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Environmental analysis of mining operations: Dynamic tools for impact assessment

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ABSTRACT

Keeping a high mineral production rate while protecting the environment requires a mining framework where several perspectives are considered and weighed up. The concept of sustainability provides just such a framework. Social and financial needs determine mineral production rates, resulting in a global demand for minerals. To ensure effective environmental protection, different tools and techniques have been developed. One of the most widespread is the so-called Environmental Impact Assessment (EIA). This technique is extremely useful but there are also drawbacks. For instance, subjectivity in initial value choices makes model comparison difficult. To overcome some of these problems, this paper sets out a methodology to establish an environmental analysis, focusing on the evolution of environmental impacts over time. This analysis provides a dynamic tool which could be included as part of any EIA-based techniques. The proposed methodology is general enough to apply to different mine project designs since the model includes a typical mining operation layout together with adaptive parameters.

1. Introduction

The development of modern society is based on the need to fill a demand for goods and services, therefore industry must evolve and adapt to be able to provide and bring to market those products (Kogel et al., 2006). The first step in that process is the supplying of raw materials for further processing and transformation. In fact, the mining industry could become one of the major forces in the global economy, occupying a vital position in the supply chain of raw materials. In this scenario, mining is facing one of the greatest challenges that might arise in any industrial activity. This is the extraction of minerals from the earth's crust without damaging the environment and without producing permanent negative impact. Thus, we find the need to adapt the concept of "sustainable development" in mining arises. Strictly speaking, sustainable development requires that human activities should be carried out in a manner that will not reduce environmental options for future generations. That means sustainable development should meet the needs of present generations while preserving the natural environment in its undisturbed state. Economic development must not compromise environmental integrity (Hilson and Murck, 2000). Hence, as things stand, once a mineral deposit has been completely mined, future generations will have no way to extract that deposit again; therefore, mining cannot be classified as a strictly sustainable activity (Amezaga et al., 2011). Assuming that mining could reach sustainability, sustainable development in mining must be based on fundamental considerations such as the environment, the economy, the society, their efficiency and safety (Laurence, 2011).

1.1. Tools for environmental protection

The development of techniques for the analysis of the environment, and therefore, their use in establishing the foundations for sustainable mining, is focused on knowing, predicting, monitoring, minimising and mitigating potential impacts that mining projects might have on the environment. One of the techniques developed to get to know and predict effects on the environment is the Environmental Impact Assessment (EIA) method. The EIA technique is a standardised process widely recognised and accepted by the authorities. It is a tool to identify how a certain activity might affect human health and the environment (Robinson, 2005). The EIA process is an interdisciplinary multi-step procedure used to ensure that proper considerations are taken into account when making decisions relating to projects that may have an impact on the environment (ELAW, 2010).

In a broad sense, to apply any "environmental analysis" to any project, a knowledge of the production process developed is

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required. This aspect is an "objective" aspect, which allows us to develop a descriptive analysis of all the phases or stages involved. However its accuracy depends on the experience of the working group that develops the analysis (Kontic, 2000; Swor and Canter, 2011). Sometimes groups may not have enough work experience in the process studied (Spitz and Trudinger, 2008).

Furthermore, although there are certain frameworks established, the environmental impact valuation of the production process is carried out through a subjective interpretation, because there could be external factors which have an influence on environmental impact. Thus, the project location, the presence of urban centres, the presence of other environmentally sensitive areas nearby, all these aspects could make an intolerable impact in one area, while, in another location they might prove harmless. Also, when social issues are taken into account, the idea of "risk perception" comes into play (Peterlin et al., 2008; Tukker, 2000) and, this concept will, by definition, be a subjective one.

During the development of environmental assessment, there are several stakeholders with different, or even conflicting, interests that will make certain opinions seem more "credible" than others (ELAW, 2010; Kontic, 2000). During the development of major projects, many working groups are involved to carry out feasibility studies, the engineering projects, and so on. This may result in several points of view, because each group could have different objectives, all depending on the project stage that specific team is working on.

It is also important to note that the process of environmental impact assessment does not guarantee that a project will not be modified or rejected if that process reveals that there are serious environmental impacts at risk.

