

# **International Review of Environmental Rehabilitation Approaches for Artisanal and Small-Scale Mining**

**A Review of Best Practices for Frugal  
Rehabilitation of ASM in Mongolia**



**The Asia Foundation**

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# **INTERNATIONAL REVIEW OF ENVIRONMENTAL REHABILITATION APPROACHES FOR ARTISANAL AND SMALL-SCALE MINING**

*A Review of Best Practices for Frugal Rehabilitation of ASM in Mongolia*



*By Leah Butler with contributions from Paul Mitchell and Estelle Levin*

*Editor Estelle Levin*

*For The Asia Foundation*

April 2014

## About Estelle Levin Ltd.

Estelle Levin Ltd. (ELL) is a specialist consultancy dedicated to responsible mining and sourcing. Working from concept to implementation, in all cases we help our clients transform their ideas, businesses and operations into something more sustainable not just for them, but for their stakeholders too. We provide world-class research, advisory and capacity-building services to leading brands and small businesses from along the value chain (mining, trading, manufacture, and retail), governments, aid agencies, and NGOs. We stand amongst the world's foremost development consultancies with expertise on Artisanal and Small-scale Mining (ASM) and developing highly tailored and context-specific responsible sourcing systems for artisanal minerals, especially from fragile economies. Managing the environmental impacts of ASM is an important part of our work; we investigate the issues, design the initiatives addressing them, educate stakeholders on these, and support organisations in implementing systems for mining responsibly. You can find out more about us at [www.estellelevin.com](http://www.estellelevin.com) and [www.asm-pace.org](http://www.asm-pace.org).

### Authorship

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### About This Report

This report has been prepared by Estelle Levin Ltd. for consideration by The Asia Foundation. Following its review, the report will be translated and published to a wider audience, including government ministries, public agencies, academics, and national and local ASM and environmental NGOs, so as to assist in policy development with respect to ASM in Mongolia.

### About the Client

The Asia Foundation is a nonprofit international development organization committed to improving lives across a dynamic and developing Asia. Its programs address critical issues affecting Asia — governance and law, economic development, women's empowerment, environment, and regional cooperation. The Asia Foundation works through a network of offices in 18 Asian countries and in Washington, DC.

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## ACRONYMS

|                |  |
|----------------|--|
| <b>AMD</b>     | Acid Mine Drainage   |
| <b>ASM</b>     | Artisanal and Small-scale Mining                           |
| <b>DFID</b>    | Department for International Development                   |
| <b>ELL</b>     | Estelle Levin Ltd.   |
| <b>ESEC</b>    | Engaging Stakeholders in Environmental Conservation        |
| <b>FESS</b>    | Foundation for Environmental Security and Sustainability   |
| <b>GEF</b>     | Global Environment Fund                                    |
| <b>GIS</b>     | Geographic Information System                              |
| <b>GMP</b>     | Global Mercury Project                                     |
| <b>HSHH</b>    | Hand-Held Seed Harvester                                   |
| <b>IFC</b>     | International Finance Corporation                          |
| <b>ITCAM</b>   | International Training Center for Artisanal Miners         |
| <b>LRC</b>     | Land Reclamation Committee                                 |
| <b>LSM</b>     | Large Scale Mining   |
| <b>NGOs</b>    | Non-Governmental Organisations                             |
| <b>POMIGER</b> | Post-Mining Income-Generating Environmental Rehabilitation |
| <b>PRADD</b>   | Property Rights and Artisanal Diamond Development          |
| <b>SDC</b>     | Swiss Agency for Development and Cooperation               |
| <b>SAM</b>     | Sustainable Artisanal Mining Project                       |
| <b>SMARTER</b> | Sustainable Mining by Artisanal Miners                     |
| <b>SRI</b>     | Superfund Redevelopment Initiative                         |
| <b>TAF</b>     | The Asia Foundation  |
| <b>UNDP</b>    | United Nations Development Program                         |



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|              |  |
|--------------|--|
| <b>UNEP</b>  | United Nations Environmental Program               |
| <b>UNIDO</b> | United Nations Industrial Development Organization |
| <b>USAID</b> | United States Agency for International Development |
| <b>USDoS</b> | United States Department of State                  |
| <b>USEPA</b> | United States Environmental Protection Agency      |

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## KEY DEFINITIONS

| Phrase                                  | Definition   |
|---|--|
| Acid Mine Drainage                      | A major environmental risk associated with mining, where the exposure of sulphide minerals to water and oxygen produces an acid solution contaminated by metals and other potentially toxic elements that negatively affects water quality and plant life (also widely referred to as Acid Rock Drainage).   |
| Biodiversity                            | The variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.  |
| Biodiversity Action Plan                | Plan that addresses all aspects of biodiversity management and the issues involved in design and implementation of mitigation measures, including, inter alia, application of the mitigation hierarchy. A BAP may also include biodiversity offsets.   |
| Biodiversity Baseline                   | A description of existing conditions to provide a starting point against which comparisons can be made, allowing change to be quantified.  |
| Biodiversity Offset                     | Measurable conservation outcomes of actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity. The process of implementing offsets includes calculating losses and gains, selecting conservation objectives, evaluating offset options, budgeting, and implementation (including defining roles and responsibilities, long-term legal, institutional and financial arrangements, monitoring, evaluation, and adaptive management). |
| Capping                                 | A process used to cover contaminated soils or other solid materials to prevent or minimise the contact between these and water and/or the physical movement of contaminated material. This method can be applied when contaminated soils and/or materials are to be left in place at a mine site.  |
| Conservation                            | The deliberate management of biological resources to sustain key biodiversity components or maintain the integrity of sites so that they support characteristic types and levels of biodiversity. Conservation includes preservation, maintenance, sustainable utilization, restoration and enhancement of the natural environment.  |
| Ecological Restoration                  | Reinstatement of the original (pre-mining) ecosystem in all its structural and functional aspects and emulation of the structure, functioning, diversity, and dynamics of pre-existing ecosystem (an option for ecological or biological rehabilitation).  |
| Ecosystem                               | A community of plants, animals and microorganisms, along with their environment, that functions as a unit.   |
| Ecosystem Services                      | The benefits people obtain from ecosystems. These include provisioning services such as food, water, timber, and fiber; regulating services that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling.   |
| Integrated Biodiversity Assessment Tool | A web-based tool that provides access to accurate and up-to-date spatial and descriptive information for Protected Areas, Key Biodiversity Areas, Alliance for Zero Extinction sites, IUCN Red List of Threatened Species, Biodiversity Hotspots, Endemic Bird Areas, and High Biodiversity Wilderness Areas.  |
| Key Biodiversity Values                 | Species and ecosystems that have local, regional, national, or global ecological or cultural significance, including critical habitat as identified through IFC PS6 and  |

|                        |   |
|------------------------|---|
|                        | priority ecosystem services.  |
| Net Gain               | Defined as the point at which the biodiversity gain from application of the mitigation hierarchy exceeds losses related to mining impacts.  |
| Overburden             | Material overlying a useful mineral deposit.  |
| Plant Growth Media     | A material or substance that provides suitable nutrients to allow plants to establish and grow.   |
| Re-grading             | The process of raising and/or lowering the levels of land, usually performed to limit slope angles, improve land stability, and/or to manage drainage patterns (also referred to as physical or technical rehabilitation).  |
| Reclamation            | To return an area to its previous habitat type but not necessarily to restore fully all functions.  |
| Rehabilitation         | To restore or improve an ecosystem to some state of beneficial use or enhanced biodiversity value.  |
| Replacement            | Creation of an alternative ecosystem to the pre-mining original.  |
| Revegetation           | Process of planting or re-establishing vegetation on disturbed or barren land, an activity undertaken as part of different approaches to rehabilitation (also referred to as ecological or biological rehabilitation).  |
| Soum                   | Administrative unit equivalent to a district.   |
| Sustainable            | The use of natural resources in a way that will not permanently destroy them for future use; meeting the needs of the present without compromising the ability of future generations to meet their own needs.   |
| Sustainable Livelihood | A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base. |
| Tailings               | Materials left over after the recovery of the valuable mineral(s) from an ore. Tailings may be coarse to ultrafine in terms of particle size, depending on the mining and processing methods employed. Tailings may range from dry solids to slurry form (fine particles suspended in water).   |
| Waste Rock Dump        | A surface location where rocks or minerals with no commercial value (but which must be removed to access the ore) are dumped.   |



## EXECUTIVE SUMMARY

Mongolia is a mineral-rich country with expanding industrial and artisanal and small-scale mining (ASM) operations throughout its territory. While the official number of ASM miners in Mongolia is unknown, current estimates suggest there are approximately 100,000 ASM miners working throughout the country, which represents about 20% of the rural workforce. About 90% of artisanal miners focus on alluvial and underground gold deposits, while the remainder focus on coal and fluorspar.

