Version: March 2009
Learn more about the Environmental Guidelines for Small-Scale Activities in Africa *and download this and all chapters at www.encapafrica.org.*

Environmental Guidelines for Small-Scale Activities in Africa (EGSSAA)

Chapter 4.5: Small-Scale Mining: Cleaner Production Fact Sheet and Resource Guide

Contents

Purpose

This fact sheet offers basic information on the important adverse environmental impacts of small-scale mining, as well as associated health and safety impacts. It also discusses opportunities for mitigating those impacts, with an emphasis upon "cleaner production" strategies that may also provide financial benefits to micro- and small enterprises (MSEs). In addition, each fact sheet offers a substantial, annotated list of resources for organizations seeking more information.[1]

This fact sheet has been prepared for (1) **business development services (BDS) providers**, which offer services such as management training or marketing support to MSEs, and (2) **intermediate credit institutions (ICIs) and direct lenders** that provide financial credit to MSEs. It is intended to be used in concert with other sections in Part III of the *Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities*, which is USAID Africa Bureau's principal source of sector-specific environmental guidance.

[1] At the time of writing, USAID cleaner production fact sheets are available for the following subsectors that are likely to have substantial adverse impacts on the environment and/or workers' health: brick and tile production; leather processing; small-scale mining; food processing; metal finishing; wood processing and furniture making, and wet textile operations.

This EGSSAA Chapter was prepared by The Cadmus Group, Inc. for International Resources Group, Ltd. (IRG) under USAID Africa Bureau's Environmental Compliance and Management Support (ENCAP) Program, Contract Number EPP-I-00-03-00013-00, Task Order No. 11. Its contents are the sole responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government.

Why Focus on Cleaner Production for Mitigation?

Cleaner production is a preventive business strategy designed to conserve resources, mitigate risks to humans and the environment, and promote greater overall efficiency through improved production techniques and technologies. Cleaner production methods may include:

- substituting different materials
- modifying processes
- upgrading equipment
- redesigning products

In addition to environmental, health and safety benefits, many cleaner production techniques provide opportunities to substantially reduce operating costs and improve product quality. MSEs can profit from CP through more efficient use of inputs and machinery, higher quality goods that can command higher prices, and reduced waste disposal costs. Improved safety measures can also help MSEs avoid costly accidents and worker absences.

Experience has demonstrated that, with assistance, MSEs can frequently identify cleaner production opportunities that produce a positive financial return, sometimes with little or no investment. Many enterprises that change to CP methods may realize substantial financial and environmental benefits, indicating that CP should be the first option considered in addressing MSEs' environmental problems.

Yet, although this approach can offer tremendous advantages, readers should

Small-scale mining activities can generate many kinds of environmental damage. It is important to ensure that they use resources more efficiently and that they prevent serious health problems from occurring.

also recognize that cleaner production options showing clear financial benefit will only be available to varying degrees among different enterprises

and often may not completely mitigate environmental problems. In some cases, even when pursuing CP techniques, some businesses may need to use solutions that offer no measurable financial return—if such solutions are required by USAID's Regulation 216 or local regulations or desired for other reasons, such as community goodwill.

Adverse Environmental Impacts and Mitigation Opportunities

Several key environmental issues associated with small-scale mining are listed in the box at right and discussed below. For each environmental impact, the fact sheet provides a list of questions to assist in the assessment of individual MSEs. These questions are followed by a number of mitigation strategies that can be considered, with an emphasis on cleaner production strategies where possible. The strategies presented typically represent a range of available options, from profitable activities that require no investment to other activities that may increase MSE costs.

Important Environmental Issues Addressed by This Fact Sheet

- Open pit mining
- Mercury use
- Inefficient extraction
- Dust
- Noise
- Underground hazards
- Long-term hazards

❑ *Open pit mining*

Open pit mining activities can alter the landscape in ways that are potentially dangerous and costly. Excessive land clearing or steeply sloped pits can lead to landslides that destroy working sites, harm workers, or block waterways. Costly work stoppages, loss of future mining sites, or damage to water bodies may result.

