LSM the Capex requirements for ASM mines are comparatively low, ranging from 0.2 to 5 Million US\$.

Also, the aforementioned licensing, permitting and planning exercise allows the prediction of profits (and losses) of the mining operation and enables the government to levy royalties and taxes. Instead of paying the entire taxes, the ASM company may pay into a ASM fund that provides the necessary financial means for the development and maintenance of regional/district offices, the support to ASM during the lifetime of the mine and reclamation of mine out land.

6.1 Supervision of ASM

In regard to the supervision of the ASM mining operation within the “ASM zone”, the regional/district ASM office should adopt an “incentive” attitude rather than a “command and control” point of view. The ASM office should give incentives to mining co-operatives or small enterprises to implement an “efficiency and pollution-reduction ethos”, meaning that entities which save energy and water as well as reduce negative environmental impacts, should pay lesser taxes or pay a smaller percentage into the aforementioned fund.

As in any mining operation regular auditing to review the technical performance and environmental compliance of the mining operation should be conducted. This exercise should be realized jointly by the person responsible for environmental/social and OHS issues in the mine and representatives of the regional/district ASM office.

For the audits adequate checklists should be developed, which could be based on already existing ones. For example, BGR (2014) developed and adapted in cooperation with mining authorities a mine inspection form for ASM, which is being used for regular governmental mine inspections in Rwanda, Burundi and DR Congo.

This mine inspection form is very adequate for technical and environmental mine audits of ASM, as it looks, apart from supply chain and traceability issues, also into technical, environmental and social matters such as:

- ✓ Occupational health and safety (OHS) issues such as ground support, lightning, ventilation, use of PPE etc.
- ✓ Energy and water efficiency such as water recycling or use of renewable energy
- ✓ Environmental issues such as compliance with effluent standards, water standards, safe and environmentally sound handling of chemicals, fuel and combustibles etc.
- ✓ Sanitary and health issues such as drinking water supply, domestic waste, sewage, First Aid kits etc.
- ✓ Social issues such as child labour, forced labor and gender issues
- ✓ Conflict risks and due diligence

The expenses for required effluent and water analysis to check the compliance with existing norms should be initially covered by the ASM office, but later born by the mine enterprise itself.

In case that the mine audit detects shortcomings it is advised that the co-operative or small enterprise is not punished and fined right away. Rather, the problems should be discussed and jointly resolved through corrective actions.

Such regular performance and compliance audits of the mining operations in the “ASM zone” are very supportive for fulfilling the prerequisites of joining a supply chain initiative such as iTSCI for 3T (tantalum, tin, tungsten), Fairtrade/Fairmined for precious metals or CTC for 3T and gold.

The figure below summarizes the extent of the supervision for ASM operations in “ASM zones”.

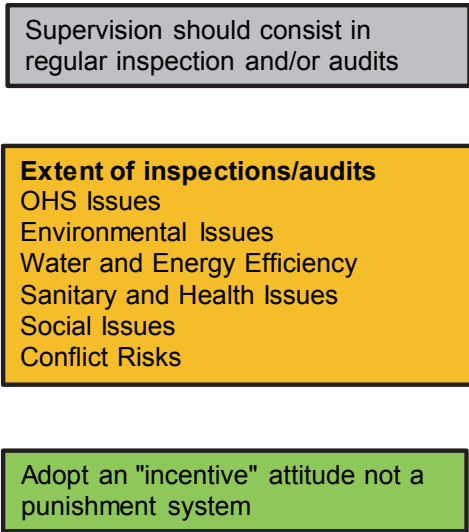


Figure 6: Kind and extent of supervision of ASM operations

6.2 Support to ASM

Depending on the governmental attitude towards the ASM sector there exist a lot of assistance measures which could be provided to the sector as a whole. To name just a few, a lending purchase scheme for equipment, a governmental buying scheme for the ASM mining products or the establishment of facilities for further processing these products could be implemented (see IGF Guidance for Governments on Managing Artisanal and Small-scale Mining, 2015). However, these topics are beyond the scope of this document, which shall describe only support measures within an established “ASM zone”.

