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Brazilian gold mining industry and relations amid ASM, MSM and LSM: Sustainable development initiatives

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SERIE ENVIRONMENTAL TECHNOLOGY

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ASM, MSM and LSM: Sustainable Development
initiatives**

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RESUMO

Este trabalho enfoca as relações entre empresas de diversas escalas que atuam no setor de mineração aurífera no Brasil, e é um recorte de um projeto maior, onde se analisou a viabilidade de replicação do modelo de comércio justo para a mineração artesanal e de pequena escala no Brasil. Este por sua vez, esteve alinhado à busca de incentivos de mercado para a formalização da mineração artesanal e de pequena escala na América Latina. Entre as diversas tentativas de implementar boas práticas de mercado para as empresas de grande porte através dos sistemas de certificação, o referido projeto é um dos pioneiros no Brasil. Este trabalho busca atender a uma das recomendações do GRI (Iniciativa Global para Relatórios), que é a das relações das MLE (Mineração de Larga Escala) ou MME (Mineração de Média Escala) para com a MAPE (Mineração Artesanal e de Pequena Escala). Segundo esta iniciativa, recomenda-se que as empresas de diversas escalas, como a MAPE, a MME e a MLE alinhem suas práticas às potenciais iniciativas em desenvolvimento sustentável intrasetoriais, promovendo, assim, uma maior sinergia e melhoria de performance da indústria de extração aurífera Brasileira. Ao se alinharem os interesses das empresas aos objetivos de desenvolvimento sustentável – traduzidos por exemplo nos Objetivos do Desenvolvimento Sustentável das Nações Unidas – há ganhos para a sociedade como um todo: ganham as comunidades, ganham os trabalhadores da indústria mineral, ganha o meio ambiente e, conseqüentemente, o benefício se reverte para a sociedade. Existe, assim, o potencial de se endereçar a sustentabilidade nas suas três dimensões: econômica, social e ambiental.

Palavras-chave

Mineração aurífera, MAPE, MME, MLE, desenvolvimento sustentável, sustentabilidade, saúde-segurança-meio ambiente.

ABSTRACT

This work focuses on the relationships among companies of different scales operating in the gold mining sector, and it constitutes a cut of a larger project, in which the feasibility of replication of the fair trade model for artisanal and small scale mining in Brazil was analyzed. This, in turn, was aligned with a program that searched market incentives for the formalization of artisanal and small-scale mining in Latin America. Already known the various attempts to implement good market practices for large companies through certification systems, the project is one of the pioneers in Brazil when it refers to small-scale mining enterprises. This work aims at meeting the grounds for one of the recommendations of the GRI (Global Reporting Initiative), which is the relationship of the LSM (Large Scale Mining) or MSM (Medium Scale Mining) to the ASM (Artisanal and Small Scale Mining). According to this initiative, it is recommended that companies of different scales, such as ASMs, MSMs, and LSMs align their practices to potential initiatives in sustainable intra sectoral development; thus promoting greater synergy and performance improvement of mining in the Brazilian extractive industry. By aligning corporate interests with sustainable development goals – for example, the United Nations Sustainable Development Goals – there are gains for society as a whole: communities gain, workers in the mineral industry have gains, the environment gains protection, and, consequently, the benefit reverts to society in terms of better health, safety and environmental performance of mining industry. Hence, there is the potential to address sustainability in its three dimensions: economic, social and environmental.

Keywords

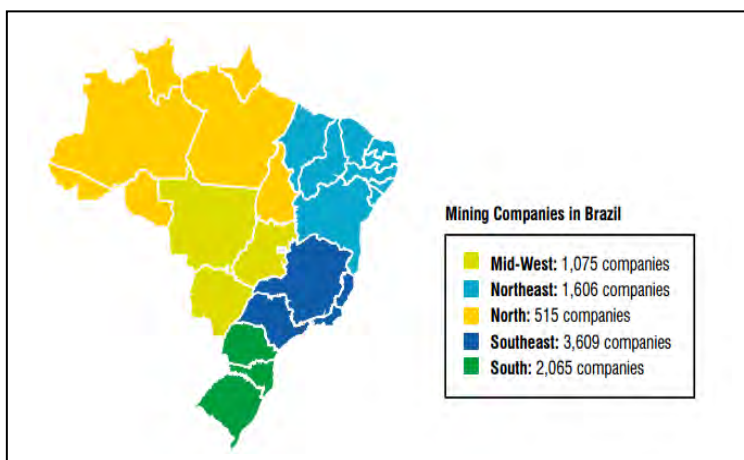
Gold mining sector, ASM, MSM, LSM, sustainable development, sustentabilidade, HSE.

1 | INTRODUCTION

This study focus on the relations amidst ASM (Artisanal and Small-Scale Mining) with LSM (Large Scale Mining) and MSM (Medium Scale Mining) towards sustainable development in the gold mining industry, as some guidelines on social responsibility envisaging good practices in the market have recommended. Despite possible conflicts of interests and perspectives among the smaller, medium and large scale enterprises in the gold minerals sector, there is also space for cooperation, as some examples will be pointed out in this work. To reinforce the market trend of sustainability certification schemes, very common within the large scale companies – which also aims at improving overall performance in the sector, several initiatives have been introduced, as for instance the ICMM (International Council on Mining and Metals) principles to address ASM; the guidelines from CASM (Communities and Artisanal and Small-Scale Mining) in association with the World Bank claiming for possible partnerships; and the United Nations Millenium Goals (which were replaced by the Sustainable Development Goals in 2015). These parties have worked together towards aligning actions in the extractive resources industry to target sustainable development with social responsibility, aimed at reducing threats to human health and the environment, especially due to risks associated to Mercury use, so common in the gold mining extraction. At the same time, those guidelines address the social disruption commonly associated to ASM, and multiple socioeconomic impacts of the activity.

Figure 1 depiction illustrates the total number of mining companies operating in Brazil, according to the National Department of Mineral Production (DNPM) *apud* the Brazilian

Mining Association (IBRAM). That figure is meant to illustrate the whole scenarium of players, where gold mining companies operate in the country.



Source: DNPM (2012) *apud* IBRAM (2012).

Figure 1. Mining companies distributed per regions in Brazil.

Despite the focus of this work being the Brazilian gold mining context, it is important to bear in mind that inputs to resolutions for the resources industry may come from different realities, heritage, economical, social and cultural contexts, and they rely upon governance to implement innovative technologies or management practices. In this sense, international agencies have an important role to play, as they may offer frameworks of best practices worldwide, even from companies operating other commodities. Indeed, some differences can be observed when comparing practices from overseas with the initiatives of the same large scale gold mining companies operating in Brazil. This regard to individual experiences worldwide can be complimentary to build a body of knowledge in this incipient and

also controversial issue of sustainability – or sustainable development as it will be discussed in chapter 2 – in the minerals industry.

In previous work of this Center, Albuquerque (1991) had claimed for the need of addressing medium and small scale mining companies according to their features. Amendments to the Federal Constitution of 1988 have shown an effort to attend needs of smaller miners, named “*garimpeiros*”, in the Brazilian context. For a broader understanding of this issue, refer to Law n. 7.805 from 1989; and Law n. 11.685 from 2008.