Key questions to consider:

- Is the structure of the pit stable?
- How much loose rock or soil is above the work site?
- Does each rainfall move significant amounts of soil?

Selected mitigation strategies:

- Before mining starts, assess the site and see how close it is to sensitive resources (e.g., unique ecological, cultural, historical or archeological sites or areas of scenic value). Assess the full range of alternatives for avoiding or minimizing impacts on these resources, including selecting an alternative site or taking no action at all.
- Once a mining site has been selected, assess the full extent of the resource. Devise a engineering plan for reclaiming and restoring the mined area at the same time the resource is being extracted. If owners or managers do not know the extent of the resource, many mines remain open longer than is useful and restoration is delayed indefinitely. If possible, engage a geotechnical engineer and landscape architect to help develop the mine extraction and reclamation plan.

- If land is being cleared, try to leave enough trees and vegetation to prevent soil erosion. Use cleared brush or other materials to create erosion barriers.

- Ensure that the road leading to the mine is well-designed, with low slope and good drainage to keep water off the road. (See the chapter on rural roads in the *Guidelines*.) Avoid creating roads that pass close to sensitive resources (e.g., forests or wetlands).

- While mining, where feasible, avoid creating pits that will accumulate water, presenting health and safety hazards (e.g., dangers from drowning and creation of breeding grounds for mosquitoes).

- Plant vegetation on the site before leaving the area. Bare soil causes landslides, which can occur both before and after mining activities are completed. Landslides may destroy working sites and make future mining more difficult. Landslides may also kill workers, innocent community members, and animals, and they can seriously damage the local ecology.

- Angle the mine's pit faces to prevent unexpected collapse. This preserves the investment in excavation, guaranteeing a longer life to the working site and less danger for those working inside. It may be necessary to disturb additional land in order to make the angle less steep, but take care to disturb as little land as possible.

- Retain topsoil for later use in reclaiming the site. Segregate other subsurface materials which might have potential value in construction or road works. Store these materials away from water bodies to reduce the potential for cumulative siltation, interference with water flows, and subsequent damage to ecosystems, as well as to the people who depend on these for their livelihood.

❑ *Mercury*

Using mercury to extract gold or silver from ore can severely affect worker and community health. Mercury entering the human body may cause kidney problems, headaches, tremors, comas and other serious health problems. It is especially hazardous to children. Mercury exposure can occur directly, through physical contact, or indirectly, through contaminated water or fish. Mercury poisoning will result in the loss of skilled labor and long-term damage to communities. Reducing mercury use may also lower production costs, although in many countries the cost of mercury is low.

Key questions to consider:

- Do managers or workers experience tingling or tremors in fingers or toes?

- Does the business use mercury to process ore near a water source or in your home?

- Where does the business dispose of water with mercury in it?

- Does the business use extra mercury to speed up the extraction process?

Selected mitigation strategies:

- Recognize mercury poisoning. In the short term, high levels of mercury exposure result in tingling and tremors in fingers or toes. Be aware of the signs and reduce contact before long-term damage occurs.

- Dispose of mercury-contaminated water far away from water sources, fish-bearing waterways, and human settlements. Make sure rain cannot wash away mercury or mercury-contaminated materials.

- Avoid inhaling mercury vapor. Try to recycle mercury, and avoid emissions by using an open oven to capture and condense mercury vapor for reuse. This method can save money on the purchase of mercury. In addition, heat amalgam in a well-ventilated room or outside, to allow any mercury vapor to disperse.

- Reduce mercury use through more efficient production. For example, miners frequently overuse mercury during amalgamation. Miners should use only the correct amount of mercury, since additional mercury does not speed or improve the amalgamation process—it only increases costs and risks. Miners should avoid grinding and amalgamating at the same time. Separating these processes helps ensure that mercury is not overused.

❑ *Inefficient extraction*

Mining wastes often pose serious threats to human health and wildlife, and have persistent and hazardous impacts to groundwater, surface waters, and soils. Small-scale mining often uses inefficient extraction methods that result in substantial loss of the product. Finding and removing ore from pits with inadequate or poorly operated machinery reduces yields. Crude processing technologies can lead to lost earnings and more waste.

