DEVELOPMENT OF SOLID MINERALS IN AN ENVIRONMENTALLY AND SOCIALLY SUSTAINABLE MANNER

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ABSTRACT

In the development of solid mineral in any nation, the most important issue of noteworthy is that whereas mineral industries appreciate that they mine and process mineral to maintain and advance standard of living of humanity, they must do so in a manner that protects the earth and its environs so that the generations unborn are not adversely impacted and can enjoy its bounties. However, this paper explores solid mineral mining in the perspective of sustainable development or sustainability, and provides some guiding principle for mining industries wanting to operate more sustainably. Social and environmental issues are highlighted. Some sustainable practices for solid mineral development were brought to light which includes sustainable mining practices (safety, economy, resource efficiency, environment, community). Others sustainable practices discussed comprise environmentally sustainable mining, which recommended reduction in both the input (water, energy, land disruption) and output (waste, acid rock drainage) flow into mining system; and framework for responsible/ sustainable solid mineral development. Now that Nigerian government has recently revisited solid mineral roadmap with the view of license issuance to prospective miners, it will become increasingly important that mines should start pursuing socioeconomic and environmental issues with improved strategy that involves sustainable development into mode of operations in the companies.

Key Words: *environment, social, sustainable development, mining*

1.0 INTRODUCTION

Minerals are considered to be the key to development and the foundation upon which our modern society is built. Goods made from mineral raw materials are the basis of all advanced societies. Adequate supplies of mineral materials and wise usage of mineral resources have always been the most important determinants of a nation's survival (Adekeye, 1999). Minerals and metals have brought huge benefits to society – they are vital commodities that serve as a foundation to society's material quality of life. In today's world, population growth, urbanization, social and economic development and even demands for a green (or low carbon) economy are all contributing to an increase in the demand for minerals. However meeting that demand and achieving the benefits comes at a cost (ICMM, 2012; Adekeye, 1999).

There have been disputes over land use, property rights and environmental damage, concerns about revenue transparency and corruption and a growing debate about the distribution of the benefits of mineral wealth. Tensions within communities and regions have often been the result. In the extreme, there has been conflict. However, mining is a key contributor to economic growth and improved material quality of life. Mining's long time horizon, its need for both skilled and unskilled labour, its links to regional infrastructure and service development as well as the importance of the products that it produces, means that its activities should be conducted in a manner which is environmentally and socially acceptable to be able to contribute sustainable development. With responsible public and private management, the mining and metals industry can contribute to poverty alleviation across the world while maintaining ecosystem integrity (ICMM, 2012).

To date, it appears that the main constraints to sustainability in the mining sector derive from the ever-increasing demand for mined resources; the consumption of resources (mostly energy and water) needed to extract and process metals; and the increasing pollution generated by the extraction process. This holds true for both large-scale, often multinational corporate, operations as well as for small-scale or artisanal ventures (SDKP, 2016). Unless the environmental and social issues that are associated with solid mineral development are managed, the considerable disruption to livelihoods and to the social fabric of communities in the mines can negate any positive and long- term benefits that solid mineral mining brings (Rajaram *et al*., 2005).

From the perspective of mining companies, reducing impacts and risks eventually translate into lower costs of doing business—and provide opportunities for building relationships with local communities. Better community relations reduce the chances of conflict between the mining industry and those who work in or live nearby mining operations. Poor community relations can even lead to the militarization of the mining site and draw the company into wider conflict (Rajaram *et al.,* 2005).

Transparency, effective regulation and good corporate governance can unlock the potential for extractive industries to operate as a force for social progress. In this work, solid mineral mining operations are thoroughly explored in light of sustainable development for responsive social and environmental practices.