The Engaging Stakeholders in Environmental Conservation Phase II (ESEC II) project reports that land degradation is a key concern of ASM stakeholders and there is a need for more “appropriate, easily available, economically affordable and efficient rehabilitation approaches.” Given the principles of *economical affordability, social acceptability and ecological viability*, the definition of frugal rehabilitation in this report includes the *use of inexpensive and low-tech approaches to improve ground and hydrological conditions, followed by an informed approach to ecological rehabilitation*.

To this end, Estelle Levin Ltd. has prepared this report by drawing on best practices of rehabilitation approaches for ASM, using international case studies that illustrate real-world rehabilitation methods that can be applied to ASM in Mongolia. In the context of ASM, land rehabilitation attempts to mitigate the negative impacts of mining by restoring or improving an ecosystem to some state of beneficial use or enhanced biodiversity value.

This report documents the current state of knowledge and experience in the ASM rehabilitation space. This report profiles 18 case studies from Liberia, Central African Republic, Mongolia, Brazil, Mozambique, Sierra Leone, United States, and Ecuador (see Annex 1). Where information was available, the case studies provide details about the main features of each project including the location, date, and stakeholders involved; the goals and methods; a description of the implementation and outcomes; and the successes, challenges, and lessons learned. The case studies provide a summary of each project, with additional details available in the reference documents in some cases. The case studies are supplemented with relevant large-scale mining (LSM) and non-mining examples that illustrate rehabilitation concepts that could be applied to frugal ASM rehabilitation in Mongolia. Some additional case studies were identified but were not profiled due to a lack of sufficient and reliable information or because the nature of the case study was not aligned with the scope of this research. These additional case studies are listed in Annex 2.

A key finding of this research is that, while examples of frugal rehabilitation in an ASM context exist around the world, they are limited in number and are not well-documented overall. The limited number of successful, self-sustaining ASM rehabilitation examples as well as the lack of detail is a product of the fact that the application of environmental rehabilitation to ASM is not widespread and is a nascent but growing practice. In many ways, ESEC II is pioneering this practice and is bringing together, for the first time, an array of heretofore disparate approaches to land rehabilitation for the ASM context. While the research provided in this report identifies a range of both theoretical and practical approaches and short-term, small-scale pilot projects, there is a relative lack of experience in successfully implementing long-term, self-sustaining rehabilitation projects at the ASM scale. From the perspective of ESEC II and ASM stakeholders in Mongolia, this means that successful planning and implementation of these projects will require continued innovation, adaptive approaches, and a long-term investment. ESEC II has an opportunity to lead this practice and bring value to the international community by documenting and communicating its progress, successes, and lessons learned.

In reviewing the case studies and rehabilitation methods, it becomes clear that instilling rehabilitation practices within an ASM context takes time and requires significant oversight and direct assistance to miners and nearby communities. External organizations and local government can play a key role here. Communities and governments need to recognize the political, institutional as well as economic incentives for their commitment to the rehabilitated areas in order to prevent re-mining and maintain the long-term benefits of the rehabilitation project. The importance of local government and civil society in implementing long-term interventions cannot be overstated.

Building norms around ASM rehabilitation requires building the knowledge and skills of miners in the areas of physical and ecological rehabilitation and identifying and communicating the long-term economic incentives. The economic incentives to miners for rehabilitation should be identified in consultation with ASM miners and thoroughly communicated throughout the training and demonstration process.

Additionally, social factors—such as community acceptance, cooperation, and monitoring—are also critical to the long-term success of rehabilitation projects. While the technical and ecological components are critical to successful rehabilitation, resources should also be invested in providing consistent, long-term, and responsive assistance to mining communities so that the post-mining land use can be sustainable. This is the only way to avoid sponsoring poorly-planned and fleeting rehabilitation projects that leave no lasting benefit to communities or the environment. Successful ASM rehabilitation cannot be accomplished by ASM miners alone but can be accomplished with the sustained interest and support of the full array of local stakeholders.

This report identifies actions that can be taken by ASM miners and stakeholders to improve their abilities to plan, implement, and monitor rehabilitation projects. Some of the methods are hands-on and address the opportunities and constraints for on-the-ground rehabilitation throughout the mining process. Other methods address opportunities and constraints for planning and capacity-building for rehabilitation. The methods can be used independently or in combination, depending on the resources available, the type of site, and the desired outcome for each project. The methods are also scalable and can be adapted to sites with varying complexities, sizes, and contexts.

The case studies reveal several key best practices that have been applied to ASM rehabilitation around the world or are applicable to frugal ASM rehabilitation in Mongolia. These best practices, in the order presented in the report, are as follows:

| Best Practice           | Key Characteristics   |
|-------------------------|---|
| Biodiversity Management | <ul style="list-style-type: none"> <li>• Encourage best management practices for reducing mine footprint, disturbance, sedimentation and chemical use; identifying and avoiding the most sensitive areas; and managing wastes effectively.</li> <li>• If conservation of key biodiversity values is desired, restore degraded areas to functional ecosystems for conservation of key biodiversity values and then annex restored land to existing protected areas.</li> <li>• Invest in miner training programs that increase awareness of biodiversity attributes, values, and best practices.</li> <li>• Discourage prospecting and mining in areas with high biodiversity values.</li> </ul> |
| Rehabilitation Planning | <ul style="list-style-type: none"> <li>• Encourage the methodical planning of site-specific rehabilitation activities.</li> <li>• Think ahead to define the rehabilitation goals, objectives, strategy, procedures, inputs, budget, timeline, risks / threats to success, and roles / responsibilities of key actors.</li> </ul>  |
| Systematic Exploration  | <ul style="list-style-type: none"> <li>• Prospect in a systematic manner.</li> <li>• Refill prospecting holes.</li> <li>• Divert surface water, if necessary.</li> </ul>  |
| Concurrent Backfilling  | <ul style="list-style-type: none"> <li>• Restore a more natural topography of mined areas by backfilling pits and trenches with overburden as mining progresses.</li> <li>• Divert surface water, if needed.</li> </ul>   |
| Soil Management         | <ul style="list-style-type: none"> <li>• Salvage, store, and use topsoil for rehabilitation.</li> <li>• Keep topsoil separate from overburden.</li> <li>• Store topsoil near areas where it will be used.</li> <li>• Minimise soil dump height (to avoid compacting and maintain aerobic soil conditions).</li> </ul>   |

|  |  |
|--|--|
|  | <ul style="list-style-type: none"> <li>• Use sediment barriers or temporary seeding to reduce erosion while soil is being stored.</li> </ul>   |
| Seed Management                        | <ul style="list-style-type: none"> <li>• Collect appropriate native seed mixes for revegetation that are representative of natural ecological communities.</li> <li>• Provide training to rehabilitation teams on correct seed collection, cleaning, and storage techniques.</li> </ul>  |
| Mining Cooperatives                    | <ul style="list-style-type: none"> <li>• Engage with organized groups of miners and recruit them to take an active role in rehabilitation projects.</li> <li>• Foster improved communication, cooperation and coordination between miners and with external organizations.</li> <li>• Encourage shared-learning experiences with miner cooperatives on a range of topics, from improved mining practices to rehabilitation methods.</li> <li>• Alleviate resource-based conflict by using cooperatives as a potential leverage point.</li> </ul> |
| Mercury Management                     | <ul style="list-style-type: none"> <li>• Encourage use of improved technologies to reduce chemical use, chemical exposures, and chemical releases.</li> <li>• Build demonstration plants and training centres.</li> </ul>  |
| AMD Management                         | <ul style="list-style-type: none"> <li>• Segregate acid-generating materials from safe materials.</li> <li>• Prevent or reduce contact of acid-generating material with oxygen or water.</li> </ul>  |
| Miner Training Centers                 | <ul style="list-style-type: none"> <li>• Locate centers within mining communities.</li> <li>• Staff centres with local miners, geologists, engineers, and technicians.</li> <li>• Improve technology by hosting improved processing and refining equipment and 'intermediate' technologies.</li> <li>• Support research and demonstration projects.</li> <li>• Offer miner training on various environmental and ecological topics.</li> </ul>   |
| Integration of Sustainable Livelihoods | <ul style="list-style-type: none"> <li>• Integrate rehabilitation into wider policy and sustainability context.</li> <li>• Convene multi-stakeholder meetings and workshops.</li> <li>• Use written agreements.</li> <li>• Initiate community planning.</li> <li>• Implement alternative livelihood skills training.</li> <li>• Use a multi-sectoral approach.</li> <li>• Adopt sustainable land use planning.</li> </ul>  |
| Site Reuse Assessment                  | <ul style="list-style-type: none"> <li>• Engage in medium- and long-term land use planning based on local community input.</li> <li>• Convene multi-stakeholder meetings and workshops.</li> <li>• Gain multi-sectoral and diverse viewpoint on long-term land uses.</li> </ul>  |
| Grazing Management                     | <ul style="list-style-type: none"> <li>• Promote intentional and active herd management.</li> <li>• Use rotational grazing plans.</li> <li>• Create grazing exclusion zones.</li> <li>• Fence rehabilitated areas to encourage and protect plant establishment.</li> </ul>   |
| Site Monitoring                        | <ul style="list-style-type: none"> <li>• Conduct baseline surveys before rehabilitation starts.</li> <li>• Document measures taken during rehabilitation.</li> <li>• Document costs, inputs, and labor required.</li> <li>• Monitor short, medium, and long-term outcomes.</li> <li>• Evaluate outcomes based on stated goals and objectives.</li> </ul>   |
| ASM/LSM Cooperation                    | <ul style="list-style-type: none"> <li>• Identify employment opportunities for LSM rehabilitation.</li> <li>• Improve access to finance and credit.</li> <li>• Achieve biodiversity conservation through synergistic rehabilitation with large mining companies.</li> <li>• Consider potential of LSM as a source of funds and expertise for miner training programs.</li> </ul>   |