Key questions to consider:

- How often does the business conduct maintenance or repairs on machinery?

- How much waste is produced for a given amount of product? Could this waste be reduced?

- Have workers been trained in operating machinery efficiently and safely?

Selected mitigation strategies:

- Maintain machinery. To maximize efficiency, make sure machinery is working properly and train workers in operating and maintaining it. Ensure that operators are keeping maintenance logs.

- If little or no machinery is used, consider low-cost technologies that may increase yields. Improving separation methods, such as by using sluices or gravity centrifuge machines, increases productivity and reduces waste.

- Evaluate mining techniques to see if product is being lost in the extraction process. Check rock waste or the extraction area to see if mineral is being wasted or if potentially valuable mineral veins are being destroyed. Train workers in proper techniques for identifying and removing ore.

❑ *Dust*

Dust generated by rock, metal and coal mining can be harmful. Using wind to separate metal from ore, or using machinery that generates rock dust, can lead to silicosis. Silicosis is a disease caused by inhaling silicates in the dust of crushed rocks; it can severely decrease workers' lung capacity and productivity, and it sometimes results in their deaths.

Key questions to consider:

- How much dust is produced in a typical working day?

- What protective materials are available?

- Is ore being ground or crushed by hand?

Selected mitigation strategies:

- Small-scale mines can produce a substantial amount of dust; maintain tree or vegetation cover to capture dust and prevent dust clouds from traveling long distances.

- Ventilate underground mines so dust can escape and ease working conditions.

- If possible, wet materials so less dust is produced. Use water when running a pneumatic drill. Dampen ore before crushing in a mortar and pestle. However, use water conservatively to avoid wasting this resource, and prevent water used in these activities from contaminating other water sources.

- Avoid crushing or grinding ore in the home. The transport of raw ore to the home can be inefficient. In addition, this practice produces a great deal of dust since it is often done by hand, and most homes are not properly ventilated. This makes workers and their families, especially small children, particularly vulnerable to silicosis.

- Provide all workers with face masks and instruct them to wash their hands after working so they will not ingest dust with their food.

❑ *Noise*

Mining activities can involve equipment that can be very noisy or cause strong vibrations. This can affect workers' hearing and health, as well as the community around the working site. This may work against the enterprise's ability to expand production in the future.

Key questions to consider:

- Are some machines louder than others?
- Is machinery left running when not in use?

Selected mitigation strategies:

- Provide earplugs for workers.
- Repair and maintain machinery so that excessive grinding or squeaking is minimized. Frequent repair and maintenance will typically also make the machinery operate more efficiently, reducing fuel costs.
- Provide protective insulation or cushioning to those working with vibrating machinery.
- Use machinery efficiently. Do not run machinery longer than necessary. This saves energy and reduces environmental damage.
- Try to use noisy machinery only at times when the surrounding community is least likely to be disturbed. For example, it may be better to operate such machinery during the daylight hours.

❑ *Underground hazards*

Underground mines are often hazardous to work in and are extremely susceptible to major accidents. Poorly constructed mining spaces can lead to injuries that reduce productivity, as well as large-scale accidents that destroy working sites.

Key questions to consider:

- How old is the mine?
- What kind of supports are in the walls and ceilings? Are these supports in good condition?
- How are explosives used to clear new spaces?
- Is the site for the mining operation geologically stable?
- Is the site subject to periodic flooding?

Selected mitigation strategies:

- Eliminate minor safety hazards. For example, construct underground space so that falls are minimized. Make passageways wide and tall enough to accommodate workers comfortably. Workers who cannot walk or stand normally are apt to suffer from debilitating chronic musculoskeletal injuries that reduce their productivity.

- Use explosives wisely. Explosions can weaken underground structures and cause cave-ins. Any worker using explosives should have training in their proper and safe use. Take care to evacuate the mine before detonating any explosives, even when trained personnel are using them.