In order to manage the ASM mining activities in a proper and sustainable way, the activities of the regional/district ASM office should at least comprise the following:

- ✓ Dialog with local communities
- ✓ Delivery of ongoing training measures
- ✓ Assistance in mine based and regional exploration
- ✓ Assistance with mine closure
- ✓ Provision of communal sanitary, health and education facilities
- ✓ Provision of communal mineral processing and/or tailings facilities (if feasible)

Dialog with local communities

To prevent any conflict between ASM miners and nearby non-mining communities, the regional/district ASM office has to establish a constant consultation and grievance mechanism in the vicinity of an “ASM zone”.

Training measures

Training should cover the whole mining cycle with all its environmental and social implications. After the induction training course, required for environmental permitting, training should be an ongoing exercise, not counterproductive in regard to the work of the miners, tailored to the needs of a particular mine and as much practical and participative as possible. A good example of a training needs assessment and recommendations for training measures for the ASM sector in Rwanda are presented by Metcalf (2015).

Training measures to be delivered could be:

- ✓ Administration of a small mining business (e.g. accounting, purchasing, marketing)
- ✓ Mine based exploration techniques (e.g. mapping, sampling, assaying, evaluation of results)
- ✓ Adequate mining and mineral processing techniques (tailored for a given type of deposit)
- ✓ Occupational health and safety (e.g. ground support, PPE, lightning, ventilation)
- ✓ Environmental issues (e.g. water management, dust suppression etc.)
- ✓ Closure planning (e.g. refilling of pits, fencing of open shafts and edits, capping waste rock piles and tailing storage facilities, revegetation)

Training should preferably be delivered by staff of the regional/district ASM office, with the possible assistance of local consultants.

Assistance in mine based and regional exploration

To direct the daily work and to create more minable reserves at an operating mine, a geologist of the ASM office should assist the miners with mapping and sampling the working faces, assaying of samples and evaluating the results. The costs for mine based exploration have to be covered by the mine.

Concerning regional exploration, the regional/district ASM office should continuously map and sample new areas in the “ASM zone”, which have potential to host new ore bodies for ASM mines. If applicable, this should also include trenching and drilling. In addition, bulk samples should be obtained for mineral processing test. Based on the regional exploration work, new resources/reserves for future ASM mines in the ASM zone should be established.

Assistance with mine closure

Despite continues mine based exploration the resources/reserves of a mine will be depleted some day. At that stage the mine has to be closed in an environmentally and socially sound manner. To achieve this goal the regional/district ASM office has to assist ASM mines to implement the closure measure, which have been described in the environmental/OHS management plan established in the initial phase of the ASM mine (see chapter 3.2.2). This could consist in planning and supervising the dismantling and reclamation measures and to establish and maintain aftercare measures like water monitoring and/or passive water treatment.

In addition, the regional/district ASM office should assist the members of the mining co-operative or small enterprise (through regional exploration) to find another orebody to continue its mining business. In case this is not possible, the ASM office, in cooperation with other governmental agencies, should give support to encounter alternative ways of earning a livelihood.

Provision of communal sanitary, health care, power supply and education facilities

To establish right from the beginning a satisfactory standard of living within the “ASM zone” it is strongly advised that the government, with or without the assistance of NGOs and donors, implements communal drinking water supply sources (boreholes, developed springs) as well as pit latrines and simple household waste facilities for improved sanitation. In addition, one medical post with appropriate personal should be established in the “ASM zone”. Supplementing the provision of these services, appropriate training measures should be delivered by health professionals in hygiene and sanitation. It is also recommendable that the ASM zone should be connected to the regional power grid. If this may not be feasible, alternative power supply facilities, preferably from renewable resources, should be installed. Depending on the distance of the “ASM zone” to educational facilities, a primary school could also be established, to facilitate schooling for children.