# 1 INTRODUCTION

As part of The Asia Foundation's (TAF) programme on Engaging Stakeholders in Environmental Conservation (ESEC II) in Mongolia, Estelle Levin Ltd. (ELL) conducted this study to identify best practices for rehabilitation approaches in artisanal and small-scale mining (ASM). The examples of rehabilitation provided in this report are meant to assist TAF in fostering frugal rehabilitation within ASM operations in Mongolia.

The case studies contained in this report highlight examples from a range of ecosystems in North America, Africa, Latin America, and Asia that have demonstrated successful rehabilitation and are relevant to the Mongolian context and climactic conditions. Case studies from arid and semi-arid ecosystems were incorporated when available. The report combines the outcomes from case studies with best practice guidance to offer options and a comprehensive approach for advancing frugal rehabilitation of ASM in Mongolia. The report also promotes the use of ecological restoration planning concepts to encourage scientifically sound and economically and socially desirable rehabilitation projects.

In summary, this report:

- Details the range of existing ASM environmental rehabilitation approaches;
- Profiles international case studies of ASM rehabilitation;
- Focuses on rehabilitation practices with the highest relevance for Mongolia, considering climate (arid/semi-arid), minerals of interest (gold, coal, and fluorspar), and land-use (pastoral); and
- Includes application of the mitigation hierarchy for biodiversity conservation where possible and appropriate.

## 1.1 Research Goals and Objectives

This report documents the current state of knowledge and experience in the ASM rehabilitation space. This report is action-oriented and seeks to facilitate the implementation of frugal rehabilitation in Mongolia by highlighting practical approaches and processes. To accomplish this, the report is structured in a way that facilitates the flexible application of existing approaches to the demonstration projects planned during subsequent phases of ESEC II. The report also aims to be progressive in the application of current science and policy around biodiversity and ecosystem management.

## 1.2 Research Approach

The research team consisted of Leah Butler, lead researcher and rehabilitation advisor; Paul Mitchell, senior advisor (environment and mining), and Estelle Levin, senior advisor (ASM). The research process involved desk research (28 January – 2 March) and expert consultations (11 February – 5 March). The report was written between 19 February and 14 March with subsequent reviews.

The study involved the activities included in Figure 1. The research process was extensive and is based on extensive bibliographic research; outreach to 40 professionals, academics, and practitioners with expertise in ASM, mine rehabilitation, and ecological restoration; and the authors' experiences.



Figure 1: Research Approach

While it is possible that the researchers missed some relevant case studies, the researchers attempted to cast a wide net to identify case studies, to document the most relevant and complete case studies, and to ‘dig deep’ into the case studies that were identified. A list of other potentially relevant case studies that were not profiled in this report but may be useful in the future are included in Annex 2.

## 2 RATIONALE FOR LAND REHABILITATION

In the context of ASM, land rehabilitation attempts to mitigate the negative impacts of mining by restoring or improving an ecosystem to some state of beneficial use or enhanced biodiversity value. The benefits of rehabilitation include:<sup>1</sup>

- Improved water quality;
- Land availability for future investment;
- Habitat protection for animals and plants;
- Positive relationships between communities, regulators, and miners; and
- Reduced environmental and social impacts of mining as a whole.

Mine and land rehabilitation, and ecological restoration principles and methods have been employed by LSM over the past half century as a way to mitigate the industry’s damage on ecosystems. While numerous challenges in LSM land rehabilitation persist, the science and best practice in this field is evolving and there are opportunities to adapt and apply some of this to ASM.

Currently, the methods for rehabilitation of ASM sites and areas are not generally well developed or accessible to artisanal miners. However, as the following case studies reveal, incidents of rehabilitation of land affected by ASM has increased over the past decade. This is, in part, due to increasing acknowledgement of ASM as a legitimate livelihood and increasing awareness of its environmental impacts in relation to sustainable development. On the other hand, it remains uncommon for ASM miners to rehabilitate land during or after the mining activity has ceased. The urgency for improved environmental stewardship of ASM, including the need for rehabilitation, is now widely recognized by various international development agency programs, LSM companies, non-governmental organizations (NGOs), and government agencies.

### 2.1 Frugal Rehabilitation

Ideally, preventative measures should be taken to reduce the need for rehabilitation, which often requires significant time, technical capacity, and financial investment. However, where adequate prevention has not occurred or where impacts persist, it is necessary to develop practical and affordable methods to rehabilitate degraded areas.

Given the principles of *economical affordability, social acceptability and ecological viability*, TAF’s definition of frugal rehabilitation is *use of inexpensive and low-tech approaches to improve ground and hydrological conditions, followed by an informed approach to ecological rehabilitation*.

ELL has amended this definition to further enhance it based on the following characteristics of frugal rehabilitation:

#### *Outcomes*

- Supports socially-acceptable end-uses with added value that deter re-mining.

#### *Inputs*

- Requires basic technical skills and scientific knowledge.
- Relies on machinery, tools, and equipment that are typically present on ASM sites.
- Uses predominately local materials (except in cases where topsoil regeneration requires initial inputs that trigger natural regenerative processes).

<sup>1</sup> The Asia Foundation. “Land Reclamation: A Mongolian Citizens Guide.” (2009)

*Cost*

- Low overall cost.
- Low negative impact on ASM revenue and profits.

*Environment*

- Appropriate storage, management, and deployment of topsoil.
- Supports and builds upon natural processes of vegetative regeneration and succession.
- Encourages reintroduction of native species that facilitate succession to a stable climax.
- Results in landscapes that are compatible with surrounding ecosystems and are characterized by an appropriate level of habitat diversity and heterogeneity.

*Operations*

- Integrates rehabilitation activities into existing mining and processing activities.
- Promotes the efficient and safe handling and use of overburden and waste materials.
- Encourages positive reuse of disturbed materials.

### 3 CONTEXT

#### 3.1 ASM Minerals and Mining

Copper, molybdenum, gold, coal, and fluor spar concentrates are Mongolia's major export minerals. The major mineral types for ASM include gold (placer and hard rock), coal (placer), and fluor spar (hard rock) with deposits distributed widely across the country (see Figure 2).

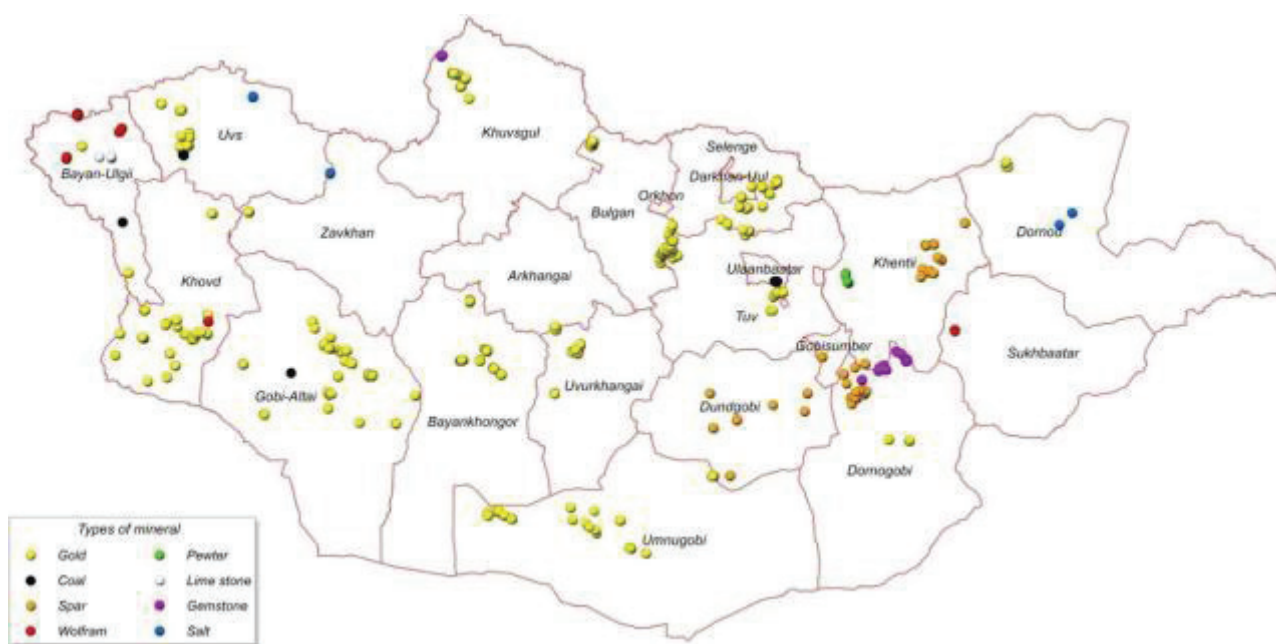


Figure 2. Location of Minerals Mined by Artisanal and Small Scale Miners<sup>2</sup>

