



Review Paper

Review on Sustainable Mining Practices

N. Pavan Kumar

Cyient Ltd., Software Units Layout, Infocity, Madhapur, Hyderabad-500081, Telangana, INDIA

Available online at: www.isca.in, www.isca.me

Received 18th September 2014, revised 25th October 2014, accepted 22th November 2014

Abstract

Mining can become more environmental friendly and sustainable by adopting and integrating the Social, Environmental and Economic developments that will minimise the environmental impact of mining operations. These include less usage of water and energy consumption, minimizing land disruption and waste production, preventing air, water and soil pollution at mine sites, and conducting successful mine closure, reclamation and rehabilitation activities. Some of the practices are discussed to make mining sustainable.

Keywords: Mining, Sustainable, Environment, Safety.

Introduction

In the mining sector, sustainable development means a concept of needs, an idea of limitations, and a future oriented paradigm and a process of change. The investments in minerals projects should be economically profitable, technically suitable, environmentally sound and socially responsible. The Strategy for incorporating involved in extracting non-renewable resources have come under increasing pressure to embed the concept of sustainability into strategic decision-making processes and operations. In addition to these considerations, responsible corporations have been able to move towards sustainability by developing a range of appropriate stewardship initiatives. Economic development, environmental impact and social responsibilities must be well managed, and productive relationships must exist between government, non-government organisations, industry and stakeholders. Achieving such a situation is simply a 'good way to do business'.

Material and Methods

Safety: For both ethical and business reasons, a mining operation should aim to prioritise safety. Characteristics of safe mines include a commitment to risk management; appropriate attitudes and behaviours; reporting systems need to be in place; a focus on education and training; and a focus on processes and equipment¹.

Economy: Unless a mine is profitable, it cannot sustain. Since mining has the potential to shape and affect economy directly and indirectly, the aim for mine managers is to generate profit responsibly for as long as possible by keeping the costs to a minimum while maximizing revenue. This will also maximize the equitable benefits to all stakeholders, including shareholders, employees, local communities and businesses, which depend on

the mine, as well as the governments that benefit by means of taxes and royalties.

Resource Efficiency: A mine has to be well-organized in the way the resource is managed and extracted. The Coordination between the Mining engineers, geologists and metallurgists will help to enhance the resource extraction.

Environment: Adopting leading environmental management practices and enhanced understanding of key issues, environmental challenges, sharing of information and understanding with the conservation community, improving communication between stakeholders on mining projects makes excellent business sense. Unless steps are taken in the planning and operational stages to protect environmental values, long-term liabilities such as acid mine drainage, may result.

Community: Finally, a mine needs a 'social licence to operate'. Unless the community is engaged with strategic approach to community development, human rights issues across mining operations and enhancing relationships with local bodies, confrontation may ensue. Mining operations run by companies have been disrupted on many occasions in the recent past particularly from local artisanal and small-scale miners, who were mining in many cases before the commencement of the larger-scale operations.

The Mineral Cycle: A mining project involves several stages, starting with initial Exploration and settling with Reclamation and Rehabilitation (post-closure scenario). Phases of mine life cycle are Exploration, Mine planning, Construction of access roads, Mineral Extraction/Processing, Mine closure (Planning/Implementation) and Reclamation and Rehabilitation (post-closure scenario). The major objectives and activities carried out during different stages of mining are outlined in table-1.

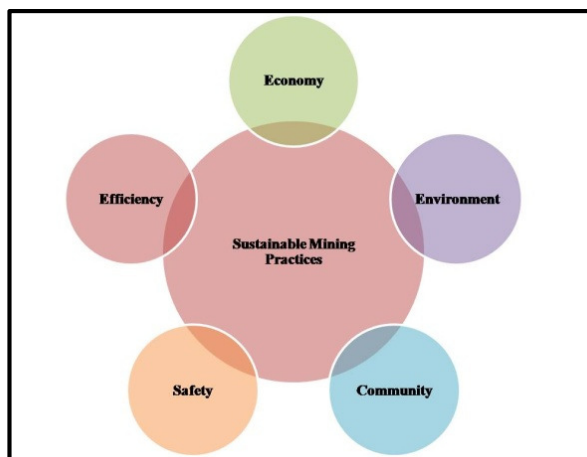


Figure-1
Sustainable Mining Practices²

Table-1
Major objectives and activities carried out during different stages of mining