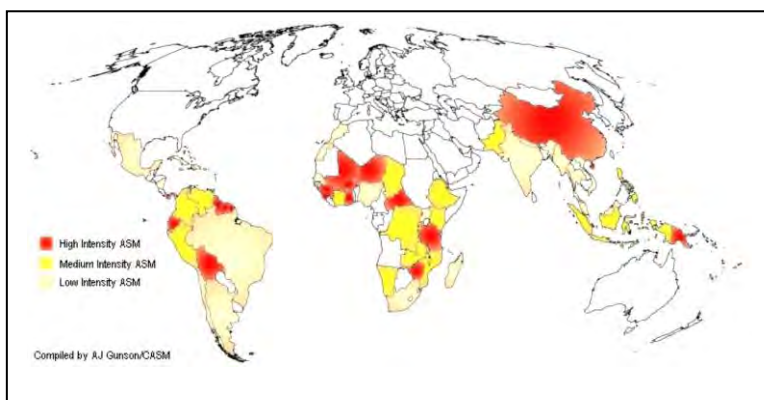
Indeed, there is the recognition that the federal constitution and these amendments opened new avenues for the small miners operations. However, there is still some criticism that the amends do not attend all requirements (Barros, 2016), especially on work rights. Therefore, further steps need to be taken towards sustainable practices in the sector, what can broaden the avenues. One example is something peculiar happening in the Brazilian context within the interaction between ASMs and MSMs, as it will be presented in topic 1.2. dedicated to MSMs, whose mining projects have increased in the country in recent years.

In a globalized economy, one must take advantage of the great chances to share knowledge, specially those related to innovative practices, given that sustainability is necessary but it still constitutes a challenge to be well understood and put into practice in the resource industry. Therefore, this work aimed at mapping and analysing opportunities to improve paths for sustainable development initiatives.

The present work compiles findings from research developed at CETEM Institutional Traineeship Program (PCI/CETEM), with funds from the National Council for Scientific and Technological Development (CNPq) granted to the researcher. These research findings were already partially presented on research reports; in the 5th Internal Seminar of CETEM PCI researchers; at Simexmin – Brazilian Symposium of Mining Exploration; and at the 24th World Mining Congress 2016.

1.1 | Artisanal and Small-Scale Mining (ASM)

ASM is considered a reality with socioeconomic roots very common in developing economies, including Brazil. This “small” sector has potentially upwards of 20-30 million workers globally, according to the World Bank, while the LSM and MSM employ approximately 7 million people (WB, 2013). Figure 2 shows how ASM is distributed worldwide according to a mapping initiative from CASM.



Source: CASM (2008), adapted from Gunson (2004).

Figure 2. ASM distribution and frequency of occurrence worldwide.

ASMs have potential to drive socio, economic and environmental changes, as pointed out by CASM, whether their productive processes are improved, *i.e.*, this subsector can bring opportunities for change towards more sustainable practices in the mining industry; but, firstly ASM need to be well understood to be properly addressed. As Hentschel, Hruschka & Priester (2003: p.14) remarked, “the sector has traditionally received a low proportion of aid relative to its contribution to livelihoods” (Hentschel, Hruschka & Priester, 2003: p.14).

The United Nations Development Programme (UNDP) refers to them simply as small-scale, not using the term artisanal; and a ‘G’, standing for gold, is added, what forms the acronym as follows: SSGM. UNDP also names SSGM a subsector in the industry.

However, one must be aware that the acronym ASM can be applicable to all commodities mined in general. In this sense, ASM of gold mining could be also referred to as ASGM in the literature. In the present work, it will be kept the acronym ASM even when talking about gold.

As the ICMM (International Council in Mining & Metals) already highlighted, the definitions of ASMs, based on size, tend to be schematic as their features vary considerably worldwide. Hence, there is no international consensus on how to define ASM, and in this work, it will be considered the UNDP’s definition applied to gold sector processing, for whom small-scale gold mining (SSGM) is “mining with rudimentary methods and limited mine planning, by a workforce that is not formally trained in mining engineering or geology and operates entirely or partly in the informal economy” (UNDP, 2011, p.13).

Additionally, it will be considered the definition of companies scales based on production, according to the Geological Service of Brazil (2000) that seems more applicable to gold mining subsector than other criteria as number of employees or profits, given the availability of information in the Brazilian ASM context. For instance, in many cases, ASMs can count upon a large number of employees, who are associated into cooperatives to share expenses with investments to keep up with the business. These numbers can vary largely, but many of them still use rudimentary methods for mineral processing. In this case, once more, the abovementioned UNDP definition also applies to address ASM features. On the other hand, some cooperatives are organized in the country, and they manage to acquire some equipments to improve their mineral processing.

Hence, the description from Geological Service of Brazil is yet functional, and it is illustrated in Figure 2. It is just recommended that in the case of gold, the unit is adapted to ounces (oz) instead of tones as the original publication suggests, as it was a general information for the mineral industry as a whole.

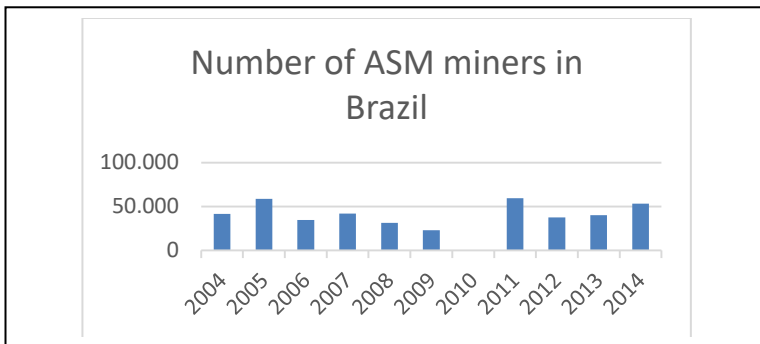
LSM	MSM	ASM
<ul style="list-style-type: none"> • Production >1,000,000 (oz/year) 	<ul style="list-style-type: none"> • Production >100,000 < 1,000,000 (oz/year) 	<ul style="list-style-type: none"> • Production < 100,000 (oz/year)

Source: Ribeiro-Duthie & Castilhos (2016a), adapted from CPRM (2000). Author creation.

Figure 3. A framework for scale of gold mining companies in Brazil based on production.

Hence, the unit is adapted to ounces (oz), as it is the universal unit for gold. In spite of that, sometimes the numbers will be reported in kilograms and the conversion to ounces should be done by multiplying to 35.274 to have an aligned unit.

Recent study from the Centre for Mineral Technology (CETEM) tried to map the ASMOs (artisanal and small scale mining organizations) in the country. Registration of 25 cooperatives were found, according to the National Department of Mineral Production (DNPM) database (Castilhos *et al.*, 2015; 2016a). In addition, 162 individuals holding an individual mining permit were mapped in early 2016. It is of note that these numbers can change overtime, specially in moments of global economical crises, when gold tends to become a target for investors, what has the spill-over effect of increasing the demand, soaring the value of the commodity, and peaking the artisanal and small scale mining activity – what also includes the informal and rudimentary practices.



Source: IBGE/PNAD 2004-2014. Data not available for 2010.