While the official number of ASM miners in Mongolia is unknown, current estimates suggest there are approximately 100,000 working throughout the country (see Figure 3), which represents about 20% of the rural workforce.<sup>3</sup> The most common minerals include gold, coal, and fluor spar though other minerals including semi-precious stones and tungsten ore are also mined. Of Mongolia's ASM miners, about 90% work alluvial and placer gold deposits.<sup>4,5</sup> ASM is generally characterized by the use of

<sup>2</sup> National Statistical Office of Mongolia. "Survey on Artisanal and Small-Scale Mining" SAM Project (2012).

<sup>3</sup> UNEP, "Analysis of formalization approaches in the artisanal and small-scale gold mining sector based on experiences in Ecuador, Mongolia, Peru, Tanzania and Uganda," (June 2012).

<sup>4</sup> The World Bank. "Mongolia: A Review of Environmental and Social Impacts in the Mining Sector," Environment and Social Development Unit (EASES) of the East Asia and Pacific Region (2006).

<sup>5</sup> UNEP (2012).

rudimentary tools techniques, low levels of mechanization, use of manual labor, low safety standards, low levels of education, poor economic conditions, and scarce infrastructure (see Figure 4).<sup>6</sup>

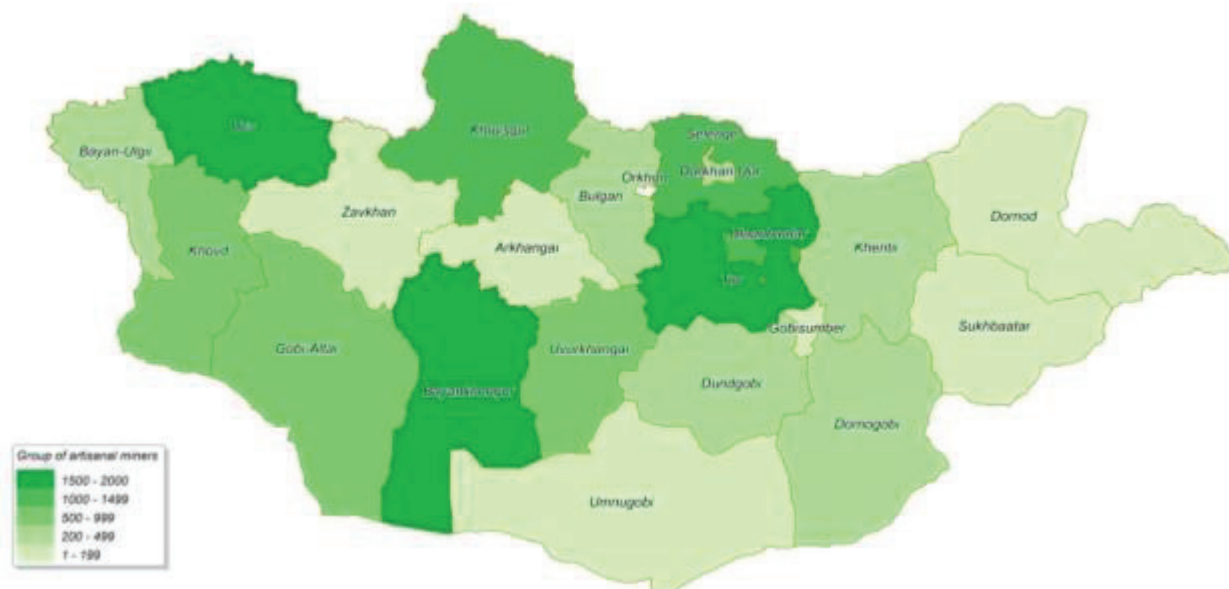


Figure 3: Distribution of Artisanal and Small-Scale Miners in Mongolia<sup>7</sup>



Figure 4: Artisanal Gold Mine in Mongolia<sup>8</sup>

### 3.2 Climate

Mongolia has a continental climate, characterized by long, cold, dry winters and brief, mild, and relatively wet summers (See Climate Maps in Annex 3).<sup>9</sup> Mongolia's extreme climatic conditions

<sup>6</sup> Tumenbayar, B. *et al.* "Result of ASM Data Collection. Workshop on the State-of-the-Art of Science and Technology to Protect the Environment and People." CASM – Asia. Bandung, Indonesia. (Nov 2006).

<sup>7</sup> National Statistical Office of Mongolia. "Survey on Artisanal and Small-Scale Mining" SAM Project (2012).

<sup>8</sup> Photo credit Estelle Levin, 2007 CASM Mongolia workshop.

<sup>9</sup> Mongolia: Geology, Mineral Deposits, and Investment Opportunity (March 2008).



increase the susceptibility of its ecosystems to human and natural disturbances. Ecosystem rehabilitation in arid and semi-arid landscapes is known to be more challenging due to:<sup>10,11</sup>

- Scant, unpredictable rainfall and prolonged dry seasons.
- Heterogeneity of water and nutrient sources.
- Heterogeneity of energy resources.
- Skeletal soils with:
  - Increased susceptibility to erosion;
  - Salinity levels elevated above average levels;
  - Reduced capacity to retain nutrients; and
  - Reduced activity and diversity of soil organisms.
- Reduced vegetative and litter cover.
- Lower species diversity.
- Shorter growing season.

However, while restoring ecosystem structure and function is more difficult in dry climates, some issues associated with the physical and chemical rehabilitation of mining-impacted areas are minimized. Some of the most technically challenging and persistent issues, which also present the greatest risks to humans, animals, and ecosystems are those created and exacerbated by the presence and flow of water. For example, acid mine drainage (AMD), a challenging long-term issue for site rehabilitation, only occurs in the presence of water. Similarly, surface water and groundwater are two major pathways for contaminant release and transport that are minimized in dry environments. On the other hand, even without the presence of water, mines in arid- and semi-arid environments can have problems with windblown contamination. Tailings piles that may contain chemicals or elevated levels of naturally occurring metals and other potentially harmful elements can be eroded by wind, resulting in large areas of contaminated surface soil downwind.

In either case, the nature and scope of rehabilitation efforts will be factors of both the direct disturbance from mining activities and subsequent changes to the surrounding environment from wind and/or water erosion over time. Therefore, the site-specific context must be taken into account when planning and implementing rehabilitation.

### 3.3 Ecosystems

Mongolia consists of large tracts of relatively intact natural habitats, including taiga, forest steppe, mountain steppe, alpine, semi-desert, desert, some wetlands, and grasslands (see Figures 5 and 6 and Annex 4). Mongolia's steppe ecosystems support stable herds of large invertebrates, numerous IUCN Red List species, and large numbers of breeding and migratory birds. One quarter of Mongolia's territory consists of critical natural habitat. As defined by BirdLife Asia, this includes State Special Protected Areas, Local Special Protected Areas, Internationally protected areas (i.e., Ramsar Sites, World Heritage Sites and Biosphere reserve core areas), community protected areas (i.e., natural sacred sites), supporting sites that maintain conditions vital for the viability of protected areas, and supplementary sites, critical for rare, vulnerable, migratory or endangered species (e.g.: Important Bird Areas) (see Annex 5).<sup>12</sup>

<sup>10</sup> Whisenant, Steven G. "Landscape Dynamics and Arid Land Restoration" in *Proceedings: Wildland shrub and arid land restoration symposium* (1995).

<sup>11</sup> Aronson, James et al. "Chapter 20: Semi-arid woodlands and desert fringes" in *Handbook of Ecological Restoration. Volume 2: Restoration in Practice*. Cambridge University Press (2002).