2.0 SUSTAINABILITY IN RELATION TO SOLID MINERAL INDUSTRIES

The concept of sustainability has been defined as "meeting the needs of the present without compromising the ability of the future generations to meet their needs" (WCED, 1987). To the perspective of solid mineral development, sustainability should mean to meet the people's need at a safe, low cost, and low environmental harms pending the availability of an appropriate alternative energy resource is put in place; and not to mean production sustenance of the energy source for indefinite time (Lyn, 2003). In a nut shell, the various competitive needs of human needs have to be balanced economically, socially and environmentally in the domain of sustainable development (Sustainable Development Commission, 2011; WCED, 1987).

Furthermore, sustainable development can be seen by solid mineral industries, firstly, in terms of concern on environment that results from the way and manner they operate. Their manner of industrial operations can lead to damages on the environment, for example, air, soil and water pollution, disruption of vegetation and wildlife, waste, and greenhouse harms. Secondly, in terms of development which explains the big role private sector can play in poverty reduction and educational improvement through practices of social responsibility. Development is still an aspect of social problems which also includes health, human rights, safety, and issues relating to the harmful impacts of industrial activities on indigenous communities in developing countries (Jenkins, 2005).

3.0 SOCIAL ISSUES IN MINING SOLID MINERALS

In most of resource-rich countries, especially the developing countries, extractive industries employ relatively few people. But their operations have wider effects on local communities, which often feel excluded from the benefits and the wealth that extractive industries generate, and harmed by the disruption or ecological impacts of extraction (Africa Progress Report, 2013). In respect of this, there is need for effective social responsibility, which is the responsibility of an organisation for the impacts of its decisions and activities on society and the environment, through transparent and ethical behaviour that:

- contributes to sustainable development, including health and the welfare of society;
- takes into account the expectations of stakeholders;
- is in compliance with applicable law and consistent with international norms of behaviour; and
- is integrated throughout the organisation and practised in its relationships (ISO, 2010).

The following are "Big Five –Tough" Social Issues as it relates to solid mineral development (SRK Consulting, 2015).

i. Involuntary resettlement. Economic and physical displacement of communities often accompanies mining projects. Resettlement is an emotional issue, with human rights a prominent concern. When resettlement processes are badly managed, reputations can be severely damaged, and the process is difficult to reverse. There is need to develop best-practice Resettlement Frameworks and Action Plans, incorporating provisions to restore livelihoods and to improve quality of life.

ii. Indigenous peoples. Indigenous peoples have strong links with the natural environment, and especially with land. Miners seeking to work in areas where land and other traditional rights are in play face complex issues, and sometimes get limited help from governments reluctant to deal with traditional rights. So it is required to plan and undertake appropriate consultation with local indigenous communities.

iii. Artisanal mining. Artisanal mining provides a living for many poor people in resource-rich developing countries. The sector is often unregulated, with formal miners having to compete with artisanal diggers for their own resources. Governments often deal erratically with artisanal miners, and some companies that have taken strong action have been accused of rights abuses. There is need to develop Strategies and Action Plans to address volatile artisanal mining situations.

iv. Corporate governance and standards. Many developing countries have weak legislation on the management of mining impacts, and the use of tax and royalty revenues. This may allow some officials to adopt corrupt practices, and some miners to dodge responsibilities. Therefore it is advisable that the mining industries to make use of international instruments that promote financial transparency (for example, the Extractive Industries Transparency Initiative), and on internal arrangements to promote and entrench best-practice governance.

v. Corporate social investment (CSI). Mining contributes to the economies of many developing countries; however, the wealth may not reach local communities. Responsible

miners often seek to contribute to local development, but they face a number of challenges, including unrealistic expectations and a plethora of deserving projects. The mining industries should pursue CSI strategies that are defensible and sustainable. They should also establish Development Foundations, based on a partnership between mines and communities.

4.0 ENVIRONMENTAL ISSUES IN MINING SOLID MINERALS

Mining activities are carried out in various stages, each of which raises specific environmental concerns. Broadly speaking, these stages are: deposit prospecting and exploration, mine development and preparation, mine exploitation, and treatment of the minerals obtained at the respective installations with the aim of obtaining marketable products. The most important environmental impact as a result of solid mineral development includes: impacts on water resources (acid mine drainage and contaminant leaching; erosion of soils and mine wastes into surface waters; impacts of tailing impoundments, waste rock, heap leach, and dump leach facilities; and impacts of mine dewatering). Others are impacts of mining projects on air quality as a result of emissions; impacts of mining projects on wildlife (habitat loss; and habitat fragmentation); impacts of mining projects on soil quality; leakages of chemicals; and lastly, climate change considerations (EIAs, 2015).