Detailed considerations are assessed for a single project. However, the problems might be accentuated when two projects coexist in the same area, affecting the same region (Castilla-Gomez and Herrera-Herbert, 2014). Many papers have been published on the general theme of cumulative effects and the situating of cumulative impacts within a regional context. A multiple project approach recognises that many of the challenges of addressing such impacts arise as a consequence of the organisational boundaries that exist between different project proponents (Franks et al., 2013).

Environmental cumulative effects have the characteristics of time, space and human activities, that is to say the phenomenon of time cumulative effect or "jam" will happen when the interval between two perturbations affecting the environment is less than the time needed for the environmental system to recover from each perturbation (Yun-jia et al., 2009).

Cumulative Effects Assessment (CEA) is a tool that can be useful in making decisions about natural resource management and allocation (Hegmann and Yarranton, 2011). Assessing cumulative effects is good practice, makes good sense, and should assist in making good decisions about sustainable development. Further, it is a legal requirement in many countries. Following the introduction of cumulative effects assessment, as a legislative requirement, a number of countries have developed guidance material in response to concerns that the legal requirements may have exceeded the ability of our mining sciences to deliver (Council on Environmental Quality, 1997; European Commission, 1999; Cooper and Sheate, 2002; Connelly, 2011; European Parliament, 2014). Cumulative impact has been defined as "the impact on the environment which results from the incremental impact of action when added to other past, present and reasonably foreseeable future actions, regardless of what agency or person undertakes such other action". Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time (Connelly, 2011).

To carry out an environmental management system in a regional context, regional plans may be designed to manage the combined impacts of existing and future activities on the landscape. This may require detailed knowledge of the current state of each region and an assessment of cumulative effects and their implications for future regional development. However, the current standard environmental assessment system focusses on individual project assessment and is therefore inadequate to fully support the development of regional plans. Thus the need for a new approach is clear. This approach is known as "regional strategic assessment". A detailed description of the environmental, economic and social conditions in a region is necessary to understand the current state of both the human and the natural environments. This knowledge will provide a platform for assessing the cumulative effects which may be associated with past, present and future development activities, as well as offering an understanding of the influence of driving forces. A "public envisioning exercise" that sets desired outcomes is necessary to establish the link between what society wants for a given region and the management approaches and development strategies that might be designed to achieve them. The visioning exercise should be based on a discussion of public preferences and priorities (Johnson et al., 2011).

Cumulative effects assessment, typically, requires the analysis of large complex data sets involving multiple actions, environmental resources and their selected indicators, and impact-causing factors, associated with the spatial and temporal distribution of any actions. As the practice of cumulative effects assessment and management (CEAM) is maturing, new tools are also emerging. This takes place together with the realisation that existing tools might very well be used if their focus is shifted from EIA to CEAM (Atkinson and Canter, 2011).

The problem increases if there is no standard criterion. That is when it is not possible to compare environmental impacts, including cumulative impacts coming from different projects. In this scenario, varying subjective assessments may suggest that it is not possible to know the true environmental conditions of one and the same spot.

An accumulative impact approach is, potentially, just as relevant at the other end of the project life cycle (Franks et al., 2013). In that scenario, we shall describe a methodology which will make the definition of actual environmental impact on a certain location easier, specifically because of the development of several projects in the same area.

1.2. The mining process

Mining is that industry which is focused on the extraction of mineral resources from the earth's crust to make them available to the processing industry. If ore processing techniques are excluded, mining is a compound of a set of various activities, techniques and highly specialised technologies used to reach the mineral extraction target.

To carry out a mining project a number of conditions are necessary, without those conditions success would not be possible (Darling, 2011):

- A mineral deposit has to be found.
- The quality and quantity of mineral should be sufficient for our needs.
- The geographical location of the site must be accessible.
- The location of the site must be technically exploitable by mining methods.
- The trading price of the mineral must be consistent with an economic benefit to be gained from the exploitation.
- The risks of the project should be assumable: the technical risk, the environmental risk, the financial risk, the economic risk, the political risk, the social risk, and the like.