Experience tells, however, that the establishment of public infrastructure such as water supply, power supply, medical posts, schools etc. requires a lot of coordination and cooperation between the beneficiaries, different governmental agencies and donors. This could take a great deal of time and delay the timely handover to the beneficiaries.

Provision of communal mineral processing and/or tailings facilities

To better control the environmental performance of mineral processing it is strongly recommended to establish communal processing plants, particularly in gold processing, where mercury and/or cyanide is involved. As learnt from cases particularly in Zimbabwe, Bolivia and Namibia, the installation of a communal mineral processing plant needs to be carefully planned in regard to their capacity and the perception of the users (Hentschel, et al., 2003). Often the installed capacity of the facility does not match the requirements of the ASM miners and therefore the miners lose interest to use the facility. However, through the activities during the prior designation as well as implementation phases, the number of individual mines and their milling needs are better known, which makes the capacity calculation easier.

If it may not be possible to install a communal mineral processing plant, the installation of a communal tailings facilities should definitely be assessed. That requires that an appropriate site is available and that the ASM mines are not too far apart. The capacity problem also applies to communal tailings storage facilities, as the combined tailings production of the individual processing plants is often underestimated and the maximum capacity of the facility is reached too fast. But, as with the mill capacity, based on the results of the prior phases, the tailings production of the individual mines and the life of the mines should be sufficiently known, which facilitates the capacity estimation of such a facility.

The figure below presents options for the government to support ASM operations within a given "ASM zone".



Figure 7: Option for governments to support ASM operations

6.3 Summary, time and costs of the Management Phase

The supervision, meaning the regular auditing, of the ASM sector is a regular task of the regional/district ASM office and does not create additional costs apart from the salary payments and transport costs. Considering three professionals and three vehicles in the ASM office, the monthly expenses should be around 6,000 to 8,000 US\$.

Regarding the support of the ASM sector there are the ongoing training measures and the assistance with mine closure. In addition, there is a need for assistance in mine based and regional exploration. Finally, the support might enclose communal sanitary, health care and education facilities as well as communal mineral processing and tailings storage facilities.

The ongoing training and closure assistance do not need much extra budget, as they could be conducted by the staff of the regional/district ASM office. Therefore, the costs of these activities are covered by the aforementioned monthly salaries and travel costs ranging from 5,000 to 6,000 US\$.

The required financial means for regional exploration work have to be covered by the ASM fund. However, in the early days of a newly established “ASM zone”, exploration funds have to come from other sources, e.g. a LSM company, which has given land to the ASM sector, or the governmental mining sector. It is estimated that a annual budget of around 250,000 US\$ should cover the exploration costs.

The provision of the above mentioned mining and public infrastructure facilities call for substantial budgets to develop, operate and maintain them.

The costs for water supply and pit latrines are best estimated based on the number of members of a mining co-operative or small enterprise. The costs for power supply, medical posts and a school should be estimated based on the number of people in a mining community within the “ASM zone”.

According to the IRC (2012) the preparation and installation of a borehole with a hand pump range from 20 to just over 60 US\$ per person. In addition, the annual maintenance costs for such a borehole with hand pump range from 3 to 6 US\$ per person per year. Finally, the capital costs of a septic-tank latrine range between US\$ 100-350 US\$. The annual maintenance amounts to 12 US\$ per person per year for such a latrine.

To estimate the costs for power supply, an average daily power consumption of 3 kWh per capita is taken (UNdata, 2016), which is typical for countries with ASM. Assuming a mining community with 100 to 300 people (miners and family members), the daily power consumption would be between 300 and 1,000 kWh. For this demand, the IEA (2013) states that the connection to an existing rural power grid costs typically from 8,000 to 13,000 US\$ per kilometer. In comparison a hybrid based power plant (solar-diesel) for satisfying such a demand requires an initial investment ranging from 400,000 to 600,000 US\$.