- Ventilate coal mines well to reduce excessive heat and dust and minimize chances of spontaneous fires. Sink new shafts or widen existing mine openings to increase airflow. Doing so can improve worker health and productivity and decrease the risk of destroying the mine through an accidental explosion.

- Reinforce walls and ceilings to avoid an unexpected collapse of the mine. When working in older and abandoned mines, be aware that removing pillars or wall supports to extract ore can quickly lead the mine to collapse.

❑ *Long-term hazards*

The environmental impacts of even a short-term mining operation often last many years, even centuries, beyond the working life of the mine. Unless they are mitigated, contaminated waste, hazardous mine structures and disturbed land can pose problems long after mining operations close. Adequate waste disposal and careful mine closure represent additional cost to the mining operation, but may reduce community and government opposition to future mining activities.

Key questions to consider:

- How will time affect waste disposal sites or mine structures?

- Has the landscape significantly changed as a result of mining activities?

- How will the community use the mine area in the future?

Selected mitigation strategies:

- Seal underground mines. Cover entrances to underground mines so they do not present safety hazards.

- Construct waste disposal sites that will last. Make sure tailing ponds or chemical waste dumps are secure and can withstand severe weather.

- Plant trees. This prevents landslides and keeps remaining topsoil on the land.

❑ *Mining camps and mine workers*

Mining activities are sometimes undertaken by transient groups of laborers who come in from outside and can indirectly lead to social and sanitation problems. Unsanitary living conditions in mining camps can spread contagious diseases like dysentery and typhoid. Epidemic disease disrupts work and can destabilize communities. Unsafe sex practices can promote the spread of AIDS. Social problems may occur, including gambling, alcohol abuse, theft, violent behavior and prostitution.

Key questions to consider:

- Where is human and food waste disposed of?
- How often do people get sick? Are there any nearby medical facilities?
- What water sources are available?

Mining is dangerous for both workers and local communities. Be sure that small mining operations are aware of safety measures and protect workers and community health.

- What kinds of social problems exist at other small-scale mining sites in the region?

Selected mitigation strategies:

- Improve sanitary measures. Construct enough toilet facilities and make sure they cannot contaminate water sources. Ensure that there are enough water sources for workers to wash themselves, and promote clean food preparation.

- Educate workers about HIV/AIDS and other sexually transmitted diseases (STDs). Encourage the use of safe sex practices.

- Establish miners' committees for health, safety and welfare. Create mechanisms for democratic self-policing.

References and Resources

- Developments in Small-Scale Mining (1996). Committee on Natural Resources, Report of the Secretary-General, United Nations.

- Jennings, Norman S. ed. Small-Scale Gold Mining: Examples from Bolivia, Philippines and Zimbabwe. Industrial Activities Branch Working Paper, International Labour Organization (ILO). http://www.ilo.org/public/english/dialogue/sector/papers/goldmine/index.htm.

  This document is a case study of three pilot projects in small-scale mining. A practical example of problems and solutions in mining activities; it includes a section on lessons learned as well as examples and diagrams of alternative amalgamation machinery.

- *"Mercury."* The Pollution Prevention Abatement Handbook (1998).World Bank. http://www.ifc.org/ifcext/enviro.nsf/Content/PPAH.

  A good explanation of the hazardous characteristics of mercury and the different health impacts of mercury exposure.

- Social and Labour Issues in Small-Scale Mines. Report for discussion at the Tripartite Meeting on Social and Labour Issues in Small-Scale Mines, in Geneva, 17-21 May 1999. International Labour Organization (ILO). http://www.ilo.org/public/english/dialogue/sector/techmeet/tmssm99/tmssmr.htm.

  An excellent discussion of health issues associated with small-scale mining. Attention is paid to solutions to occupational health and safety issues, including reducing mercury use and decreasing the incidence of silicosis.

- *"Surface Mining."* In Environmental Handbook: Documentation on Monitoring and Evaluating Environmental Impacts, Vol. 2.German Federal Ministry for Economic Cooperation and Development (GTZ). http://ces.iisc.ernet.in/energy/HC270799/HDL/ENV/enven/vol212.htm.

