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A simplified matrix of environmental impacts to support an intervention program in a small-scale mining site

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ABSTRACT

This paper describes a tool developed to evaluate environmental risks at a Brazilian artisanal small-scale gold mining site. The tool consists of a matrix used to determine the relevance of such risks through the classification of mining activities according to the likelihood that they may cause environmental impacts. The language and method are very simple, and thus appropriate for local stakeholders. It ensures their participation when developing a plan of action for intervention and training. When applied to a pilot site in the Brazilian Amazon, the matrix revealed the variables that pose higher environmental risks. These activities were subsequently addressed in a training program to promote better practices. As a result, the mining activities were improved by 28.8% when comparing compliance to environmental requisites before and after the training program. Specifically, the training program resulted in improved gold recovery, and reduced environmental and health impacts.

1. Introduction and background

Artisanal and small-scale gold mining (ASGM) generally involves rudimentary mining and processing methods, and occurs in conditions where few safety precautions are exercised. Often, artisanal gold miners are poorly trained, have low levels of formal education, produce very little gold, and have minimal consideration for the environment. Moreover, ASGM is typically undercapitalized and illegal, carried out by individuals who do not have concession rights (Labonne and Gilman, 1999). With few exceptions, ASGM is strongly associated with poverty, and employs at least 30 million people directly and indirectly worldwide (UNIDO, 2009). Losses of mercury – used to amalgamate gold – to the atmosphere, soils and water contamination are the industry's most significant environmental impacts, although these activities cause a range of other problems, including deforestation, water siltation, cyanide contamination and soil degradation (Sousa and Veiga, 2009).

While there are many issues facing the ASGM sector, this paper focuses specifically on poverty and (the lack of) education. Poverty has been identified as a main driver of environmental degradation worldwide (Brundtland, 1987). Education is a critical determinant of public health (WHO, 2009). To further discuss the link between poverty and education, Krishnamurti (1956) defines the latter as something broader than merely acquiring knowledge, or gathering and correlating facts; it also involves recognizing the significance of life as a whole, and is deeply connected with health and the environment. In the ASGM context, miners struggle to survive and have little access to education, demonstrating the cycle of poverty and depressed safety, health and environmental conditions and standards that persist in ASGM locations.

The need to address poverty as a means to reduce environmental and health impacts and other social related problems in ASGM has been recognized. Hilson (2010a), studying artisanal mining in Africa concluded that the phenomenon of child labour in ASGM is a poverty-driven problem and increased educational support is capable of discouraging children from engaging in mine-related work. Also in Africa, attempts by governments and policy makers to encourage mining communities to move into farming ("re-agrarianize") has failed and artisanal mining has become the primary indispensable economic activity for poor communities (Banchirigah and Hilson, 2010). Other African studies demonstrate that despite the social and environmental problems related with artisanal mining, evidence suggests that people working in ASGM are less likely to be impoverished than those with other

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occupations (Fisher et al., 2009; Hilson, 2010b). In many aspects, the situation in Africa resembles the ASGM scenario in the Amazon region, where people also see mining as a better alternative to traditional agriculture and farming. This scenario demands attention to the better organization and regulation of ASGM, making the application of simple tools to help control environmental and health impacts invaluable.

Worldwide, the formal mining sector is frequently the target of stringent environmental regulations and legislation, a result of pressures exerted by environmentalists and NGOs, and society as a whole. However, informal mining sectors such as ASGM in most cases are not subject to proper regulations, or if they are, governments lack the capacity to provide adequate technical assistance or to enforce compliance. Overall, environmental impacts caused by the world's poorest population are less subject to monitoring and control than impacts caused by formal sectors. As the poorest global population is concentrated in developing countries, most governments lack efficient mechanisms to implement programs to mitigate and control environmental risks, or to enforce their own legislation. Within developing countries, the misuse of mercury is a prominent focus for governments, researchers, NGOs and international organizations. Despite the existence of alternatives solutions based on gravity concentration and cyanidation of concentrates, for instance, mercury amalgamation remains the preferred method of application at most ASGM sites (Vieira, 2006; Sousa et al., 2010).