Figure 4. Number of miners in the ASM activity of metals extraction by self declaration, what includes (but it is not limited to) gold.

Heider (2014) highlights several reasons to impact the price of gold, such as: the pressure for gold purchase due to the rebuilding of reserves by central banks; the diversification of financial assets in emerging countries associated with the global increase in population; the same increase in population soars the consumption of mobiles and computer devices – which contains gold – in emerging countries. These factors combined increase the consumption of the metal and, as an indirect effect, lead to peaks in the commodity price.

When the high demand for the mineral increases its value, the number of miners on those periods soars in the sector, setting up the so called 'gold rush'. The number of small scale miners (holding PLG) as per self declared positions can be observed in Figure 3, what includes metals and non-metals extraction; gems; stones; or other minerals. According to the national bureau of statistics, there was no further way to split data to focus on one mineral only. The self declaration of occupational activity may include people involved in formal or informal ASM.

Unfortunately, the lack of planning especially at these moments of rush, the misuse of Mercury or other rudimentary methods, leave a history of impacts on environment and communities, either due to an abrupt increase in environmental pollution, diseases spread and social disruption. If on the one hand, it has led to the creation of some villages or cities (Barros, 2016); on the other hand, it can intensify contamination of rivers and population, affecting the health and social context of many neighbouring communities.

A recent study from FIOCRUZ demonstrated one of those serious effects of Mercury misuse in ASM extraction of gold. The brief summary below shows how an indigenous community

that lives in a forest preservation area has been impacted by the operations of small scale miners (or “garimpeiros”). Again, the observation of ICMM applies, as in some cases the activity is named small for the sake of classification, but the number of people operating or the volume of production, or even the profits may range in terms of scale. In fact, “what is deemed to be small to medium size in one country” (ICMM, 2013: p. 7), may be considered large in another country and *vice versa*.

In the brief case study presented below, there was no clear or secure information on the production and profitability of the gold mining activity undertaken in the preservation area. But it is known – and required by law – that any legal trade of gold requires the reporting of the area where the gold was extracted from. A synthesis on the effects of some ASM activities is summarized in the form of a case study and analyzed below. This data is meant to inform in the sort of socio-environmental impacts, the social disruption, and threats to health ASM can cause.

In the state of Roraima – North region of Brazil – 90% of mineral resources occur in conservation areas such as ecological parks and indigenous lands. Initiatives to protect the Yanomami people have already been carried out, such as the one guaranteed by the Federal Constitution of 1988 when recognizing indigenous rights. As a result of the constitution, the government demarcated and granted 9,664,975 hectares of land to the Yanomami people in 1992, after the expulsion of illegal miners from the same lands, carried out in 1990 by the government itself. However, the ASM miners (‘garimpeiros’) continued to invade, to exploit and devastate the lands of the Yanomami indigenous population.

Only between 1986 and 1990, it is estimated that 20% of the Yanomami indigenous population (1,800 people) died due to illnesses and violence caused by 45,000 garimpeiros who invaded their lands (ISA, 2016). Therefore, we can see the impact and the threat that illegal mining represents to that indigenous population, which has already been reported to government agencies, as shown in the chronological list of conflicts and facts presented below:

1993 - *Execution of 12 indigenous people (mainly children and women, while men of the tribe were participating in event in another village). Action taken by 22 'garimpeiros', which became known as the "Haximu Massacre". The episode led to chain only 4 among all the 'garimpeiros' involved.*

2006 to 2010 - *documentation of the growing number of 'garimpeiros' invading the Yanomami lands carried out by the agencies Hutukara Yanomami Association (HAY, in Portuguese acronym); Socio-Environmental Institute (ISA, in Portuguese acronym); Rainforest; and Survival International.*

2009 - *invasion of indigenous lands by illegal 'garimpeiros' busted by the Police to Combat Environmental Crimes.*

2010 – *proliferation of the use of firearms by 'garimpeiros' in the region.*

2010 – *demonstration of the Yanomami people in front of the FUNAI (National Foundation for Indigenous Population, in Portuguese acronym) of Boa Vista requesting the withdrawal of the 'garimpeiros' from their lands. Protest had legitimacy recognized, but no action was taken to comply with the request.*

2014 to 2015 - a research conducted by the Oswaldo Cruz Foundation (FIOCRUZ) and Instituto Socioambiental (ISA) revealed that the Yanomami population is contaminated by mercury (used by gold miners).

2016 - FIOCRUZ researchers, accompanied by representatives of the Yanomami people, presented the results of the study that show the mercurial contamination to the presidencies of IBAMA and FUNAI in Brasilia, and demand the withdrawal of the garimpeiros from the Yanomami lands.

As explained by Acselrad, this case involves "social groups with different modes of appropriation, use and signification of the territory, having origin when at least one of the groups has the continuity of the social forms of appropriation of the environment where they live threatened by undesirable impacts" (Acselrad, 2004: p 26). There are effects, for example, on "soil, water, air or living systems" - as a result of "the practice of other groups" (Acselrad 2004: 26). Despite all the requests and manifestations, the invasions continue, as well as the environmental impacts, to health, to life, to mechanisms of social functioning of the tribe, not to mention the cultural impacts. In this case study of the Yanomami people selected, one can observe that both the material appropriation - with the use of land and rivers as objects of mineral exploration - as well as symbolic appropriation occur.

And because of the asymmetry of power, one can see how the indigenous are vilified, since having their rights legitimized by the constitution, they do not have sovereignty over their own land and are subjected to the illegal exercise of mining without any effective mechanism that allows them defend their rights.

In the midst of this social conflict, which shows a different valuation of nature: on the one hand, the indigenous population, with a particular way of dealing with the land and assuring its subsistence; on the other hand the 'garimpeiros', for whom the rivers are not more than useful means to guarantee their subsistence, with rudimentary practices highly impacting nature and their own and others' health. It is not the aim to demonstrate a manichaeism; however, because we know that ASM is an activity with social roots and that in Brazil it is also forgotten by the public initiative, as we have heard in the field survey, ASM miners ("garimpeiros") as well as from stakeholders involved with the ASM cause. Therefore, it is seen that the issue is complex.

The ASM miners (or "garimpeiros") might themselves be likewise contaminated; however, data as statistics on HSE (Health Safety and Environmental) impacts related solely to ASM miners in the gold sector was not found, and actually there are only estimatives available for the entire country. In spite of the known socioeconomic and environmental effects of ASM activities, they represent an important livelihood and income source (WB, 2013) for populations worldwide, and ASM involves a large number of people globally. The challenge CASM, the World Bank and the United Nations embrace is to formalize and integrate the activity as the sector represents a great opportunity to address poverty. In Brazil, ASM is responsible for 13% of the official gold production. It seems that the homework of countries where the activity remains – and constitutes an income source – is to find paths for sustainable development of the regions with minerals occurrence, which are generally remote areas.