<sup>12</sup> BirdLife Asia. *Safeguarding Important Areas of Natural Habitat alongside Economic Development. Mongolia Discussion Papers*. East Asia and Pacific Region Sustainable Development Department, World Bank, Washington, DC (2009).



**Figures 5 and 6: Grassland ecosystems in Mongolia<sup>13</sup>**

While Mongolia has a long history of establishing and expanding protected areas, many of these areas lack management structures and oversight, which further increases their vulnerability to degradation. Furthermore, the remaining natural habitats outside of protected areas also lack management safeguards.<sup>14</sup> Mongolia's rapid economic growth combined with expanding forestry, agriculture and mining all increase pressure on natural habitats. Of these, the mining sector presents a particularly potent threat to natural habitats because of the remote locations of many mineral deposits within relatively intact habitats and the secondary impacts from project developments (e.g. supporting infrastructure such as roads, power, and transport infrastructure and the influx of people to staff and service the project).<sup>15</sup>

### 3.4 Environmental Impacts

The severity of environmental disturbance from ASM is a factor of the type and size of mine, the mining method, the ecological context, and the extent to which environmental safeguards were considered and used before and during mining (see Figure 7). Common environmental impacts of gold, coal, and fluorspar ASM in Mongolia include:<sup>16</sup>

- Local and regional hydrological changes from dredging of rivers, tailings discharges into surface waters, and the creation of artificial pits.
- Reduced water quality from increased turbidity, the generation and discharge of acid mine drainage, and poor management of other effluents.
- Changes in topography from the creation of overburden and waste piles and excavations, subsidence from underground mining, and slope instability.
- Contamination of soil and water with processing-related chemicals.
- Biodiversity loss by burial or clearance.
- Direct disturbance and accumulative indirect impacts displacing fauna within and outside of protected areas and/or Critical Natural Habitats.
- Degraded soil quality and increased susceptibility to erosion.
- Reduced air quality from dust generation.
- Degradation of ecosystem health and significant damage to ecosystem functions.

<sup>13</sup> Photo credits Estelle Levin and Paul Mitchell.

<sup>14</sup> BirdLife Asia (2009).

<sup>15</sup> BirdLife Asia (2009).

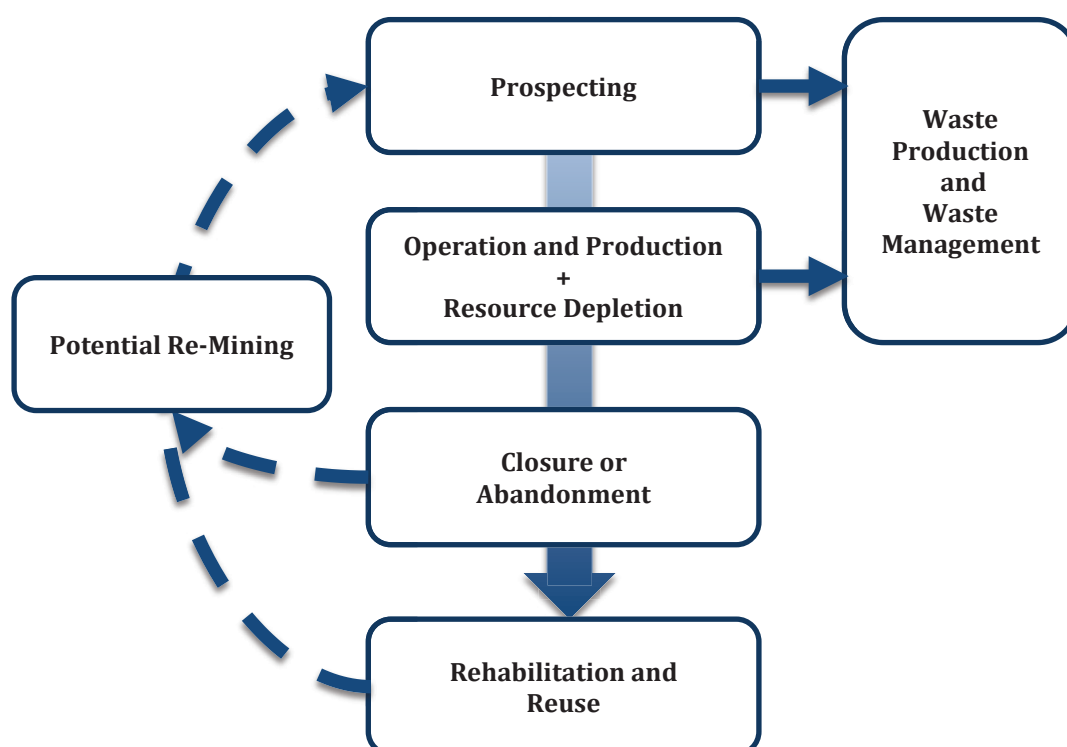
<sup>16</sup> The World Bank (2006).



Figure 7: Landscape impacts from ASM<sup>17</sup>

## 4 MINE LIFECYCLE

Though ASM typically occurs in a non-linear manner and has widely varying formality, it is conceptually useful to apply a lifecycle approach to identify leverage points for rehabilitation (see Figure 8). Incorporating environmental rehabilitation considerations into the beginning of the mine lifecycle, and acting on these considerations throughout the mining process, reduces the burden for time- and resource-intensive rehabilitation after a mine is abandoned or closed.



<sup>17</sup> Photo credit Estelle Levin, 2007 CASM Mongolia workshop

**Figure 8: ASM Mine Lifecycle**

Taking a lifecycle view to rehabilitation leverages the full range of opportunities to efficiently address negative environmental impacts as they occur so that rehabilitation can be accomplished as efficiently and successfully as possible. Best practices for frugal rehabilitation can be incorporated and implemented throughout the mining process.

## 5 BIODIVERSITY MANAGEMENT

ASM has direct and indirect impacts on biodiversity that occur throughout the mine lifecycle. Direct impacts include removal, disturbance or burial of terrestrial and freshwater habitats, reduced water and air quality, soil contamination and alterations to freshwater flow regimes that support ecosystems. Indirect impacts include longer-term systemic social or environmental change which affect community resource utilization patterns and increase pressure on biodiversity (e.g., subsequent human migration). These physical impacts to biodiversity, while damaging on their own, can lead to additional secondary effects on people and communities. Because functioning habitats form the basis of rural economies in Mongolia, especially for livestock herders and agricultural communities, natural habitat loss presents a risk to rural community resilience in Mongolia.<sup>18</sup>

Over the past decade, impacts to biodiversity from both LSM and ASM activity have come under increasing scrutiny from governments, NGOs, and the financial community. This scrutiny is a response to a marked increase in extinction rates due to habitat loss, overexploitation, invasive species and other factors related to overall globalization and development. Across the globe, the incentive to actively manage biodiversity is being driven by increased regulation, more stringent financial lending requirements, and rising civil society expectations for biodiversity management.

Integrating biodiversity management into ASM is challenging for many reasons: 1) Effective biodiversity management can be time and resource intensive and frequently involves the input of ecological specialists over long time-periods; 2) Best practice for biodiversity management for LSM has begun to take shape over the past ten years and has not yet fully emerged for ASM; and 3) Urgent issues including chronic or acute health problems, poor working conditions, conflict, human rights abuses, poverty, and food insecurity often take precedent over environmental concerns in the ASM context.

Nevertheless, to the extent that ASM stakeholders in Mongolia have both a willingness to address biodiversity concerns and the ability to increase their capacity to do so, biodiversity management considerations can begin to inform ASM planning and practice. This shift has the potential to contribute to the long-term conservation of important natural habitats in Mongolia. By introducing biodiversity considerations into ASM planning and practice, miners can be given the opportunity to adopt roles as stewards of the environment. This in itself contributes to greater community engagement, consultation, and integration and can diffuse tensions within wider communities where ASM occurs.

While current examples of biodiversity management within ASM contexts are rare, applying the overall principles of biodiversity management to ASM reveals a range of opportunities available to integrate biodiversity conservation into ASM planning and practices.

- Identify key stakeholders, including local communities, and engage them in dialogue around planning and decision-making for ASM/biodiversity management.
- Identify the local, regional, or national regulatory provisions and plans relating to biodiversity and consider how they might inform ASM/biodiversity management.

<sup>18</sup> Birdlife Asia (2009).