In Brazil, regulations have been established to attempt control the ASGM activities. For instance, the Brazilian government has adopted bureaucratic procedures that require environmental impact or risk assessment studies for ASGM activities. The definitions of these processes (Environmental Impact Assessment/EIA and Environmental Risk Assessment/ERA) may have distinct meanings depending on the authors (Covello and Merkhofer, 1993; Fairman et al., 1999; Murray and Claassen, 1999; Glasson et al., 2005). For instance, Glasson et al. (2005) define an EIA as "the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made". The USEPA (2010) defines ERA as a process that evaluates the likelihood that adverse ecological effects are occurring or may occur as a result of exposure to one or more stressors. Suter II et al. (2000) offer a similar explanation, defining ERA as the process of collecting, organizing and analysing information to estimate the likelihood of undesired effects on non human organisms, populations, or ecosystems.

While conventional EIA/ERAs are appropriate tools for large organizations, they are inappropriate for regulating artisanal miners, who are not organized at the desired scale or sufficiently empowered to develop and use these elaborate tools. Most ASGM activities take place in poor communities in isolated locations, where people lack formal education, interest and/or resources to invest in any comprehensive monitoring systems. In such conditions, it is imperative that technological assistance and education are simplified and made user-friendly (Hilson, 2005). To ensure successful implementation of EIA/ERAs in such an environment, risk assessment tools must be simple, inexpensive and easy to apply. In addition, local stakeholders (local government, local environmental agency, miners' associations, community leaders) must be able to participate, discuss, understand and use the risk assessment tool. Respecting different contexts and realities, it is hypothesized that the ASGM sector requires a far more simplified approach, and the development of simple alternatives to evaluate the environmental risks posed by activities carried on by informal sectors such as ASGM is of great usefulness to support intervention programs.

This paper examines some of the differences between conventional EIA/ERAs and the developed tool, a simplified matrix of environmental impacts. This paper also describes how the matrix can be applied as a practical and useful tool for local stakeholders and implementing agencies to classify the significance of impacts resulting from ASGM activities. The matrix tool is not as comprehensive as conventional EIA/ERAs, however it is the authors opinion that it is sufficient enough to support interventions grounded in the belief that the most relevant activities are identified, and can be addressed in interventions to improve environmental conditions and standards.

Concepts related to a matrix of environmental impacts have been evolving for decades. The NEPA (USA's National Environmental Policy Act), developed in 1969, is an original tool used for the evaluation of environmental aspects and impacts related to development projects (NEPA, 1969). NEPA established the need to accomplish evaluations of environmental impacts, including accounting for the beneficial and adverse impacts resulting from actions capable of significantly affecting environmental quality. The evaluation of environmental impacts can be subdivided into three distinct phases: "identification", "estimation" and "comparison". In the identification phase, environmental elements are defined traditionally as physical, biological and human components of a specified ecosystem. The identification of environmental impacts establishes the possible consequences (impacts) of a quantified number of activities (aspects). The concept of an identification matrix, broadly used to support management systems, is based on ISO 14001(Barrow, 1999), and is a useful tool according to Leopold (1971). The matrix of impacts correlates activities to the affected elements. Leopold's system (1971) was used as a guide and is realized through a bi-dimensional matrix. In one dimension, the existing characteristics and conditions of the environment are characterized and include the following components: physical and chemical characteristics, biological conditions, cultural factors, and ecological relationships. The other dimension entails the proposed actions which may cause environmental impacts and includes commentary related to: modification of regime, land transformation and construction, resource extraction, processing, resource renewal, chemical treatment, and accidents. After the identification phase, it is necessary to estimate the evolution of all environmental impacts. Models are developed to estimate the magnitude of the current impacts and there are at least three employed methods for this representation: simple mathematical functions, dynamic models and verbal declarations (Veiga and Meech, 1995). Simple mathematical functions of the models can be heuristic equations representing the knowledge of an expert. These functions can be defined mathematically, or simply by employing a ranking system. The linguistic expression allows for the treatment of variables in ranks, in which a group of logical statements can be algebraically represented. These logical affirmatives are later transferred to a flowchart tree, defined for a group of experts. The final phase, called the comparison phase, uses the information generated in the previous phases to identify a "best fit" solution that takes into consideration the magnitude and the significance of the environmental impact.

The method adopted for the identification, evaluation and control of the environmental aspects with significant impact is based on information gathered from the local interested parties, identification of pertinent legislation, numeric evaluation of the significance of potential impacts, and monitoring and control of significant environmental parameters. The term "interested party" is defined by ISO 14001 (1999) as an individual or group interested or affected by the environmental performance of an organization.