Challenges of the smallest players are not only legalization, but also WHS practices – what is a consequence of the risks of the sector processes but also from the own informality within the ASM practices. Generally speaking, it is known that mining is a critical sector when it comes to HSE (Health, Safety and Environment) performance in several countries where the activity is of relevance. HSE requires regular investments, research and improvements for a better performance. In Brazil there is lack of information due to the pattern the information on OHS (Occupational Health and Safety) is released for the entire country, where the steps to retrieve data per industry sector is not clear nor linear in the year books released by the Ministry of Work and Employment. Therefore, data can only be collected from indirect sources. This fact is of relevance as it blocks possibilities of research or further studies and comparisons to promote better OHS (Occupational Health and Safety) practical solutions, what could contribute to policies design and their proper implementation. Therefore, whether sustainable development is a target, these blockages need to be addressed. It seems that solutions from the market have been attended through certification schemes.

1.2 | Medium Scale Mining (MSM)

Medium Scale Mining enterprises have entered the sector and show participation in the minerals industry at an increasing rate in Brazil. It is still hard to track their presence through media of any kind or websites; neither the release of reports according to the Global Reporting Initiative (GRI) or other standard. Probably, the level of organizational maturity has influence on the type of behavior from companies, and transparency and

availability of information is still not the most common trend among these medium scale players whose production would stand between 100,000 to 1,000,000 ounces per year. It is also of note that these amounts of production can vary largely among companies. Together they are estimated to count upon 20% of Brazilian total official gold mining production, according to the Brazilian Mining Association, demonstrated in figure 4.

Information about MSM were obtained through online general search, and also through the National Department of Mineral Production. Additionally, the field research and word of mouth showed that there have been associations between MSMs and ASMs, with support from government in some cases. It seems that there has been some movement towards organising and legalizing the smaller players of the gold mining market by stimulating their association to companies, and this initiative departs from government. For small miners, it seems these associations are an opportunity to formalize their business and increase their chances of surviving in the market. Previous work from CETEM already considered the hypothesis of creating opportunities for smaller enterprises to survive (Rodrigues Filho *et al.*, n/d). The smallest producers have prevalence on land, while MSM companies have the ability to raise capital from investors. This association between ASM and MSM was also remarked as attempts to bear with the competition (Cunha, 1991: p. 21).

Along the years, once those associations are more established, it might be possible to better analyse this market behaviour in the Brazilian gold mining industry. For the time being, it is possible to list some of the MSMs who have been operating in the country, or some that are planning to start operations (identified in the table as projects). They are located mostly in remote

areas of the North region of Brazil, but also elsewhere, as it can be observed in Table 1. The start of a project or operations does not assure that the company will be operating in the long term, as it is also common that projects or mine sites are merged to or acquired by other major corporation groups.

Table 1. Some examples of Medium scale gold mining enterprises or projects found in the Brazilian scenarium with respective locations.

MSM Company/Project Nomination	Localities of Operations/Mine sites
1) Luna Gold	1) Aurizona; Cachoeiro
2) Brazil Resources	2) Jaú; Patoá; Tucunaré; Colônia; Artulândia
3) Brazilian Gold	3) Itaituba; Surubim; Boa Vista; Tapajós Nova Xavantina
4) Eldorado Gold	4) Itaituba; Cuiabá; Novo Progresso; Tapajós; Água Azul; Cuiú-cuiú; Caraíbas
5) Carpathian	5) Riacho dos Machados
6) Collosus/Coomigasp	6) Serra Pelada
7) Jaguar	7) Turmalina; Caete
8) Magellan Minerals	8) Coringa; Cuiú-cuiú; Maranhense; Porquinho
9) NX Gold	9) Nova Xavantina
10) Serabi Gold	10) 75 km from Novo Progresso
11) Project Coringa	11) Creporizão
12) Project Porquinho	12) Tapajós; Tocantinzinho
13) Rio Novo	13) Almas; Guaranta
14) Standard Gold Mines	14) Paracatu; São Pedro
15) Tabipora	15) Cuiabá-Santarém
16) Troy Resources	16) Andorinhas

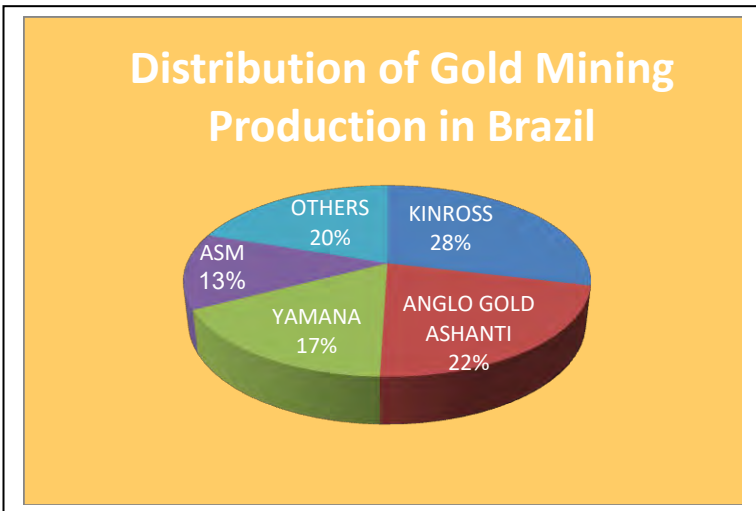
Sources: Online search; field survey; Heider (2013). Table: Author creation.

Table 1 indicates one example of the association between MSM and ASM (at least while this work is written), which is placed on line 6. One can see sixteen of the projects, which does not represent the largest, nor the smallest companies in the

Brazilian gold mining sector, *i.e.*, the production is (or is meant to be) above 100,000 ounces/year and below 1,000.000 ounces/year. As the mining engineer from the National Department of Mineral Production analyses, this type of enterprise seems to be a trend for the next years in the country (Heider, 2014). As up to now only three LSM are responsible for almost 70% of Brazilian total gold production, whether associations between MSM and ASM (either formal or informal) continue in this rate, perhaps the distribution of gold production in the country may change in the long term.

1.3 | Large Scale Mining (LSM)

Large Scale Mining companies in the Brazilian gold mining industry are represented by three main multinational corporations: Kinross; AngloGold Ashanti and Yamana.



Source: IBRAM, 2012, adapted from Ribeiro-Duthie & Castilhos, 2016a. Author creation.

Figure 5. Distribution of production in the Brazilian Gold Mining sector.

Together they are responsible for approximately 67% of the total gold production in the country, as it can be observed in Figure 4. In the pie graph it also can be seen that two of the LSMs are located in the same state – Minas Gerais – and the sum of their productions accounts for 50% of Brazilian production. These percentages and numbers can change overtime, and should be taken as a snapshot, as it is common that some mine sites or projects are negotiated among larger scale players and sometimes the dynamics of mergers and acquisitions cannot be fully tracked and reported at the moment they occur.

For instance, Vale – the Brazilian headquartered giant in the resources industry – used to be a great gold producer in the country since the 1990's. However, in 2003 the company sold “Fazenda Brasileiro” mine site to Yamana, perhaps due to the drop in the value of the commodity, the depletion of some sources or even changes on its market strategy. With that decision, Vale stopped being a leader in gold production. Some time later, in 2011, Vale acquired the “Salobo” mine site and in the last two years there has been movement towards producing gold again, now as a byproduct of copper (Heider, 2014), what could place the company again as one of the largest gold producers in Brazil once operations start. However, as this initiative was before the occupational disaster occurred in Mariana, for the time being it is not possible to completely analyse the scenarium, as Samarco was run with greater amount of capital from Vale.