- Consider if and how ASM/biodiversity management can be incorporated into soum-level environmental action plans.
- Conduct biodiversity assessments. Identify areas of high biodiversity value (e.g., critical natural habitats, sacred sites, national and local protected areas, etc.) near or within areas hosting ASM and use this information to evaluate risks to biodiversity. A list of online resources to assist with biodiversity assessments is included in Annex 6.
- Use biodiversity assessments to manage future ASM development (e.g. develop guidance for assessing where ASM should or should not occur) and form the basis of mitigation plans.
- Use ASM and mineral endowment assessments to inform the level of protection afforded to critical natural habitats.
- Apply the mitigation hierarchy to ASM. Avoid, minimize, and mitigate adverse impacts on biodiversity by implementing measures, including rehabilitation and restoration, to achieve pre-identified outcomes. See Table 1 below for examples.
- Balance and, where possible, seek synergy between community needs and conservation needs in the process of determining long-term land uses for rehabilitated land.
- Stakeholders involved in large-scale biodiversity management decisions can evaluate opportunities to use International Finance Corporation (IFC) Performance Standard (PS) 6 (Biodiversity Conservation and Sustainable Natural Resource Management-January 2012) as a guide for identifying opportunities and risks to biodiversity conservation, especially when ASM may affect critical natural habitat. With broad uptake and support from financial institutions, industry, governments and civil society, IFC PS6 is rapidly gaining recognition as global best practice guidance.
- Become a leader in integrating biodiversity conservation into ASM practice. This may attract positive interest from the donor community, certification organizations, or private companies that are eager to invest in sustainable development, including more environmentally-responsible mining.
- Explore the potential of biodiversity conservation to improve relationships between miners and non-miners, to the extent that biodiversity conservation actions enhance the quality of shared resources (e.g., land, water).
- Initiate education and training programs for miners on the importance of biodiversity in or near the areas they work in and steps they can take to minimize impacts on biodiversity.
- Explore opportunities for sustainable livelihood development where biodiversity plays a key role as a natural resource.

The mitigation hierarchy is currently regarded as the global best practice in minimizing and mitigating the impacts to biodiversity from development. The application of the mitigation hierarchy to ASM is novel, but also highly relevant and applicable, if one recognizes that impact avoidance is important to reduce future rehabilitation commitments and costs. While biodiversity offsetting is not appropriate in the ASM context due to significant resource and capacity limitations, appropriate and affordable additional conservation actions can be taken to defuse tensions between ASM and affected communities and increase the cohesion and synergy of local or regional conservation projects. The following table (Table 1) provides definitions for application of the mitigation hierarchy in the ASM context as well as examples of how each step might be applied.



Table 1: Application of the Mitigation Hierarchy to ASM

| Step                                   | Description  | Example   |
|--|--|---|
| <b>Avoid</b>                           | Actively manage spatial or temporal authorization for ASM to avoid unacceptable biodiversity impacts from the outset.  | Discourage prospecting and mining in areas with high biodiversity values.   |
| <b>Minimize</b>                        | Take measures to reduce the duration, intensity and/or extent of mining impacts where ASM occurs.  | Encourage best management practices for reducing mine footprint, disturbance, sedimentation and chemical use, identifying and avoiding the most sensitive areas and managing wastes effectively.  |
| <b>Rehabilitate</b>                    | When possible, repair ecosystem structure, processes, and services to a socially desirable end-use.  | Conduct concurrent mine reclamation such that degraded land can be converted to grazing land.   |
| <b>Restore</b>                         | Assist the recovery of an ecosystem that has been degraded, damaged, or destroyed by re-establishing the pre-existing biotic integrity.  | Restore degraded area to functional ecosystem for conservation of key biodiversity values. Annex restored land to existing protected area.  |
| <b>Offset</b>                          | Measurable conservation outcomes of actions designed to compensate for significant residual adverse biodiversity impacts arising from mining after prevention and mitigation measures have been taken. | Likely technically and financially infeasible in ASM context.   |
| <b>Additional Conservation Actions</b> | Encourage other activities that are intended to benefit biodiversity.  | Develop community and consensus-based environmental action plans that are appropriate to ASM scale and affordability; invest in miner training programs that increase awareness of biodiversity attributes, values, and best practices. |

The following sections describe best practices for frugal rehabilitation of ASM, present the associated opportunities and constraints for each practice, and provide illustrative international case studies where possible.

## 6 ASM REHABILITATION PRACTICES

### 6.1 Rehabilitation Planning

| Characteristics  | Opportunities  | Constraints   |
|--|--|---|
| <ul style="list-style-type: none"> <li>Methodical planning of site-specific rehabilitation activities</li> <li>Describes the rehabilitation goals, objectives, strategy, procedures, inputs, budget, timeline, risks / threats to success, and roles / responsibilities of key actors</li> </ul> | <ul style="list-style-type: none"> <li>Improve short- and long-term planning</li> <li>Partner with local universities or LSM companies to share planning knowledge and expertise</li> <li>Create practice of thoughtful, informed, and methodical rehabilitation practice</li> <li>Track and document successes and failures for future projects</li> <li>Create a framework plan that can be scaled and adapted to different sites</li> </ul> | <ul style="list-style-type: none"> <li>Mostly appropriate for larger sites</li> <li>Requires planning expertise</li> <li>Can become a complex and lengthy process</li> <li>Elaborate plans can be costly</li> </ul> |

Rehabilitation planning facilitates the development of scientifically sound and economically and socially desirable outcomes through a systematic process. Literature on rehabilitation of mined lands shows that successful rehabilitation requires careful consideration of the local ecological context in combination with rehabilitation goals. The overall goal, especially in the context of ASM and frugal rehabilitation, is to achieve rehabilitation with minimal management interventions and minimal expenses by stimulating natural processes. Optimally, rehabilitation should occur throughout the mining process to minimise environmental impacts and capture efficiencies from better integration of equipment use, reduced earth moving costs, and improved topsoil management.

The potential for rehabilitation is influenced by local climate, topography and surface hydrology, and plant growth media as well as the nature of the disturbance and the resources (financial, human, etc.) available for rehabilitation activities. Some rehabilitation projects may be straightforward while others may be quite challenging. In arid and semi-arid landscapes, ecological restoration is limited by scarce resources (water, nutrients, soil organic matter, and propagules) and challenging environmental conditions that limit seed recruitment. Accordingly, successful efforts will involve identifying and implementing appropriate methods of conserving or increasing these scarce resources and will address the obstacles common to arid land rehabilitation noted in Section 3.2.

The following process chart outlines the fundamental steps of a simplified rehabilitation process. While planning is presented here as a linear process, in practice, many of these steps can occur concurrently or in a different order.

|               |   |
|---------------|---|
| <b>Step 1</b> | Identify future use(s) and rehabilitation objectives    |
| <b>Step 2</b> | Reduce or eliminate the causes of degradation           |
| <b>Step 3</b> | Integrate and leverage landscape interactions           |
| <b>Step 4</b> | Reconstruct and stabilize degraded landforms            |
| <b>Step 5</b> | Improve soil quality and provide a root zone for plants |
| <b>Step 6</b> | Establish vegetation and fauna communities              |
| <b>Step 7</b> | Establish future use                                    |
| <b>Step 8</b> | Monitor and maintain                                    |

**Figure 9: Rehabilitation Process Steps**

Rehabilitation planning helps guide the rehabilitation process by taking account of baseline conditions, rehabilitation goals, and resources available to generate feasible strategies to reach the desired outcomes. Rehabilitation planning should include the identification, through collaborative and inclusive stakeholder engagement, of anthropogenic stresses to rehabilitation projects that might cause the projects to fail. These might include re-mining, premature grazing, over-grazing, lack of frugal rehabilitation safeguards, and project abandonment. Approaches to reduce or address these risks should be discussed with ASM stakeholders and integrated into the rehabilitation planning process.

While ASM rehabilitation may be desirable to ASM miners and stakeholders, rehabilitation *planning* may seem unnecessary, impractical, or undesirable to some ASM miners and stakeholders due to the time and resources involved. However, when time, money, or labor are put towards rehabilitation even in a small-scale context, all parties are better off if these resources can be spent in the most effective and efficient way possible. Rehabilitation planning can help work towards this goal.

As mentioned previously, arid and semi-arid land rehabilitation comes with a unique set of challenges that demand particular focus and attention to specific issues. Providing a complete description of the physical, biological, and technical aspects of arid and semi-arid land remediation is beyond the scope of this report. However, it is worthwhile pointing out a few key sources of information that will help with these aspects of ESEC II.

A comprehensive, practical, and reputable resource on desert and dry-land restoration is David Bainbridge's "Guide for Desert and Dryland Restoration" (2007). This book discusses the particular challenges of dryland restoration based on international research and outlines the processes and procedures needed to assess, plan, implement, and monitor rehabilitation projects. The book provides straightforward guidance for restoration planning; selecting equipment and supplies (including frugal hand tools); project management; soil salvage and restoration techniques; seed collection, storage, and management; plant propagation and planting; water management; monitoring; and land use. Additionally, the book provides practical tools like budget planning worksheets, planning process and timeline templates, planning diagrams, restoration photos, sample seed collection labels, plant sampling methods, and techniques to diagnose and treat problems. The techniques described in this book are relevant to the forthcoming ESEC II demonstration projects. This book could be an indispensable resource for the ESEC II rehabilitation team as it develops an overall rehabilitation methodology and site-specific methodologies for ASM rehabilitation projects in Mongolia. Additional resources that may also assist in rehabilitation planning are included in Annex 7.

