



# Sustainable mining development with community using design thinking and multi-criteria decision analysis

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## ABSTRACT

The economic and social outcomes of mining development can be enhanced by positioning local communities central to development activities. Conventional approaches have failed to respond to the needs of the community without this involvement in decision making. Accordingly, novel development approaches for community involvement and sustainability have to recognize the complex nature of social systems in which mining sector exists. The objective of this paper is to develop a community-centered approach by integrating rapid and participatory nature of design thinking with multi-criteria decision analysis (MCDA) in order to support sustainable development. While design thinking engages multiple stakeholders for generating alternatives, MCDA provides metrics for assessing these alternatives. Drawing on an example from a small scale mining development in Central America, this paper shows that early community involvement and rigorous impact assessment on a regular basis motivate community involvement and give value to the social outcome of mining development.

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## Introduction

A decade ago corporations were questioning whether they should consider social and environmental issues in conjunction with profitability. According to a more recent study by consulting firm Accenture, 93 percent of global CEOs believe today that sustainability issues need to be fully incorporated into their strategies and operations (Grayson, 2010). This sustainable approach to development calls for new thinking and subsequent economic and social innovations for sustainability (e.g., Linnanen, 2005; Dean and McMullen, 2007; Neck et al., 2009). In particular, for an industry that is recognized to cause severe environmental and social impacts such as mining, developing a sustainable model for miners and local communities without losing economic profitability has been a critical challenge for operators (e.g., Hilson and Murck, 2000; Prno and Slocombe, 2012).

Previous research work on sustainable development for mining has long examined sustainability issues due to nature of mining, e.g., extraction of a finite resource, health-concerning working conditions and social costs for different stakeholder groups (e.g., Cademartori, 2002; Bartlett, 2006; Mudd, 2007). Specifically, the

alleviation of mining problems has been effective by adapting initiatives to the specificities of artisanal miners and local communities (Labonne, 1999; Childs, 2008; Milanez, de Oliveira, 2013). Thus, designing proper models for mining industry should address this sustainability challenge and potentially increase the performance of the mining operations and thus lives of social community. In this endeavor the outcome of any sustainable business concerned with more than a single factor (that is, mainly profits) depends on the business design involving environmental and social factors, the choice of metrics and weights used in combining key factors, working with multiple stakeholders, and implementation with feedback for continuous improvement (Greenberg et al., 2011).

Nevertheless, designing for and assessing social value is far from being straightforward, partly because one party cannot fully know the perspectives of diverse stakeholders; in particular, local community. Therefore, the approval and acceptance of society to conduct mining activities require new arrangements which facilitate establishment of social license in different development contexts (Prno and Slocombe, 2012). Despite growing interest in mining industry and research on community participation in mining development (e.g., Zillman et al., 2002; Baker and McLelland, 2003), previous work has thus far offered limited perspectives on how to establish a varied and complex governance structure. In this paper, we take an ensemble of design and multi-criteria decision analysis (MCDA) approach to examine a

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community-inclusive structure in order to better understand, assess and advance sustainable development.

Past work on design thinking has shown the importance of including stakeholders to enhance the outcomes of a project (Brown and Wyatt, 2010) and its effectiveness in identifying social problems by promoting an iterative user-centered approach that supports involvement, rapid prototyping, and systemic changes (Mulgan, 2012). Further, the approach in the paper attempts to complement quantitative analysis in design thinking by using MCDA as an analytical assessment tool with the purpose of improving decision (Köksalan and Wallenius, 2012). More specifically, MCDA is designed to converge toward preferred solutions by interacting with the decision maker throughout the solution process. This research thus recognizes similarities in design thinking and MCDA and integrates flexible MCDA conveniently with design thinking.

Our analysis leads to the following contributions. First, our study addresses a challenge in sustainable development literature when diverse stakeholders (local, societal, for-profit and non-profit) are engaged in the conversation to address social needs and improve governance structure. Second, we combine certain aspects of design thinking, such as iterative solution development with observational research, information diffusion and learning through community interaction, and those aspects of MCDA, such as testing solutions rapidly to find and measure underlying causal relationships quantitatively. Assessing the options rapidly and iteratively with the community can thus offer an approach to sustainable development and avoid environmental costs related to corrective actions (Rinkevicius, 2000) and social risks (Bridge, 2004). Lastly, we contribute to sustainable development literature by suggesting an inclusive governance structure that characterizes a systems view of mining operations including pre-operation, in operation, closure and post-closure. Accordingly, the ensemble of design thinking and MCDA could strengthen positive effects and mitigate negative impacts of mining development.