The mentioned three LSMs operating in Brazil are traditional and well-known in the market and they have done investments to keep up with their businesses for a while, and perhaps they will be the main LSM players in the sector in the long term.

Kinross, for example, invested to extend Paracatu mine life cycle, whose operations would finish in 2016, but with new investments the life cycle of the mine was extended until 2036. Anglo Gold Ashanti has doubled its production in 2012, compared to one decade before (Heider, 2014). All these changes were undertaken in spite of the increasing costs of mining, as the health and environmental impacts of mining have been increasingly regarded by society (this includes investors, communities, and consumers), what turns the planning stage of the mine life cycle more complex; also requiring higher investments to assure the necessary safety of operations.

These large scale companies have been endured by the WHS (Work Health and safety) challenges as well – what is common in the resources industry – but they have worked towards better results, as a brief look through their corporate social responsibility reports can indicate. Reduction of incidents and targeting zero fatalities always appear in the first pages of their sustainability and corporate social responsibility reports. These LSMs also report certifications related to WHS or HSE obtained or pursued, such as ISO 9001 and ISO 14000 – what indicates excellence in practices and results related to WHS. For sure, the great performance in WHS requires investment and training, but also rely on managerial decisions and policies, what places some countries ahead of others.

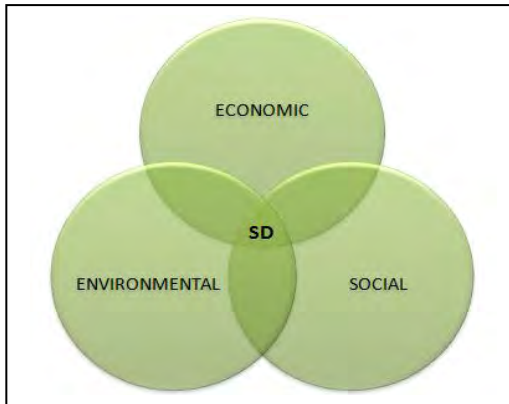
The expertise of LSMs in environmental management and WHS achievements can be a key for sustainable development initiatives towards ASM (and perhaps MSMs too), as it will be demonstrated with the results from surveys within ASMs and observational analysis. But firstly, some discussions on sustainability and sustainable development challenges for the resources industry will be introduced in the next chapter.

2 | PATHS FOR SUSTAINABLE DEVELOPMENT

Sustainability issues raised in this book are meant to be introductory and not exhaustive or definitive. Although the concern with environmental impacts of economic growth have started since the 1960's through the works of Boulding and Mishan (Boulding, 1966; Mishan, 1967) as Ayres already remarked (Ayres, 2008), the empirical aspects, or how to apply sustainability into business practices is still on the initial stages in many industrial sectors, and mining is not that different. Therefore, issues that are cornerstones in sustainability economics (Ayres, 2008) as to consider all the socio, economic and environmental impacts of an enterprise will be briefly addressed in this chapter.

These socio-economic-environmental aspects are seen as interconnected and, therefore, they need to be included and assessed in the actions of companies since planning the mine life cycle, and not only the mere monetary aspects. This is a change that the conception of sustainability and sustainable development brings to table, originating from the relevant discussion on growth and GDP (Gross Domestic Product) capacity to include and to measure quality of life and development. Socio-economic development and environmental protection go beyond mere profit maximization, as Sen announced with his conception of capabilities approach as an alternative to welfare economics (Atkinson, 1970; Robeyns, 2003). This contribution, in turn, set the theoretical basis for the conception of the Human Development Index released by the United Nations Development Programme.

A good standard in sustainability would be to consider those three dimensions inter-connected and balanced, not compartmentalizing them (Lozano & Huisingh, 2010), as Figure 5 illustrates. The intersection area is represented by sustainable development: the joint area where environmental, social and economic aspects meet – what is also in accordance with the United Nations conception of green economy and economic development.



Source: Shields (2016); depiction adapted from the Brundtland Commission (1987) *apud* Ayres (2008).

Figure 6. Three pillars of sustainable development.

As far as these three dimensions are considered and worked through, the chances of achieving sustainable development are closer than when imposing a hierarchy on each of these dimensions. Hence, these circles, as per depiction, should be considered with the same level of importance, weight and space. In this sense, it can be seen that sustainability economics is in line with a new conception within resource economics. Natural resources cannot be taken simply as a gift to be exploited for the sake of profits; and they can end as

they are finite. Thus, there are impacts caused by minerals exploration that needs to be always assessed and considered. The value of nature, environment, human health and socio-economic development should not be undermined by the monetary value. This conception involves a change of paradigm and it may constitute a challenge to be implemented, but absolutely necessary.

Important changes were brought by sustainability economics and also the Brundtland Commission (1987) with the definition of sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987: p. 8). The understanding of green economy, an inspirational goal of UNEP (United Nations Environment Program) seems in line with this conception. UNEP’s definition of green economy points out the aims as “the purposes” for a “Green Economy Initiative” establishment. In this sense “UNEP has developed a working definition of a green economy as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities” (UNEP, About GEI n.d.). It is of note that the “green economy” from UNEP encompasses not only environment but also social equity. Such definition shows commitment to “reverse loss of environmental resources” (UNEP, About GEI n.d.), which targets directly environment and sustainability.

In the same sense, UNDP since 1966 targets guidelines for least developed countries to achieve development standards such as: poverty reduction; achieving sustainable livelihoods (assuring water supply, sanitation and energy); controlling

harmful pollutants release to the environment; prevention of HIV/AIDS and endemic diseases; promoting democratic governance and policies capacity building within countries, among others. UNDP also was set to help countries to accomplish with the Millenium Development Goals (MDG), established in 2008 with eight objectives for global development. Those goals were replaced by the Sustainable Development Goals (SDG) in 2015 to be worked through an agenda until 2030 as figure 7 demonstrates.

The Sustainable Development Goals look for to assist countries in making real change to people's lives while protecting environment and sustaining development gains. As it is stated as UNDP's goal: "to strengthen capabilities and opportunities to reduce poverty and marginalization – focusing on the most vulnerable and excluded population groups – in ways that are sustainable from economic, social and environmental standpoints" (UNDP, n/d). Again, one should bear in mind that the interconnectedness between development and sustainability goes further than mere economic growth. UNEP also supports a proposal of a "new development model" demonstrating "that employment and social inclusion must be integral parts of any sustainable development strategy and must be included in policies that address climate change and ensure the preservation of the environment" (UNEP, About GEI n.d.).

UNEP's effort is to support countries in the achievement of these goals in a sustainable manner while avoiding the inefficient development model of the past. In accordance to those principles, the UNDP initiative looks forward to assist in making least developed countries and excluded populations to work out strategies through development models that are feasible. The UNDP SDGs can be observed as per figure 7.



Source: UNDP, 2015.

Figure 7. Sustainable Development Goals released by United Nations.

There is no doubt these goals constitute a challenge to be achieved and they need to be ‘translated’ into each business context, what has been worked through. The objective of this study was to bring about some examples of initial pavements on this route for sustainable development within mining industry, especially related to ASM.