Based on the World Bank (1994) the provision of health care, based on rural health centers, amounted to around 10 US\$ per person per year in 1994, which translate to 16 US\$ today. This includes both capital and operation costs. Depending on the country, the costs for primary schooling per student per year are ranging from 50 US\$ in Africa to 500 US\$ in South America and Asia (World Bank, 2004; UNESCO 2008, OECD, 2014).

Depending on the capacity of a mineral processing plant, the Capex requirements may range from 2 Million US\$ (capacity 50 t/d) to 4 Million US\$ (capacity 200 t/d). In regard to the communal tailings storage facilities, from experience in other countries, particularly Bolivia, Ecuador and Rwanda (Hentschel, et al., 2003; Tarras-Wahlberg, 2002; SLR, 2013), it is known that such kind of facilities need an investment of 2 to 5 US\$ per ton of tailings. Therefore, a tailings pond which is designed to store for 10 years the tailings of 10 individual mills, producing each of them an amount of 15,000 t/a tailings, will cost between 3 and 7.5 Million US\$.

Although the initial investment for mining and public infrastructure has to come probably from outside sources, with the development of the “ASM zone” and the mining communities, the ASM fund should be utilized to maintain and upgrade these facilities.

7. Conclusions and Recommendations

The concept of “ASM zones” is not new and was discussed already in the early 1990s. Since then the idea of delineating such zones has been adopted by several countries and in some countries even “ASM zones” have already become part of their mining law. However, so far the benefit of such zones is seen rather controversial, as their mineral potential or mineral resources are often too low for sustaining longer-term ASM activities.

In the recent IGF “Guidance for Governments on Managing Artisanal and Small-scale Mining” “ASM zones” have been presented as an important tool, along with other measures such as credit schemes, supply chain initiatives etc., to improve the formalization, administration and management of the ASM sector.

However their delineation, establishment and administration require a great deal of governmental efforts particularly that of the National Geological and Mining Authorities as well as the tight coordination with industrial mining companies and other affected stakeholders. Besides, ASM zones do not come for free, meaning a strong and constant commitment of financial and human resources is required for setting up and running them.

As described in chapters 4.4 and 5.3 governments have to dedicate at least 2 years of work and may well spend up to 2 Million US\$ to identify and delineate suitable zones in their country, which then can be allocated to the ASM sector. Subsequently, the issuance of mining licenses to ASM operations in an “ASM zone”, including the environmental permitting and planning, takes another 3 months and is estimated to cost around 20,000 US\$. Where the ASM zone is situated within a LSM license area, the costs from the identification of an ASM zone until the issuance of a license to an ASM operation could possibly be shared with the LSM company. Once mining operation has started in an “ASM zone” the incurred costs for the supervision and support could increasingly be covered by a special ASM fund, into which the ASM mining operations have to pay.

An estimation of the time and costs to establish and manage “ASM zones” is given below.

Table 6: Time and Costs for ASM Zones

Phase	Time	Cost	Financing Source
Designation (some "ASM zones")	2 years	± 2 Million US\$	Government, LSM, Donors
Implementation (one "ASM zone")	3 months	20.000 US\$	Government, ASM sector, Donors
Management (one "ASM zone")	> 10 years	± 300.000 US\$/a + OpEx and CapEx for Infrastructure	ASM Fund, Donors

The above mentioned initial amount of 2 Million US\$ may sound very high for the designation of “ASM zones” in a country. But in regard to the possibility of better planning and managing the ASM sector to increase its sustainability as well as creating formal income opportunities in rural areas, this amount is well spent.

Any country, which successfully implements and administers “ASM zones” may increase its tax revenues from ASM and reduce the adverse environmental and social impacts of this sector. Conservative estimations of losses in taxes and royalties in countries with a substantial illegal ASM sector, particularly in gold, indicate that tax revenue losses may reach tens of millions US\$ annually.

Furthermore, the implementation and administration of “ASM zones” make ASM operations more reliable for the banking sector, which could contribute to provide the necessary financial resources to develop and operate ASM mines.