| Mine Phase | Major Objectives | Activities |
|--------------------------------|--|--|
| Exploration | Discovery and mapping of the extents of an economic ore deposit | Review of existing geological information, Surface Reconnaissance(mapping , sampling), Subsurface investigations(drilling) |
| Mine Planning | Assess the economic viability of mining and processing | Development of mine and waste management plan, characterization of baseline site conditions, Environmental and Social Impact Assessment etc. |
| Construction | Construction of facilities and infrastructure for operational mine | Construction of mine infrastructure, Processing unit, waste contaminant and water treatment plants |
| Extraction | Extraction and processing of ore deposit | Mineral extraction and processing, Dewatering, Waste facilities like Tailings etc., |
| Mine Closure | Management of long term Environmental Impacts | Environmental monitoring, Site development, water treatment, waste storage facilities |
| Reclamation and Rehabilitation | Reestablishment of pre-mining conditions, Land use | Site Reclamation, water treatment |

The sustainability principles that have relevance for all the

different stages of the mining cycle may be summarized as follows: Environmental management and collection of baseline data like surface, groundwater soil types and mitigation of environmental degradation due to mining operations, The Safety management, Economically sustainable mineral development within the carrying capacity of the environment, Scientific mining with efficiency-increasing technologies and best available practical technical solutions, Continuous improvements in mining by implementing environment friendly technology, Management of socio-economic impacts and creation of alternative capital in the form of social and physical infrastructure, Inter and intra-generational equity, Stakeholder engagement and involvement of local communities is crucial in decision making, Transparency in communication and Rehabilitation of abandoned and closed mine sites.

The above principles apply to different phases of the mining cycle simultaneously, not in a sequential manner. Through the interaction of these principles with the activities carried out in the different stages of the mining cycle, an appropriate framework for sustainable development is established.

For achieving sustainability, a mining project should be economically viable, financially cost-effective and technically efficient. This will assist the mining project to have the capability to maintain continuous environmental and socio-economic improvements, from mineral exploration, through operation, to closure. In operational terms, sustainable development in the mineral sector implies a mix of scientific mining, technological developments, environmental responsibility, and socioeconomic development of local communities, stakeholder engagement and transparency in communication; this will ensure the growth and sustainability of the industry.

Scientific Mining: The aim of scientific mining is mainly to improve environmental impacts and concerns which include innovative mining methods, geoscientific knowledge and practices originating from a systematic approach to mine development and operation. It involves adoption and continuous development of technology reflected in the advances in equipment and management practices. Scientific mining ensures the efficient use of the resources, both in the management and extraction of minerals. There are many examples of non-sustainable mining practices, a common one in many developing country mines being extracting only the highest-grade material in a deposit, ignoring the lower grades, for short-term gains. Scientific mining is essential for the conservation of a non-renewable resource and its optimum and efficient utilization and thus constitutes the first step for environmental sustainability in mining.

Opportunity exists to deepen the geoscientific knowledge base as a means of optimizing the exploitation and utilization of the country's mineral resources while enhancing the capacity of regulatory agencies for the purpose.

Minimizing Environmental Impacts: In order to contribute to sustainable development, a mine must minimize the environmental and physical risks throughout the mining life cycle from exploration, through construction and extraction to closure and reclamation. This is achieved by adapting the effective environmental management plan which includes the following elements: Collection of Baseline environmental data for Environmental Impact Assessment (EIA) and preparation of Environment Management Plan (EMP) during mine planning (or pre-feasibility/feasibility stage), Biodiversity management including mitigating the effects on flora and fauna and preventing pollution of rivers, streams and creeks, Pollution control in respect of airborne contaminants, noise and vibration, Management of hazardous substances including process reagents, oil and fuel, Managing acid mine drainage and contaminant leaching, Mine Tailings including recycling and sustainable use of minerals, Management of water including that generated during mining operations, mineral handling and processes.

Technological Advancement: In recent years, developing and use of new technologies in mining industry has taken place in the application of information technology (IT) and computers to mining methods at different phases of mining operations. Automation in mining can improve the safety, can streamline operations and can reduce the operational time. In exploration, for example, a significant development has been the automated processing of a large volume of geo-statistics through the use of computers.

The collection and interpretation of various types of data helps to prepare models of mineral occurrences and to orient drilling operations, thereby reducing environmental damage and reducing waste. Significant advances in geochemistry and geophysics (including airborne geophysical and geochemical analysis) have increased the accuracy and range of data for interpreting geophysical environment. Other innovations in mineral exploration include satellite imaging, visualization at multiple temporal and spatial scales using remote sensing and geographic information system (GIS) maps, three-dimensional (3D) models, the use of global positions system (GPS) and low-impact seismic methods that minimize environmental damage and increase productivity.