2.1 | Sustainable Development and Corporate Social Responsibility (CSR)

Considering the definitions of ASM and its characteristics of providing income resource for great contingent of people; its potential for formalization; the goals of sustainable development of United Nations; the principles of ICMM and the GRI, the question guiding this study was to what extent gold mining

sector, as a whole, is embracing sustainability in its processes and practices? And how sustainable development is embedded in the industry interactions, whether they exist indeed.

In other words, given the large impact on environment, health, communities and economies of localities where gold mining facilities operate, how are the several players in the gold production sector interacting towards sustainable development? Is there space to improve those relationships?

It is known that sustainability in the resources industry can be a challenge. Starting from the concept of sustainability itself, that states the use of resources without compromising their potential use of future generations, some authors consider that there is no place for sustainability into mining, *i.e.*, the idea of sustainable development into mining would constitute an oxymoron (Mudd, 2010) since “mineral resources are widely interpreted to be ‘finite’” (Mudd, 2010: 98) or non-renewable.

Anyway, other authors believe that the net of benefits of extractive resources industry can be shared with society (Shields, 2016; Jenkins & Yakovleva, 2006; Villas-Bôas & Beinhoff, 2002). There is also the proposal to consider the benefits of the industry as a whole, and not only one sector or one company (Mudd, 2010). According to Mudd, “it is the sum of all individual mines over time and space and their respective resources, impacts and benefits, which should be considered in ascribing sustainability to mining” (Mudd, 2010: 99). In this sense, sustainable development can be more than a key for merely acquiring social license to operate, as nowadays consumers and investors have been more participative and are requiring transparency from businesses operations. Thus, as far as mining operate with social responsibility, it would be possible

to include the three aspects of sustainability within their competencies. Therefore, access to data about the industry is of paramount importance, what permits life cycle analysis, assessment of processes and how social responsibility and sustainability are embedded in the companies values. That is what the Global Reporting Initiative aims to attend by offering a protocol to improve reporting for the industry – mining included – on a voluntary basis, with indicators for social, economic and environmental aspects (Mudd, 2009).

In line with necessary changes in processes and ways of reporting, certifications as ISO (International Organization for Standardization) have spread out in the market, meant to assure standards for companies processes and practices. There is, for instance, ISO certification scheme that addresses Social Responsibility (ISO, 2014) aiming at showing how companies can pass from good intentions to good actions towards the socio-economic and environmental dimensions of their operations. Also, the interconnectedness of anthropogenic actions and its effects on environment and human health have been more clarified and understood.

United Nations has partnered with the Artisanal Gold Council (AGC) to help developing countries to find solutions for the environmental, health and social impacts of ASGM, as it will be demonstrated in the next section of this work. It is reported by the AGC that usually the small scale businesses are interested in doing their processes on a good standard, *i.e.*, considering sustainability aspects; however, often the funds for the required changes are not enough or available (AGC, 2015). In the next topic, some initiatives undertaken worldwide within ASGM regarding sustainable development are summarized.

2.2 | Sustainable Development in Mining?

Despite being a relatively new concept that may work as an umbrella to attend several perspectives, sustainable development initiatives can be observed in the mining industry expressed in different projects and frames. And the ICMM believes that mining “can make a unique and powerful contribution to sustainable development” and the industry “will play a pivotal role in the implementation of the SDGs” from United Nations. With the GRI and the trend of certifications in the market, it is possible to find reports of Large Scale Mining companies or even from some Medium Scale Mining companies on their respective websites. Those reports constituted part of the materials of the present study. However, this standard generally does not include the ASGMs.

The following examples are selected from contributions of the Artisanal Gold Council, who remarks that ASGMs in itself have searched for ways to improve their processes and reduce environmental and health threats. At the same time, there have been attempts to improve technologies and practices; initiatives to address work rights; and also to attend inclusion of women. Up to date information demonstrates actions undertaken such as per Table 2. The examples related to the Brazilian gold mining industry will be presented in the results section. The present topic retrieved from a literature review is aimed at illustrating the possibilities of addressing at present, the common and old problems of the ASGM sector.

Table 2. Actions undertaken to improve health, safety, environmental and processes performance within ASGM through partnerships for sustainable development.

Country where action occurred	Description of action
Ghana	Training provided to miners on Mercury free extraction techniques;
Senegal	Government is learning about Mercury reduction within ASGM processes;
Democratic Republic of Congo	Practices of improving concentration techniques to reduce Mercury use and release;
Burkina-Faso	Improving relationships between government and ASGM communities; Installation of crusher, wet pan mill, sluices and shaking tables for a Mercury free method of gold separation. Operation started in 2014;
Indonesia	Use of gravity concentration for a Mercury free method of gold separation
Mozambique	Use of ball mill crushing for a Mercury free method of gold separation
Mongolia	Crude preconcentration technique use

Source: Artisanal Gold Council, 2014a, 2014b, 2011.

These are initiatives set in place through partnership with international agencies, government and non-governmental organizations, The United Nations Industrial Development Organization (UNIDO); The United Nations Environment Program (UNEP); the Global Environment Facility (GEF); the United States Department of State (USDoS), among others. Those partnerships are of extreme relevance for a sustainable development of the sector. However, among companies in the sector, how does that relationship would be worked through in the Brazilian context? How have the pathways for sustainable development been paved in the gold mining industry in Brazil?

3 | OBJECTIVE

Given that CASM considers ASM a reality with socioeconomic roots and has the goal of turning this event into a tool for sustainable development, this study aimed at investigating what has been made under this regard amid ASMs, LSMs and MSMs in Brazil, and the opportunities to improve the solutions with results collected from field survey and reports review are analyzed.

As successful experiences can be a remarkable example and dictate trends in the market, be aware of market initiatives constitutes an important step specially when new practices and innovations are to be implemented. Accordingly, sustainability is a relatively new concept, and practices that can address sustainable development can be taken as a drive to bring changes to the market as a whole.

The aim of this work was also at bringing up to date understanding of the concept of sustainability and sustainable development to facilitate its identification and application in the mining sector. As lessons from Change Management already highlighted, knowledge, information and communication are milestones for any process of change (or change of processes); and cannot be avoided when organizations or industrial sectors envisage transitions.

4 | EXPERIMENTAL

Bibliographical review on the concepts and definitions of ASM, MSM, LSM, sustainability and sustainable development.

Corporate Sustainability Reports and Corporate Social Responsibility Reports review and analysis, either the versions released in Portuguese and in English by the large scale gold mining companies settled in Brazil, from 2004 to 2014.

Field survey with ASMs of gold and observational analysis.

Case studies and media review and analysis.