Environmental impacts thus become economic and social issues as livelihoods are disrupted. Environmental impacts continue well after the mine has been exhausted, so it is local communities that bear the long-term burden of mining. The environmental legacy of mining in Africa is generally that of large unfilled holes and abandoned artisanal mining sites (Kaushik and Kaushik, 2010).

5.0 SUSTAINABLE MINING PRACTICES IN SOLID MINERAL INDUSTRIES

A body of literature exists suggesting that mining can contribute to sustainable development by focusing on successful economic, environmental and community outcomes. However, in a mining context, these pillars (the triple bottom-line) fail to adequately account for two important areas, essential for a sustainable mining operation, as illustrated by the Broken Hill example. One "missing" dimension is safety, which receives more attention in the mining sector than arguably any other industry. The media coverage and political focus applied to any mine "accident" exceeds virtually all other industries. It is not unusual for regulators to force a mine to close on the basis of a poor mine safety record (DRET, 2011).

The second missing dimension is a focus on extraction practices of the mineral resource itself. In the literature, researchers have tended to concentrate on the exhaustibility of the resource as a depleting asset (Auty and Mikesell, 1998). However, the researchers approach the subject from a macro level and usually from an economic perspective. It is suggested that there is a need to focus on the micro level, at the individual mine site, where the resource is managed sustainably or unsustainably. This element or dimension can be termed 'resource efficiency' or simply 'efficiency'. It differentiates mining from other industries and is the basis or platform for any sustainable benefit to flow to the community (DRET, 2011). Mine managers will be on track in establishing a sustainable mining operation if they then focus on the following five areas: safety, environment, economy, efficiency and the community (Laurence, 2011).

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 equipment (Laurence, 2005).

Economy

Unless a mine is profitable, it cannot be sustainable. The aim for mine managers is to generate profit responsibly for as long as possible by keeping 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 also has to be efficient in the way the resource is managed and extracted. Mining engineers, geologists and metallurgists collaborate to optimize resource extraction. Examples of non-sustainable mining practices abound and include "high grading" the ore body, which entails mining only the highest grade material for short term gain. This is a practice used by companies and individuals within those companies with a short time frame. Efficiency also encompasses the management dimension at a mine site, as poor management decisions can often lead to production difficulties or equipment breakdown or industrial relations or other factors that impact on optimum resource extraction (Mitchell et al., 1995).

Environment

Adopting leading environmental management practices on mine sites 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. Thanks in part to the increasing awareness of environmental issues, there is considerable literature relating to the environment and sustainable development.

Community

Finally, a mine needs a 'social licence to operate' Unless the community is engaged and supportive of a mining

operation, opposition and confrontation may ensue. Mining operations run by corporations 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.

Dysfunctional community interaction will ultimately distract management from its main focus of efficiently running the mine. Enlightened mining companies, particularly those operating in the developing world, maintain their social license to operate by undertaking various initiatives, including preferentially employing local people; training and providing skills in businesses or enterprises that will endure after the mine closes and so on.

6.0 ENVIRONMENTALLY SUSTAINABLE MINING

Developing and integrating practices that reduce the environmental impact of mining operations can make mining become more environmentally sustainable. These practices include measures such as reducing water and energy consumption, minimizing land disturbance and waste production, preventing soil, water, and air pollution at mine sites, and conducting successful mine closure and reclamation activities.

However, although mining process itself may not consume vast portion of land but the infrastructure and pollution linked to mining activities have a serious potential to affect the health of ecosystems and reduce their ability to provide the goods and services necessary for human and environmental well-being (Rajaram *et al.,* 2005). When the environment is healthy to future generations yet unborn is recognized as satisfying the concept of sustainable development.