## 6.2 Systematic Prospecting

| Characteristics  | Opportunities  | Constraints  |
|--|--|--|
| <ul style="list-style-type: none"> <li>• Prospect in a systematic manner</li> <li>• Refill prospecting holes, pits and trenches</li> <li>• Divert surface water, if necessary</li> </ul> | <ul style="list-style-type: none"> <li>• Minimize land disturbance</li> <li>• Reduce risk of injury/death from falls into excavated areas</li> <li>• Avoid areas with high biodiversity value, important water resources, and cultural values</li> </ul> | <ul style="list-style-type: none"> <li>• Low incentive to refill prospecting pits as area might be re-mined</li> <li>• Double-handling of overburden viewed as inefficient or unnecessary</li> <li>• Limited funds available for rehabilitation if minerals are not located</li> </ul> |

**CASE STUDY ON SYSTEMATIC PROSPECTING<sup>19,20</sup>**

|                 |  |
|-----------------|--|
| <b>Location</b> | <b><i>Liberia and Central African Republic</i></b>                   |
| <b>Parties</b>  | <b><i>USAID PRADD, Government of Liberia, Mining Communities</i></b> |
| <b>Type</b>     | <b><i>Artisanal Gold and Diamond Mining</i></b>                      |
| <b>Year</b>     | <b><i>2010 – 2012</i></b>  |

**Background**

This method was developed in Sierra Leone by CEMMATS, a consulting firm in Sierra Leone, and was initially tested in Sierra Leone in 2006. Based on its initial success, the method was replicated in Liberia and in the Central African Republic.

**Method**

The method involves demarcating locations for prospecting at evenly spaced intervals throughout the mining area or along potential deposits as opposed to digging randomly placed pits. Systematic method provides more representative information about the presence of valuable minerals within a potential mining area, thus reducing the number of prospecting pits needed to make a decision about whether or not to proceed with mining. Fewer pits equates to less effort required to rehabilitate the area. Where economically viable deposits are not found, removed soil is pushed back into the hole and left to recover on its own. SMARTER prospecting uses typical ASM tools (shovels, pickaxes, wheelbarrows) and does not require additional manpower.

**6.3 Concurrent Backfilling**

| <b>Characteristics</b>   | <b>Opportunities</b>  | <b>Constraints</b>  |
|--|---|---|
| <ul style="list-style-type: none"> <li>• Restore a more natural topography of mined areas by backfilling pits and trenches with overburden as mining progresses</li> <li>• Divert surface water, if necessary</li> </ul> | <ul style="list-style-type: none"> <li>• Handle ore, overburden, and tailings more efficiently during mine operations to reduce effort needed at end of mine for rehabilitation</li> <li>• Easier access to remaining deposits (do not have to move overburden twice)</li> <li>• Minimize erosion and sedimentation</li> <li>• Reduces time and funds needed for rehabilitation at end of mining</li> <li>• Prevents creation of huge piles of tailings, which take up land and pose risks of landslides</li> <li>• Reduces number of stagnant ponds for mosquito (and malaria) breeding</li> </ul> | <ul style="list-style-type: none"> <li>• Assumes an early and planned commitment to rehabilitation</li> <li>• Size of pits, presence of groundwater, and integrity of subsurface materials may limit ability for concurrent rehabilitation</li> <li>• Requires initial training and oversight</li> <li>• May reduce speed of mining</li> <li>• Only straightforward when the material going into the pit or trench is inert (e.g. limited sulphide content, bioavailable metals or mercury contamination)</li> <li>• May impact the method of mining the deposit</li> <li>• Mining and processing wastes may not be suitable substrates.</li> </ul> |

<sup>19</sup> Butler, Leah "PRADD: Improved Mining Methods and Land Rehabilitation in Liberia's Artisanal Mining Communities," USAID (October 2012).

<sup>20</sup> Jeigula, Sallia, "SMARTER Mining Training Module for PRADD Liberia," (March 2012).

<sup>21</sup> Butler, Leah (2012).

## **CASE STUDY ON THE SMARTER MINING METHOD<sup>21</sup>**

|                 |   |
|-----------------|---|
| <b>Location</b> | <b>Liberia</b>  |
| <b>Parties</b>  | <b>USAID PRADD, Government of Liberia, Mining Communities</b> |
| <b>Type</b>     | <b>Artisanal Gold and Diamond Mining</b>                      |
| <b>Year</b>     | <b>2010 – 2012</b>  |

### **Tools**

Shovels, wheelbarrows, water pumps, and pickaxes

### **Background**

ASM is a major player in the economy of Liberia, as it employs approximately 600,000 miners. The environmental impacts of ASM in Liberia are severe. Most ASM areas are characterized by deforestation, biodiversity loss, ecosystem disruption, soil degradation and erosion, and water siltation and contamination. This project aimed to strengthen the capacity of miners to mitigate the environmental impacts of ASM through development and promotion of a trenching method.

The predominant artisanal mining method currently used in Liberia is pitting where holes are randomly dug and overburden and gravel is placed in scattered piles around mining claims. Pitting results in an array of negative economic, environmental, and public health impacts, some of which include:

- Mining of unknown deposits and grades due to lack of exploration and prospecting.
- Inefficient and incomplete gravel extraction leaves 40 - 50% of ore un-mined.
- Pits are not backfilled.
- Overburden is dumped in nearby waterways, impacting downstream water quality, fish habitat, and communities.
- Long-term tree loss in pit areas and resulting loss of shelter, shade, protection from wind and rain, protection for animals, food, and sources of medicinal plants.
- Increased accidents for children and livestock.

### **Method**

The SMARTER mining method is not only a way to prospect in a more efficient manner, it is also a method of mining that facilitates environmental rehabilitation of mined-out areas as part of the mining process (see Annex 8 for a pictorial description of the method). This method leaves mined-areas in a condition conducive to reuse and, because it is done throughout the mining process, it requires little extra time or labour at the end of mining. SMARTER mining involves systematic trenching and backfilling. By backfilling with overburden during the mining process, mined-out lands regained a natural contour more quickly and accommodated other uses including seasonal vegetable farming and rice cultivation.

### **Project Description**

CEMMATS, a consulting firm from Sierra Leone, developed a Training of Trainers (TOT) program to teach local stakeholders (government agents, civil society groups, university students, miners, and ASM community members) about SMARTER mining and to empower them with the skills and knowledge to effectively promote SMARTER mining in their communities after the PRADD project ended. While the full details of the training program are described in the referenced document, a brief summary is included here.

The TOT program consisted of three days of classroom training followed two days of field demonstration at a mining claim. The classroom portion covered a range of topics, including: mineral resources in Liberia; current mining and mineral processing methods; recommended mining and processing methods; general health, safety, and environmental issues; mining laws and regulations; and environmental laws. The field demonstration portion offered an opportunity for participants to demonstrate the application of the SMARTER mining method.

PRADD organized TOT programs in two locations and recruited trained stakeholders to participate as new trainers in three additional locations. Participants rotated teaching and oversight responsibilities



during the fieldwork. In total, PRADD trained people from 12 communities in the SMARTER mining method. Each community selected an appropriate field demonstration site. Through the training programs, miners were able to demonstrate both a theoretical and practical understanding of the SMARTER method and indicated they were willing to promote the method in their communities. After each field demonstration, participants gathered together and reviewed what they had experienced and learned in implementing the method.

### Inputs

PRADD provided protective equipment (overalls, boots, and gloves), food for each day, and an additional \$3 to \$5 per day per participant. From 28 – 50 people participated in each training program.

### Successes

SMARTER mining can be seen as a method that is feasible and appropriate in the ASM context and provides a way for mining regulators to help miners meet environmental restoration requirements. At its core, the SMARTER mining method is not novel or revolutionary: it is simply a method that manages overburden as it is generated. However, this straightforward action provides future benefits to miners, mining communities, regulators, and the environment.