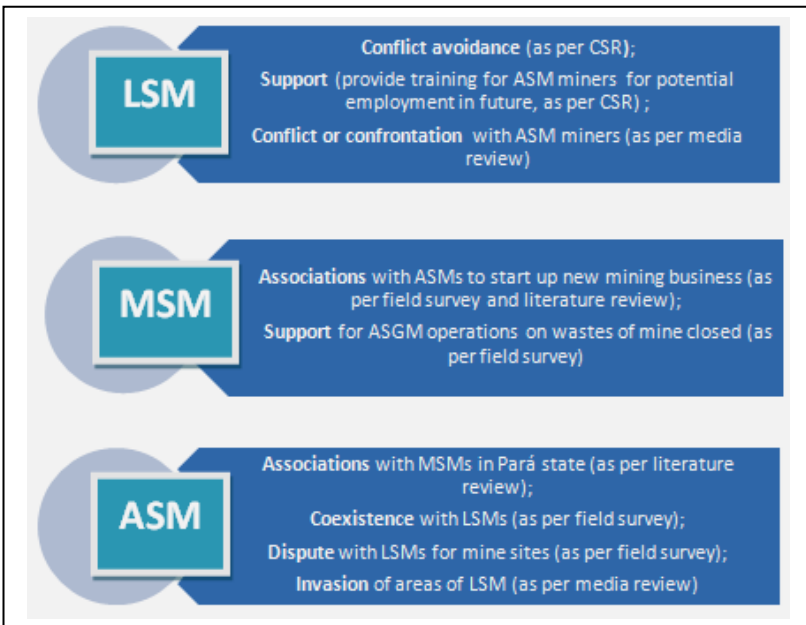
Key-words search either in Portuguese and English such as: ASM, ASGM, gold, Mercury, *garimpo*, conflict, environment, impacts, communities, sustainability, Minamata.

Interview with stakeholders related to the minerals industry either from government and non-governmental agencies.

5 | RESULTS AND DISCUSSION

5.1 | Relationships amid ASMs, MSMs and LSMs

Findings point out different types of relations, and they range from conflict avoidance, support, confrontation, associations, coexistence, indifference, conflicts, to dispute for areas to exploitation. Findings either from CSR review and analysis, field survey, interviews and media review are organized and demonstrated as per Figure 7.



Sources: CSR review, literature review, media review and field survey.

Figure 8. Types of relationships amid LSMs, MSMs and ASMs, compilation from the Brazilian scenarium.

There are indeed some actions being undertaken among LSMs, MSMs and ASMs in the country, but they are not robust if one compare to other countries where the same LMS established in Brazil are also operating. There is room to improve those relationships and set next steps further than understanding the situation of ASM. This work also intended to contribute towards better results for the industry, *i.e.*, to facilitate analysis for more effective sustainable development initiatives.

5.2 | Sustainable Development initiatives

Assessing Corporate Social Responsibility reports (CSR) from 2004 to 2014 demonstrates that LSM C reported in 2011 some action towards ASGM. This was the only example of local cooperation between LSM and ASGM from CSR. As per CSR report statement: “(LSM C) signed an agreement with the environmental protection agency to support artisanal mining cooperatives” (LSM C 2011 Report, p. 60), and the CSR states that: “(LSM C) offers professional training to artisanal and small scale miners” (LSM C 2011 CSR Report, p. 60). The type of training is not reported neither the potential position for ASM miners.

Only in 2012 reference to ASM in Brazil is reported by LSM A. However ASMs appear in a theoretical approach (LSM A Sustainability Report 2012, p. 39), what demonstrates some understanding about the ASM issues, probably guided by the GRI, ICMM and CASM role on analysing and proposing sustainable solutions for the sector. However, in 2012 there was no action in Brazil reported by any LSM.

In 2013, the report states: “there were no conflicts with artisanal miners” in that financial year (LSM C 2013 CSR Report, p. 68). In 2014 though, LSM A reports: “We, therefore, support formalization of the sector, and regulation of those aspects of ASM activity which pose risks – either to employees, community members or our operations” (LSM A Sustainable Development Report 2014, p. 24). Reason would be that ASGMs in Brazil do not pose risks to LSM and for this reason they would be disregarded.

Indeed, the type of conflicts in Brazilian mine sites – that are reported on media review but not in the CSR – are not detected by the Heidelberg Conflict Barometer; hence, actions towards ASM are not considered because LSMs explain their actions referring to this barometer. By analyzing closely the “conflict barometer” criterium, one can advance that the referred “Heidelberg barometer” considers only Rio de Janeiro and São Paulo as conflict areas in Brazil. As the LSMs do not have facilities operating in those respective cities, their actions do not address ASM. What can be seen is a matter of choice: choice of methodology to assess conflict; choice of criteria to justify support or not to ASGM in Brazil.

From media review, it was found there was a fatality of a ASM miner in the facilities of LSM C in 2015, despite this information did not appear in the CSR reports reviewed and analysed.

In terms of the solutions and support offered from LSM to ASM, whether one assume that ASM employs around 20-30 million people globally (as per the World Bank, 2013) and LSM employs 1/3 of that, *i.e.*, around 7 million workers (WB, 2013), the mere offer of training for potential employment sometime in

future does not entirely address the ASM issues. LSMs cannot absorb the population employed in ASMs with the numbers just reported above, which simple maths could demonstrate. Hence, it is understandable the strategy of CASM, UNDP, UNEP and UNIDO, and the World Bank aiming at including and turning ASMs a feasible formalized activity instead of excluding it as an informal and marginal practice.

In this sense, technologies development for this small scale sector urge, as well as training in better practices. As they have limited funds to invest in technological innovations, support in this stage of the ASM problematic can go a long way to address their socioeconomic and environmental impacts.

On the field survey, it was mentioned by ASM miners that a MSM, whose mine site used to belong to a LSM group not anymore in the production of gold market, has allowed an ASGM organization to mine their wastes on a former mine site through an agreement facilitated by the state government. Otherwise those ASM miners would not have alternative source of income to assure their livelihoods.

Information obtained from literature review that MSMs companies have associated with ASGMs to start up new businesses was confirmed and heard from ASM miners throughout the field survey method.

6 | CONCLUSIONS

Relations found amidst ASM, MSM and LSM in Brazil are limited and there is room to improve in the quality of these relations as well as in the outcomes accomplished in regards to sustainable development.

Between LSM and ASM these relationships can be of coexistence, indifference, conflict and support. Examples were demonstrated as per Figure 7, where opportunities to improve these relationships can be of large sustainability impact, and perhaps the improvement on reporting about initiatives undertaken would be also suitable.

Between MSM and ASM these relations can be of coexistence, and indifference; but also, and more importantly, relations of associations. It seems there is some non written recommendation that MSMs partner the exploration of a mine site with ASMs, which are the ones who have priority over small-scale areas previously mined. Example was described in the previous topic.

Not ignoring that there is a crucial role to government and also for assistance/consultancy from NGOs to organise their agendas, it is worth to recognize that the spectrum of issues when dealing with ASM realities points out the necessity of multidisciplinary approaches to be addressed. But at the end of the day, whether appropriate institutions fail to attend all issues raised in the quotidian relations within minerals industry when it comes to ASMs; the LSMs will need to do something in case, as a matter of fact, there are impacts to its operations.

On the other hand, the guidelines from CASM or ICMM are not mandatory; thus, much of what have been done in regards to ASM are actually from LSM initiatives and mutual cooperation between ASMs and LSMs. Therefore, there is a role for governments to rule those relationships as well.

Partnerships for sustainable development do exist. Not only, or often, from relationships amid LSM, MSM and ASM, as it was the focus of this study, and it was demonstrated in the previous topic. There are several case studies of projects undertaken as part of UNIDO, AGC, and government partnerships in countries as Nicaragua, Suriname, Mali, Senegal, Burkina Faso, Nigeria, Philippines among others. An extract of the equipments, processes and practices used on those projects undertaken in overseas localities are listed in Figure 8 to show directions for potential improvements within the Brazilian context.