  A short discussion of two different methods of surface mining-wet and dry extraction-and the environmental impacts associated with them. Contains information more relevant to medium than small mining operations.

Other Resources

- Acquah, Peter Claver. *Natural Resources Management and Sustainable Development: The Case of the Gold Sector in Ghana (1996).* Ghana: Environmental Protection Council. United Nations Conference on Trade Development. http://www.mineralresourcesforum.org/docs/pdfs/G9552829.PDF.

  A case study of natural resource management and sustainable development in the gold mining sector of Ghana. This document sets out the main environmental and socioeconomic impacts of gold mining, including water pollution, land degradation and effects on coastal and marine resources.

- *Chemicals Management: DAC Guidelines on Aid and Environment* (1993). The Organisation for Economic Co-operation and Development (OECD). http://www.oecd.org/dataoecd/37/5/1887724.pdf.

This document targets aid agencies and the need for chemical management programs. It briefly discusses the dangers of certain chemicals, including mercury, and the capacities required for adequate chemicals management.

- Maponga, Oliver and Anderson Mutemererwa (1995). *Management of Natural Resources and the Environment in Zimbabwe: The Case of Gold. University of Zimbabwe,* The Institute of Mining Research. United Nations Conference on Trade and Development. http://www.mineralresourcesforum.org/docs/pdfs/g9550334.pdf.

  A case study of natural resources management and sustainable development in the gold sector of Zimbabwe. A description of the main environmental impacts from gold mining is followed by a discussion of economic development and legislation.

- McDivitt, James F. (1990). *Small-Scale Mining: A Guide to Appropriate Equipment.* Intermediate Technology Publishing. http://styluspub.com/Books/BookDetail.aspx?productID=20833.

  A guide to available equipment on all aspects of small-scale mining, from prospecting and surveying through haulage, handling and transport. It includes a discussion of safety equipment. The book features world-wide coverage, with particular relevance to the developing world, and costs around US $28.

- McMahon, Gary, Jose Luis Evia, Alberto Pasco-Font and Jose Miguel Sanchez (1999). *An Environmental Study of Artisanal, Small, and Medium Mining in Bolivia, Chile, and Peru.* World Bank Technical Paper. http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1999/10/13/000094946_99092905340059/Rendered/PDF/multi_page.pdf.

  This paper synthesizes a study examining the environmental performance of artisanal, small, and medium mining in Bolivia, Chile and Peru. Includes summaries of the three country studies. Significant emphasis is placed on the viability of artisanal, small, and medium mines if environmental costs are taken into account, as well as policy actions to improve the environmental performance of viable mines.

- Priester, M., T. Hentschel and B. Benthin (1993). *Tools for Mining.* GTZ: Information and Advisory Service on Appropriate Technology, 537 p. http://sleekfreak.ath.cx:81/3wdev/CD3WD/APPRTECH/G10TOE/INDEX.HTM.

  This handbook serves as an information source for technicians, engineers and advisors associated with small-scale mining in developing countries. In the part of the handbook devoted to techniques, special attention is paid to
  1. ensuring local production in developing countries,
  2. offering environmentally friendly technologies and
  3. taking into account the social and cultural conditions of the miners when selecting the techniques.

- *Regularizing Informal Mining: A Summary of the Proceedings of the International Roundtable on Artisanal Mining* (1996). Roundtable organized by the World Bank, Washington, D.C. May 17-19, 1995. World Bank Industry and Energy Department Occasional Paper No. 6. http://www.natural-resources.org/minerals/cd/ssm.htm#Workshops.

  A general discussion of the challenges associated with small-scale mining activities that often occur outside the reach of environmental or financial regulation.

- Zamora, Armando (2000). *"Small Scale Mining: A Social and Environmental Problem Turned into an Opportunity for Economic Development."* Internet Journal of the Centre for Energy,

Petroleum and Mineral Law and Policy, Vol. 6-6.
http://www.dundee.ac.uk/cepmlp/journal/html/vol6/article6-6.html.

This article discusses the economic development implications of small-scale mining in developing countries and possible sustainable and legal solutions to the industry's social and environmental problems.