8. References

- AGHAM (2005): Small Scale Mining in the Philippines, towards genuine national development, 22 p., <http://de.slideshare.net/AGHAM/small-scale-mining-in-the-philippines-towards-genuine-national-development>
- Amankwaha, R.K & Anim-Sackey, C. (2003): Strategies for sustainable development of the small-scale gold and diamond mining industry of Ghana, Resources Policy 29 (2003) 131–138.
- Amnesty International (2016): “This is what we die for”, human rights abuses in the Democratic Republic of the Congo power the global trade in cobalt, 88 p., <https://www.amnesty.org/en/documents/afr62/3183/2016/en/>
- Arma (2014a): Buenas Prácticas de Gestión Ambiental para la pequeña minería y minería artesanal, 45p., <http://181.65.172.167/siararequipa/index.php?accion=verElemento&idElementoInformacion=215&verPor=&idTipoElemento=2&idTipoFuente=>
- Arma (2014b): Buenas Prácticas de Gestión Ambiental para la pequeña minería y minería artesanal que trabajan con Mercurio, 22 p., <http://181.65.172.167/siararequipa/index.php?accion=verElemento&idElementoInformacion=216&idTipoElemento=2>
- Arma (2014c): Buenas Prácticas de Gestión Ambiental para la pequeña minería y minería artesanal que trabajan con cianuro, 35 p., <http://181.65.172.167/siararequipa/index.php?accion=verElemento&idElementoInformacion=217&verPor=&idTipoElemento=2&idTipoFuente=>
- Aryee, B.N.A., Ntibery, B.K. & Atorkui, E. (2003): Trends in the small-scale mining of precious minerals in Ghana: a perspective on its environmental impact, Journal of Cleaner Production 11 (2003) 131–140.
- Bafilemba, F. & Lezhnev, S. (2015): Congo’s conflict gold rush, bringing gold into the legal trade in the Democratic Republic of Congo, The Enough Project, 35 p., <http://www.enoughproject.org/reports/congo%E2%80%99s-conflict-gold-rush>
- BGR (2010): An Occupational Safety Health System for small scale Mines in Rwanda, Interventions in Support of Mining Companies’ Capacity to Comply with CTC, prepared by Projekt-Consult GmbH, 87 p.
- BGR (2014): Mine inspection form used for governmental mine inspections in Rwanda, Burundi and DR Congo.
- Baumann, H. (1986): Zur Problematik des Kleinbergbaus. Zeitschrift für angewandte Geologie, Bd. 32, Heft 10.
- Camm, T.W. (1991) Simplified cost models for prefeasibility evaluations: U.S. Bureau of Mines Information Circular 9298, 35 pp.
- CfC (2008): Small-scale Mining in Africa -A Case for Sustainable Livelihood, http://common-fund.org/fileadmin/user_upload/Repository_docs/CFC_Report_Mining_2008_final_2_.pdf
- Cox, D.P. & Singer, D.A. (1986): Mineral deposit models. United States Geological Survey, Bulletin 1693, 379 p.

Davidson, J. (1993): The Transformation and Successful Development of Small-scale Mining Enterprises in Developing Countries, *Natural Resources Forum* 17 (4) 315–326.

Dompig, G. (2013): Suriname Small Scale Mining Sector, Status, Progress and Future, OGS, Paramaribo,
<http://www.nimos.org/smartcms/downloads/GDOMPIGPresentationOGS14maart2013.pdf>

Eshun, P.A. (2005): Sustainable small-scale gold mining in Ghana. Setting and strategies for sustainability, In: Marker, B.R., Petterson, M.G., McEvoy, F. & Stephenson, M.H. (eds.) *Sustainable Minerals Operations in the Developing World*. Geological Society, London, Special Publications, 250, 61-72.