In order to be more environmentally sustainable, mining operations are increasingly conducted in a manner that minimizes their impact on the surrounding environment, and leaves mine sites in an acceptable state for re-use by people or ecosystems. A number of management strategies and technologies that should be developed and used by the mining industry to reduce the environmental impacts of mining, and are discussed below:

a. Reducing Inputs

i. Water

In mining, water is used within a broad range of activities including mineral processing, dust suppression, slurry transport, and employee requirements. Water is used in a number of applications at mine sites. By diverting surface water and pumping groundwater, mining operations can reduce both the quantity and quality of water available downstream for aquatic ecosystems and other industrial and municipal water users, especially in areas with arid climates.

In response to water scarcity in many mining regions, a number of innovative water conservation practices are being developed and implemented to reduce water use.

Various control techniques can be used to reduce the potential for water contamination and minimize the volume of water requiring treatment. These techniques include (Lottermoser, 2012):

1. **Intercepting and diverting surface water** (rain and snowmelt runoff, streams, and creeks) from entering the mine site by building upstream dams to reduce the potential for water contamination from exposed ore and waste rock
2. **Recycling water used for processing ore** in order to reduce the volume of water requiring treatment
3. **Capturing drainage water** from precipitation at the mine site through the use of liners and pipes and directing the water to tailings dams in order to prevent potentially contaminated water from entering groundwater or flowing off site
4. **Allowing the water to evaporate in ponds** to reduce the volume of contaminated water; in dry regions, enough water may be evaporated that no water needs to be discharged, resulting in the containment of contaminates at the mine site
5. **Installing liners and covers on waste rock and ore piles** to reduce the potential for contact with precipitation and contamination of groundwater

Different combinations of strategies can be applied, and the selection of strategies is site-specific. (Lottermoser, 2012).

ii. Energy

Mining and metal processing can be very energy-intensive processes. For instance, diesel fuel is used by trucks and excavators during mining, electricity is used to grind ore and refine copper and aluminum, and coal is required in order to smelt iron ore and make steel (Rankin, 2011). The extraction of fossil fuels (coal, oil, and gas), and the construction of infrastructure required for energy generation have their own environmental impacts, including the production of greenhouse gases and increased risk of environmental contamination along the energy supply route. Reducing energy consumption at mines can reduce greenhouse gas emissions and extend the life of fossil fuel reserves in addition to reducing operating costs and therefore the cost of the commodity being mined (Rankin, 2011). Mining companies are also investigating renewable energy sources to reduce costs and reliance on external energy sources including solar power in Chile and wind turbines.

iii. Land disruption

Mine sites currently disturb a small fraction of the Earth's total land surface. However, mining activities use land at every stage of the mine cycle, including exploration,

construction, operation, closure, and post-closure (ICMM, 2011). Vegetation is cleared for the construction of buildings, roads, and powerlines, open pits or tunnels are dug to gain access to the ore, and waste storage facilities such as tailings ponds are expanded over the life of the mine, potentially leading to habitat loss and deforestation (ICMM, 2011).

There are a number of ways to reduce the land-use impacts of mining. These include reducing the overall footprint of the mining area, minimizing the amount of waste produced and stored, maintaining biodiversity by transplanting or culturing any endangered plants found on site, and planning mines around existing infrastructure where possible (ICMM, 2011).

b. Reducing Outputs

i. Waste

Mine waste includes solid waste, mine water, and air particles, which can vary significantly in their composition and potential for environmental contamination. In addition to preventing soil, water, and air pollution, waste management plans are required in order to select and design appropriate storage facilities for the large volumes of waste produced at most mine sites (Rajaram *et al.*, 2005). Methods for minimizing and eliminating wastes in the production of minerals and metal commodities include (Rankin, 2011): using cleaner production techniques; environmental control technologies; using waste as raw material, and reducing the amount of waste produced through process re-engineering.