In the remainder of this paper, to develop an understanding of the role of community and its implications for sustainable development, this paper describes previous work on community-included governance models in mineral development and mining industry. Then it introduces an integrated approach of design thinking and MCDA, which leads to a governance arrangement. A case study of small scale gold mining operations in Central America demonstrates a proposed application of the approach. Central America has been an active mining region with future mining potential, complex stakeholder environment, and a long history of artisanal mining activity. Small scale mining provides a good case because of the necessity and pressure for collaborative management.

## Background theory

Research for this paper has specifically focused on the role and governance of local community in sustainable mining development. Further, the decision making framework has evolved from past work on design thinking and MCDA. Design thinking is key to understanding how community can get involved in the decision making process. MCDA aims to identify and assess an analytical rule that is relevant to the aspects of design thinking, with the intention of measuring progress. These topics are explored in this section.

### *Local community involvement and governance in sustainable mining development*

Sustainability issues have always posed conflicting outcomes in mining industry. On one hand, the mining industry has been the

source for significant wealth generation and economic benefits, which can promote development and reduce poverty by providing jobs, paying local and regional taxes, expanding the market for local resources and so on (Davis and Tilton, 2005). On the other hand, the industry is associated with high environmental and social costs for different stakeholder groups (Cademartori, 2002). There has been a growing interest for the development of more sustainable practices balancing sustainability risks with economic risks to resolve core sustainability issues (Labonne, 1999; Amankwah and Anim-Sackey, 2003; Saldarriaga-Isaza et al., 2013). For a long-term comprehensive solution the social costs of mining has to be included in understanding direct and indirect impacts of a mining site for a large number of stakeholders in upstream and downstream communities (Vancley, 2003; Mudd, 2007).

Recent work on community participation in natural resource management (e.g., Berkes et al., 1991; Cleaver, 1999; Rowe and Frewer, 2000; Innes and Booher, 2004) and mining projects (e.g., Zillman et al., 2002; Baker and McLelland, 2003; Prno and Slocombe, 2012) have shown how enabled communities can influence the mining development process positively. Yet, addressing social issues has proved to be an arduous task due to a number of challenges faced by mine site managers, e.g., weak local government, lack of strategic social and economic planning, and poor planning for returns on investment for the local community and society (Esteves, 2008). In the context of artisanal and small-scale mining the efforts on technical interventions have mostly failed as long as no mechanism was supported to improve the conditions of the miners; therefore, initiatives have to be adapted according to the specificities of artisanal miners to ensure its effectiveness (Childs, 2008). In a study of artisanal opal mining in Brazil the development of mining clusters working with small economic agents, not individually but as a whole, has promoted more economic development and effectively integrated social and environmental issues (Milanez and de Oliveira, 2013).

These trends have led to governance shifts in which mineral developers were expected to gain the ongoing approval and broad acceptance of society from local communities in order to avoid costly conflict and exposure to social risks (Prno and Slocombe, 2012). Creating a new governance structure with a network of interdependent actors can help solve societal problems or generate opportunities (Rhodes, 1997; Kooiman, 2003). While environmental governance with focus on contemporary sustainability issues can improve an industry's sustainability performance (Campbell, 2003; Kemp et al., 2005; Lemos and Agrawal, 2006; Schiavi and Soloman, 2007), the difficulty in this conceptualization of governance lies in the formation of a legitimate governing agency (Kooiman, 2003). The limitations of conventional state-managed governance have supported the need for new governance arrangements to enable sustainability initiatives (e.g., Kooiman, 2003; Lemos and Agrawal, 2006).

In current practices, community relationship management has proven to be crucial to development and operations of the mine. Labonne (1999) suggests a system of considering the local community as a human capital asset as well as a stakeholder to voice its aspirations in developing the mine. This system should engage the community to include its long-term needs beyond short-term job creation and plans of protecting the community's environmental and social well-being, post-mining. Esteves (2008) identifies global initiatives supporting sustainable development, corporate social responsibility, changes to common regulations, utilizing the potential of local community in value maximization, multiple stakeholder partnerships as a number of industry trends that have affected the mining practices in a socioeconomic context.

In an effort to structure governance for sustainability outcomes, a range of contextual factors with the actions of the individuals is to be considered to influence the process for environmental and

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