Feast, B., Davids, J., Mills, T. & DeVries, P. (2006): Mining Cadastre in Africa – Lessons Learnt, Promoting Land Administration and Good Governance 5th FIG Regional Conference, https://www.fig.net/resources/proceedings/fig_proceedings/accra/papers/ts13/ts13_02_feast_etal.pdf

Fundo de Fomento Mineiro (2012): The Problems of Artisanal Gold Mining in Manica Province, https://cmsdata.iucn.org/downloads/gold_mining_in_mozambique.pdf

Garrett, N. (2013): How to govern and how not to govern artisanal and small-scale mining, RCS Global, 4 p., www.rcsglobal.com

Hentschel T., Hruschka F., Priester M. (2002): Global Report on Artisanal & Small-Scale Mining, Projekt-Consult GmbH, MMSD project of IIED, Report n°70, 67p,
<http://pubs.iied.org/pdfs/G00723.pdf>

Hentschel T., Hruschka F., Priester M. (2003), Artisanal & Small-Scale Mining, challenges and opportunities, Projekt-Consult GmbH, MMSD project of IIED, 94 p.

Hilson, G. & Maponga, O. (2004): How has a shortage of census and geological information impeded the regularization of artisanal and small-scale mining? *Natural Resources Forum*, vol. 28, no. 1, pp. 22-33.

Hilson, G. & McQuilken, J. (2014): Four decades of support for artisanal and small-scale mining in sub-Saharan Africa: A critical review, *The Extractive Industries and Society* 1 (2014) 104–118.

Hinton, J.J., Veiga, M.M. & Veiga, A.T.C. (2002): Clean artisanal gold mining: a utopian approach? *Journal of Cleaner Production* 11 (2003) 99–115.

Hruschka, F. & Echavarría, C. (2011): Rock-Solid Chances for Responsible Artisanal Mining, ARM, Series on responsible ASM, No.3, <http://www.responsiblemines.org/en/resources/arm-publications>

ICMM (2009), Working together: how large-scale miners can engage with artisanal and small-scale miners, CASM, ICMM and CommDev, Pilot Version, 108p,
<https://www.icmm.com/document/789>

IEA (2013): Rural Electrification with PV Hybrid Systems Overview and Recommendations for Further Deployment, Report IEA-PVPS T9-13:2013,
https://www.iea.org/media/openbulletin/Rural_Electrification_with_PV_Hybrid_systems.pdf

Indian Bureau of Mines (2016): Mining Plan Format (very small B category mines),
<http://ibm.nic.in/index.php?c=pages&m=index&id=218>

IRC (2012): Providing a basic level of water and sanitation services that last: Cost Benchmarks, WASH Cost Info sheet 1, 4 p., <http://www.rural-water-supply.net/ressources/documents/default/1-470-2-1359463580.pdf>

ITRI (2011): Long-term history of tin prices., https://www.itri.co.uk/index.php?option=com_mtree&task=att_download&link_id=49605&cf_id=24

Leks&Co (2012): Indonesia Mining Law, Small Scale Mining Area (Wilayah Pertambangan Rakyat), <http://www.indonesiamininglaw.com/mining-area/small-scale-mining-area-wilayah-pertambangan-rakyat/>

Macdonald, F.K.F, Lund, M, Blanchette, M. & McCullough, C. (2014): Regulation of Artisanal Small Scale Gold Mining (ASGM) in Ghana and Indonesia as currently implemented fails to adequately protect aquatic ecosystems, In: An Interdisciplinary Response to Mine Water Challenges - Sui, Sun & Wang (eds), China University of Mining and Technology Press, Xuzhou, 401-405.