Some authors are of the opinion that “partnerships must be formed among all those involved in the sector, governments, NGO’s, international development agencies, international mining companies, and the artisanal mining community itself, in order to reach long-term solutions to the problem of this activity” (Barry, 1996: p.14). In the same sense, this study looked for partnerships for sustainable development within gold mining sector with focus to the improvement of the activity in Brazil. These partnerships are not meant to be just bilateral, they can and should include other parties as ASM and sustainable development are thematic that require multidisciplinary approaches.

For better results, it is necessary a further understanding of the conception of sustainability but also a highlight on its practical examples when they occur. This approach might help in

including sustainable development actions in the industry agenda. As the conception of sustainability can be complex, actions can be taken as complex or unfeasible, and sometimes, actions can be simple for one party and of large impact on the other party that experiences the problem.

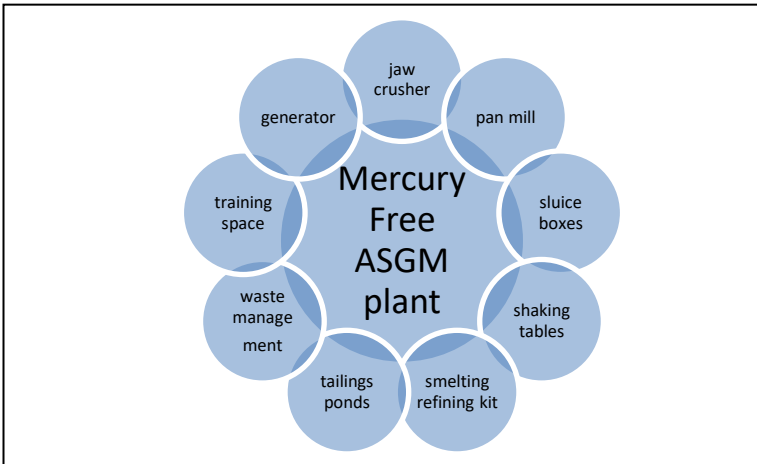
First empirical example: ASMs formalized and trying to do things right have difficulties to convince their “garimpeiros” employed to use individual protective equipments. Possible solution: LSMs share know-how and knowledge in training employees for WHS overall better performance of the sector.

Second empirical example: ASGM have nursery for reforestation with native species, but they cannot reach all areas needed to be recovered. LSMs usually have means of transportation from remote areas that could be used to a potential partnered reforestation program. Native trees nursery from ASGM could also be used to build parks for communities neighbouring mining activities – as it already occurred in Poconé – with a common funding for such a project.

Third empirical example: ASGMs develop aquaculture in former pits, which are not assessed for Mercury contamination. A technical assistance to this recovery activity could test the efficiency and improve the strategy for nature recover and livelihoods assurance.

And last, but not of least, it was found through field survey that several miners in Brazil look for more efficient equipments and they use retort and fume hoods in order to reduce the impact of Mercury use. Some former ASM miners artisanally develop technical apparatus to attend the needs of the small scale gold mining sector. Hence, innovation in technologies and practices,

as the ones listed in Figure 8 – could likewise be developed and applied to Brazilian miners challenges for processing gold and withdrawing Mercury use, as required by Minamata Convention, to which Brazil is a signatory party. Figure 8 is just an example of a pilot project sponsored by UNIDO and the AGC to show how it is feasible to artisanally mine gold Mercury free. It is of paramount importance to find alternatives and support for ASGM activities through initiatives that are not so harmful to human health and the environment.



Source: AGC (2014, 2011).

Figure 9. New Technologies and practices to improve processes for a Mercury free gold production ASM plant.

At a moment of economical crises and downturn in the Brazilian mining exports, given the role of resources industry for the trade balance of Brazil, good practices can go a long way to improve performance in the sector and drive actions towards a more sustainable economic development.

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ANNEX

Identification of companies and respective reports reviewed:

Identification of LSMs	Year	Title of Report
LSM A: Anglo Gold Ashanti	2014	Integrated Report 2014
	2014	Conflict-Free Gold Report 2014
	2013	Relatório de Sustentabilidade 2013
	2012	Relatório de Sustentabilidade Brazil 2012
	2011	Relatório de Sustentabilidade 2011
	2010	Relatório de Sustentabilidade 2010
	2009	Sustainability Review 2009
	2008	Country Report Brazil 2008
	2007	Country Report Brazil 2007
	2006	Country Report Brazil 2006
	2005	Country Report Brazil 2005
	2004	Country Report Brazil 2004.
	LSM B: Kinross Gold Corporation	2014
2014		Conflict-Free Gold Report 2014
2013		Corporate Responsibility Report 2013.
2013		Conflict-Free Gold Report 2013.

	2013	Relatório de Responsabilidade Corporativa 2013 Brasil.
	2012	Data Supplement 2012.
	2012	Communication in progress 2012.
	2011	Relatório de Responsabilidade Corporativa 2011 Brasil.
	2010	Global Compact Communication on progress 2010.
	2010	Data tables 2010
	2009	Kinross Brasil: Assumindo Responsabilidades 2009.
	2008	Nothing found available for 2008.
	2007	Relatório de Responsabilidade Corporativa 2007.
	2006	Relatório de Desenvolvimento Sustentável Brasil 2006 [Bilingual: Eng/Port].
	2005	Nothing available for 2005.
	2004	Nothing available for 2004.
	2014	Conflict-Free-Gold-Report 2014.
	2014	Corporate Social Responsibility Report 2014.
	2014	Relatório de Responsabilidade Social Corporativa 2014.
	2013	Corporate Social Responsibility Report 2013.
	2013	Relatório de Responsabilidade Social Corporativa

		2013.
	2012	Corporate Social Responsibility Report 2012.
	2011	Corporate Social Responsibility Report 2011.
	2010	Corporate Social Responsibility Report 2010.
	2010	Relatório de Responsabilidade Social Corporativa 2010.
	2009	Sustainability Report 2009.
	2008	Annual Report 2008.
	2007	Annual Report 2007.
	2006	Annual Report 2006.
	2005	Annual Report 2005.
LSM C: Yamana/Type or name of Report/ Year	2014	Conflict-Free-Gold-Report 2014.
	2014	Corporate Social Responsibility Report 2014.
	2014	Relatório de Responsabilidade Social Corporativa 2014.
	2013	Corporate Social Responsibility Report 2013.
	2013	Relatório de Responsabilidade Social Corporativa 2013.
	2012	Corporate Social Responsibility Report 2012.
	2011	Corporate Social Responsibility Report 2011.
	2010	Corporate Social Responsibility Report 2010.

	2010	Relatório de Responsabilidade Social Corporativa 2010.
	2009	Sustainability Report 2009.
	2008	Annual Report 2008.
	2007	Annual Report 2007.
	2006	Annual Report 2006.
	2005	Annual Report 2005.
MSM Eldorado Gold	2014	Relatório de Sustentabilidade 2014
	2012	Sustainability Report 2012

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