Mine Closure and Rehabilitation: The final stage of the mining cycle, the mine closure plan, refers to the process for ensuring that mining operations are closed in an environmentally and socially responsible manner. The mine closure and associated reclamation and rehabilitation of previously used lands which are utilized for mineral extraction have possibly the most important significance for sustainable development in the mining sector. The temporary use of land for quarrying and mining has a potential to establish sound reclamation practices.

Mine closure is necessary in order to provide beneficial and sustainable afteruse of the mine site in the long term, the principles of sustainability would require these lands to be returned for some other beneficial use once mining operations are completed.

Mine closure refers to the final stages of mining activity, after production and processing have permanently ceased leading to decommissioning of site infrastructure, relinquishment of the rights to mineral concession and rehabilitation planning for the mine. Reclamation is the process to bring a site to a condition similar to its pre-mining condition by removing structures, replacing overburden, replanting vegetation where mining operations have completely ceased.

The aim of the closure process including reclamation/rehabilitation is to restore “the surrounding environment to a state, resembling as closely as possible that which existed prior to the commencement of mining, as measured by both chemical and biological parameters” and “to ensure that environmental restoration is adequate to allow the establishment of a diverse and functional ecosystem in the area”³.

Environmentally, a mine closure plan⁴⁻⁸ must ensure the Public Health and Safety, protect Physical and Chemical deterioration of Environmental resources, the mine infrastructure (roads, buildings, spoil heaps, tailings and waste rock areas etc.) is evaluated and those posing safety risks are removed from the site, Closure of uncontrolled landfills (Risk based classification) and elimination of waste dumps (Hazardous substances) are identified and disposed off in a controlled manner according to hazardous waste management regulations, Implementation and construction of controlled landfills, Provisions for Pollution prevention, adequate (surface and ground) water supplies, clean air and productive land are made available for future operations, Provide beneficial and sustainable after-use of the mine site in the long term, minimize adverse socioeconomic impacts and maximize socioeconomic benefits.

Stakeholder Engagement: Strategic Stakeholder management can achieve contribution to sustainable business growth and sustainable development, by understanding the concerns and interests by gathering and analysing the information collected from different Stakeholders. It includes effective communication with local communities, by developing a communication program with all interested parties and identifying, analysing and managing the issues occurring in all stages of the mine life cycle from exploration to mine closure activities. The functional issues of consultation will differ from one stage to the other depending on the nature of the mining activity in a particular stage and its potential impact on the community and helps in decision making. Community relations and discussions is a continuous process as it is critical for a mining company to gain and maintain its “social license to operate” and need to maintain a two-way approach between the stakeholders to avoid

community opposition and confrontation that can breakdown the mining operations in any stage.

Conclusion

The Philosophy of Sustainability has application for all stages of the mine life cycle from exploration to mine closure activities. These principles will help to assist the mining industry to maximise the opportunities for economic and social development. Restoration and regulations help to minimize the environmental and social impacts of mining and by increasing recycling and sustainable use of minerals. Sustainable development of mining is possible by enhancing the benefits while mitigating the negative impacts both when mining is taking place and subsequently as well as improving stakeholder participation in the management of the resources. Social and environmental responsibility is the foundation of responsible mining and sustainable development, mining initiatives like scientific mining, technological developments, environmental responsibility, and socioeconomic development of local communities, stakeholder engagement and transparency in communication will ensure the growth and sustainability of the industry^{4,8}.

References

1. Laurence D.C., Safety Rules and Regulations on Mine Sites—The Problem and a Solution. *Journal of Safety Research*, **36(1)**, 39-50 (2005)
2. Laurence D.C., Establishing a Sustainable Mining Operation—An Overview, *Journal of Cleaner Production*, Elsevier Science Ltd, 19(2-3), (2011)
3. Heikkinen P.M., P. Noras and R. Salminen (Eds.), *Environmental Techniques for the Extractive Industries, Mine Closure Handbook*, (2008)
4. Laurence D.C. Why Do Mines Close?, Proceedings First *International Seminar on Mine Closure*, Australian Centre for Geomechanics, Perth, 83-94, (2006)
5. Ministry of Mines, *Annual Report*, Government of India, New Delhi, (2011)
6. Institute for Studies in Industrial Development, New Delhi, *Mining Report*, (2012)
7. Australian Government, *Mine Rehabilitation*, A handbook in the *Leading Practice Sustainable Development in Mining Series*, Department of Industry, Tourism and Resources, Commonwealth of Australia, Canberra, (2006)
8. Australian Government, *Mine Closure and Completion*, A handbook in the *Leading Practice Sustainable Development in Mining Series*, Department of Industry, Tourism and Resources, Commonwealth of Australia, Canberra, (2006)