Mahobe, F. & Magayane, A. (2013): Artisanal and small-scale mining in Tanzania, Presentation at the Asia-Pacific Conference in Ulaanbaatar – Mongolia, 2013, <http://www.eisourcebook.org/cms/End%20June%202013/Tanzania%20ASM%20Sector.pdf>

Meaza, A. (2011): A regulatory framework for artisanal and small scale gold mining, UNEP, http://www.unep.org/chemicalsandwaste/Portals/9/Mercury/Documents/ASGM/Nigeria/Presentations/formalization/Meaza_A%20regulatory%20framework%20for%20Artisanal%20and%20%20%20Small%20scale.pptx

MERG (2011): Legalization Guide for Artisanal and Small Scale Mining (ASM), ARM Series on Responsible ASM No.5, 28 p.

Metcalf, S (2015): Business and Technical Management of Small-Scale Mineral Producers in Rwanda, Projekt-Consult GmbH for BGR, 65 p., https://www.bgr.bund.de/EN/Themen/Min_rohstoffe/CTC/Downloads/Rwanda_ASM_capacity_assessment.pdf?blob=publicationFile&v=3

MinMinas (2016): Política nacional para la formalización de la minería en Colombia, Versión final, Bogotá 2014, 11 p., <https://www.minminas.gov.co/documents/10180/581708/DocumentoPoliticaVersionFinal.pdf/9fd087db-7849-4728-92ff-6e426accf9c>

OECD (2014): Education at a Glance, OECD Indicators, 570 p., <https://www.oecd.org/edu/Education-at-a-Glance-2014.pdf>

OpinionCaribe (2015): Delimitan áreas para formalización de la pequeña minería en la Guajira, <http://www.opinioncaribe.com/2015/12/03/delimitan-areas-libres-para-mineria-en-la-guajira/>

Peru Support Group (2012): Artisanal and small scale gold mining in Peru, a blessing or a curse, 28 p., <http://www.perusupportgroup.org.uk/files/fckUserFiles/file/Artisanal%20and%20Small-scale%20Gold%20Mining%20in%20Peru.pdf>

Plumlee, S.G., Smith, K.S. & Ficklin, W.H. (1994): Geoenvironmental of mineral deposits, and geology-based mineral environmental deposits for assessments of public lands, Open-File Report 94-203, <https://pubs.usgs.gov/of/1994/ofr-94-0203/94-203.pdf>

Republic of Zambia (1995): Section 108 – The Mines and Minerals (Application for Mining Rights) Regulation, Application Form for a Artisan`s Mining Right, <http://faolex.fao.org/docs/pdf/zam46306.pdf>

Revista Dinero (2013): Un solo trámite para delimitar zonas mineras, <http://www.dinero.com/imprimir/174195>

RSC Global (2015): Guidance for Governments on Managing Artisanal and Small-scale Mining, consulting draft prepared for the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development, 142 p., <http://globaldialogue.info/Consultation%20Draft%20-%20Guidance%20for%20Governments%20on%20Managing%20ASM.pdf>

Siegel, S. & Veiga, M.M. (2009): Artisanal and small-scale mining as an extralegal economy: De Soto and the redefinition of “formalization”, Resources Policy, vol. 34, no. 1-2, pp. 51-6.

Singer, D.A, Menzie, W.D., Sutphin, D.M, Mosier, D.L. & Bliss, J.D. (2013): Mineral Deposit Density -- An Update, USGS Professional Paper 1640-A, <http://pubs.usgs.gov/pp/p1640a/p1640a.html>

Singer, D.A. (2008): Mineral deposit densities for estimating mineral resources, Math Geosci. (2008) 40: 33–46.

SLR (2013): Rwanda Mine Waste Management, for CRONIMET Mining AG (internal report).

Spiegel, S.J. (2013): Managing Small-Scale Gold Mining and Diverse Rural Development Dynamics: Insights from Cambodia, Edinburgh Working Papers in Sociology No. 40, School of Social & Political Science, University of Edinburgh, 44 p., http://www.sociology.ed.ac.uk/_data/assets/pdf_file/0003/129702/WP40_Spiegel.pdf

Sterbik, N., Vasters, J., Franken, G. & Schütte, P. (2015): Artisanal and Small Scale Mining - past and future developments -, BGR internal report, 49 p.