Water management strategies are used to reduce the volume of waste water produced, and if necessary, to treat it to an acceptable quality before it is released (Rajaram *et al.*, 2005).

ii. Acid Rock Drainage

Acid rock drainage (ARD) or acid mine drainage refers to the acidic water that is created when sulphide minerals are exposed to air and water and, through a natural chemical reaction, produce sulphuric acid (NAP, 2012). ARD has the potential to introduce acidity and dissolved metals into water, which can be harmful to fish and aquatic life. Preventing and controlling ARD is a concern at operating mine sites and after mine closure. ARD can pollute surface and groundwater with acidity and dissolved metals, which can adversely affect aquatic organisms and water users downstream. A number of strategies are used to predict, prevent, and mitigate ARD at mine sites.

iii. Restoring Environmental Function at Mine Sites

Mining is a relatively temporary activity, and mine sites have finite operating lives which are determined by the size and quality of the ore deposit being mined. Mine site reclamation and closure activities aim to restore land disturbed by mining activities to an acceptable state for re-use by people or ecosystems.

7.0 FRAMEWORK FOR RESPONSIBLE/ SUSTAINABLE SOLID MINERAL DEVELOPMENT

To achieve a responsible solid mineral development, the following framework has been highlighted (Doreen, 2016).

i. Builds on MMSD (Mining, Minerals and Sustainable Development) and, ICMM (International Council on Mining & Metals)

ii. Deciding whether a mine is an appropriate use of land. The need to preserve ecologically and culturally significant areas and to weigh land and resource use options is very paramount to sustainable mining development. For instance, Mining should not occur in any marine protected areas or in any site that is categorized as protected or restricted areas, and companies should ensure that their projects provide net conservation benefits that are consistent with maintaining the biological resources and ecosystem services on which local communities depend.

iii. Ensuring environmentally responsible mine development. Once a decision to mine has been made, certain environmental provisions should be in place to avoid negative outcomes and capitalise on benefits. This point details the environmental issues that need to be addressed at each stage of mine development. This includes: exploration management, environmental impact analysis, water contamination and use, air, energy consumption, noise, waste management, cyanide, reclamation and rehabilitation, financial guarantees, and post-closure.

iv. Ensuring that mine development results in benefits to workers and affected communities. This includes issues related to free, prior, and informed consent of communities for mining, health and safety provisions, capturing benefits more broadly, and developing consent agreements with communities. Others include participation of workers and the host communities in decision making/consultation, access to information/disclosure, consent-benefit and compensation agreements, recognizing women's rights and addressing gender-related risks, recognizing labour rights and addressing worker-related risks, resettlement/relocation and compensation, and security issues and human rights.

v. Ensuring that appropriate corporate governance structures are in place. Include broader corporate or national governance provisions to ensure transparency in revenue payments between governments and companies, and reporting company progress made toward implementing responsible practices.

8.0 CONCLUSION

This article presented sustainability as an increasingly prominent discourse, particularly among solid mineral

mining companies, clarifying exactly how solid minerals can be developed and operated in an environmentally acceptable and socially responsible manner to be able to gain and sustain the full economic benefit derivable from this natural resource. Since solid mineral development has potentials to impact a wide range of environmental and social units in the mode of operations, there is need for commitment to improve environmental performance, and also collaborate with the stakeholders and community groups from the onset. To make this happen, the concept of sustainability needs to be employed. This paper has also presented some guidance for prospective mining industries that have interest to improve on their sustainable way of operation. Some sustainable practices for solid mineral development were brought to light which includes sustainable mining practices; environmentally sustainable mining which recommended reduction in both the input and output flow into mining system; and framework for responsible/ sustainable solid mineral development. Now that Nigerian government has recently revisited solid mineral roadmap with the view of license issuance to prospective miners (Kayode, 2015; Kayode, 2016), it will become increasingly important that mines should start pursuing socioeconomic and environmental issues with improved strategy that involves sustainable development into mode of operations in the companies.

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