Tarras-Wahlberg, N.H. (2002): Environmental management of small-scale and artisanal mining: the Portovelo-Zaruma gold mining area, southern Ecuador, Journal of Environmental Management (2002) 65, 165 – 179, <http://www.ddiglobal.org/login/resources/enviro-manag2002goldecuador.pdf>

The Philippine Star (2014): DENR wraps up IRR revisions to formalize small-scale mining, <http://www.philstar.com/business/2014/09/21/1371312/denr-wraps-irr-revisions-formalize-small-scale-mining>

The United Republic of Tanzania (2015): Annual report, Minerals Division, Ministry of Energy and Minerals, 37 p, <https://mem.go.tz/wp-content/uploads/2015/11/17.11.15annual-report-minerals-division.pdf>

The World Bank (1994): Better Health in Africa Experience and Lessons Learned, 260 p., http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/1994/09/01/000009265_3970716143108/Rendered/PDF/multi0page.pdf

The World Bank (2004): Cost, Financing and School Effectiveness of Education in Malawi. A future of limited choices and endless opportunities, Africa Region Human Development Working Paper Series, 196 p.

http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2005/07/05/000160016_20050705175204/Rendered/PDF/328020MW0Cost0financing0No178.pdf

UNdata (2016): Electric power consumption (kWh per capita)
http://data.un.org/Data.aspx?d=WDI&f=Indicator_Code%3AEG.USE.ELEC.KH.PC

UNEP (2012): Analysis of formalization approaches in the artisanal and small-scale gold mining sector based on experiences in Ecuador, Mongolia, Peru, Tanzania and Uganda, Tanzania Case study, 30 p.,
http://www.unep.org/hazardoussubstances/Portals/9/Mercury/Documents/ASGM/Formalization_ARM/Case%20Study%20Tanzania%20June%202012.pdf

UNEP (2012): Reducing Mercury Use in Artisanal and Small-scale Gold Mining, A Practical Guide, A UNEP Global Mercury Partnership document produced in conjunction with Artisanal Gold Council, 73 p.,
http://www.unep.org/hazardoussubstances/Portals/9/Mercury/Documents/ASGM/Techdoc/UNEP%20Tech%20Doc%20APRIL%202012_120608b_web.pdf

UNESCO (2008): Global Education Digest 2008: Comparing Education Statistics across the World, <http://www.uis.unesco.org/Library/Documents/ged08-en.pdf>

Upside Down World (2010): Ecuador: Small-Scale Miners Questioning Large-Scale Interests in Southern Amazon, <http://upsidedownworld.org/main/ecuador-archives-49/2703-ecuador-small-scale-miners-questioning-large-scale-interests-in-southern-amazon->

Walle, M. & Jennings, N. (2001): Safety & health in small-scale surface mines, a handbook, Sectorial Activities Programme Working Paper 168, International Labour Office (ILO), Geneva, 51 p.

Walle, M. (2007): Safety & health in small-scale underground mines, didactic material for the ASM sector, Module 2, Safe mine design and mining method, Projekt Consult GmbH, 25 p.
Wardell Armstrong (2000): Design and Pilot Implementation of a Model Scheme of Assistance to Small Scale Miners (Phase I), prepared for DFID, 145 p.,
http://www.bgs.ac.uk/research/international/DFID-KAR/ADD009_COL.pdf

Wellmer, F.W., Dalheimer, M. & Wagner, M. (2007): Economic Evaluation in Exploration, 250 p., Springer Berlin Heidelberg New York.

Wotruba, H., Hruschka, F., Livian, K., Hentschel, T. & Priester, M. (2005): Environmental Management in Small-Scale Mining, MEDMIN, CASM, SDC, La Paz, Bolivia.

Bundesanstalt für Geowissenschaften und Rohstoffe
Stilleweg 2
30655 Hannover
mineralische-rohstoffe@bgr.de
www.bgr.bund.de

ISBN: 978-3-943566-82-6 (PDF)