### Challenges

Despite successes, multiple challenges remain to maintain and expand the application of SMARTER mining in Liberia. Since SMARTER mining was introduced in Liberia in 2010, awareness and use of the method is increasing but remains limited. Without the sustained presence of PRADD, the application and promotion of SMARTER mining is questionable. The following steps were identified to further promote the application of SMARTER mining throughout Liberia:

- 1) Integrate SMARTER mining into the laws, regulations, and policies governing ASM
- 2) Include SMARTER mining education in the ASM licensing process
- 3) Include SMARTER mining as a responsibility of ASM miners with licenses
- 4) Obtain greater governmental support for SMARTER mining to continue the training



Figures 10 and 11: Miners in Liberia demarcating trenches and backfilling as they mine<sup>22</sup>

## 6.4 Soil Management

| Characteristics   | Opportunities   | Constraints  |
|---|---|--|
| <ul style="list-style-type: none"> <li>Salvage, store, and use topsoil for rehabilitation</li> <li>Keep topsoil separate from overburden</li> </ul> | <ul style="list-style-type: none"> <li>Preserve soil quality</li> <li>Improve productivity rate of revegetation</li> <li>Improve chance of long-</li> </ul> | <ul style="list-style-type: none"> <li>Requires extra time and planning at start of mining</li> <li>Soil handling may degrade the soil's advantageous</li> </ul> |

<sup>22</sup> Photo credit Leah Butler, July 2012.

|   |                               |   |
|---|-------------------------------|---|
| <ul style="list-style-type: none"> <li>• Store topsoil near areas where it will be used</li> <li>• Minimise soil dump height (to avoid compacting the soil and to ensure aerobic soil conditions)</li> <li>• Use sediment barriers or temporary seeding to reduce erosion while it is being stored</li> </ul> | term success for revegetation | chemical, physical, and biological properties |
|---|-------------------------------|---|

Topsoils contain valuable microorganisms, seeds, nutrients, and organic matter that are crucial for the fostering plant life and jumpstarting natural ecological processes on disturbed land. ASM has damaging effects on the physical, chemical, and biological properties of soils; therefore a fundamental component of land rehabilitation is repairing and enhancing soil quality before attempting to seed or plant rehabilitated areas. The key factors that should be considered in enhancing soil quality include the “natural” or pre-disturbance soil conditions, erosion, soil structure, moisture movement into the soil, soil texture, soil fertility, organic matter, soil organisms, and soil crusts.<sup>23</sup>

Correct soil salvage and resspreading requires consideration of the stripping process, storage time, and management of the topsoil piles. Stored topsoils remain healthier if kept dry in shallow piles to avoid compaction and anaerobic conditions, both of which damage the ecological and physical properties of the soil. They should also be kept separate from other types of soils, to avoid nutrient dilution and degradation of other soil characteristics.

#### **CASE STUDY ON SOIL MANAGEMENT IN MEDIUM-SCALE MINING<sup>24</sup>**

**Location** *Yalbag Mine, Toson Terrace, Zaamar Goldfield, Mongolia*  
**Parties** *New Zealand Mining Company/ Cold Gold Mongolia Ltd.*  
**Type** *Medium Scale Industrial Placer Coal Mine*  
**Year** *2000 – 2001*

#### **Tools**

Excavator, diesel, screening plant, trucks, and water pumps

#### **Summary**

This project is not ASM in scale and capacity as it uses machines but the project provides processes that are conceptually useful for land rehabilitation in the ASM context. The project employed concurrent rehabilitation where topsoil and overburden were removed at the advancing front end of the mine, trucked to the mined-out back end, and then dumped over the tailings in the pit (see Figure 12).

The initial mining pit was established by removing and stockpiling the topsoil, placing the overburden on adjacent ground, and then trucking the gold-bearing gravel for processing to the nearest area of disturbed ground where a skid-mounted screening plant was established. The mining company placed the gravel in the screening plant such that waste dropped directly into the existing hole. In this way, the originally created pit was used as a repository for unwanted material and collected process water. The nearby stockpiled overburden was then placed onto the processed material in the pits. The reserved topsoil was used as a final layer to facilitate growth and revegetation. The resulting layers consisted of topsoil, overburden, and the oversize material and tailings, which together filled in the

<sup>23</sup> Bainbridge, David A. “A Guide for Desert and Dryland Restoration,” Island Press (2002).

<sup>24</sup> Walker, D. “Placer Gold Mining in Mongolia: The New Zealand Way – World Placer Journal Vol. 2 (2001).

pits. The resulting profile maximized the speed of revegetation by ensuring that topsoil was the uppermost layer.

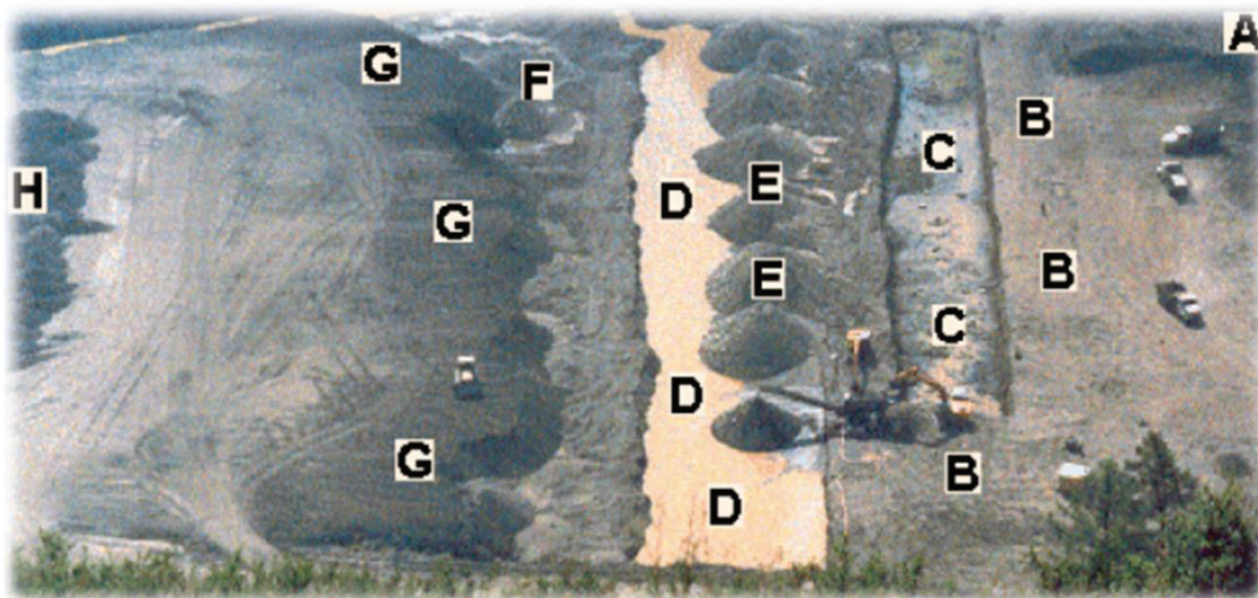


Figure 12: Mining Method for the Yalbag Mine.<sup>25</sup>

A and B = scrub clearance, topsoil removal, and overburden removal; C = block of placer mined out; D = flooded excavation of mined-out block with discharged tailings; E = oversize placed in mined-out blocks; F = oversize buried previously mined areas; G = overburden placed over oversize; H = topsoil placed over overburden.

### Successes

This method eliminated the creation of permanent pits and associated waste piles. It also minimized release of process water into surface water bodies by using a mobile screening plant (as opposed to a static plant) that dumped unwanted material and process water back into pits. Tailings were not stockpiled which reduced the risk of them washing into surface water drainages. The report states that operating costs for the Yalbag Mine were low because ore was only handled once and the additional costs to return the overburden and level the site was minimal. The report also states that because less trucks are needed, fuel costs are reduced and because rehabilitation is integrated into the daily routine, it does not become an end-of-season financial or technical burden.

This process supports the creation of conditions where natural succession or revegetation-related interventions can occur more rapidly and with a greater chance of success as overburden and topsoil placement are integrated into the mining process. Backfilling was integrated into the daily routine and therefore not an end-of season/mine financial burden. Refilling open pits was considered the most important step in rehabilitation as it made all future rehabilitation efforts easier.

### CASE STUDY OF SOIL MANAGEMENT IN ASM<sup>26</sup>

|                 |  |
|-----------------|--|
| <b>Location</b> | <b>Tapajos River Basin, Brazil</b>   |
| <b>Parties</b>  | <b>GEF/UNDP/UNIDO Global Mercury Project, independent research led by Rodolfo Neiva de Sousa</b> |
| <b>Type</b>     | <b>Artisanal Gold Mining</b>   |
| <b>Year</b>     | <b>2010</b>  |

### Tools

<sup>25</sup> Photo and explanation taken from Walker (2001).

<sup>26</sup> Neiva de Sousa, Rodolfo. "Planning and Implementing Solutions for Artisanal Gold Mining Sites, Preventing Environmental Impacts and Rehabilitating Degraded Areas: A Brazilian Case Study," (September 2010).



Hand tools, pumps, homemade sediment barriers, simple nurseries, organic and industrial fertilizers, and pesticides

## Background

The project evaluated the success of the 2002-2008 GEF/UNDP/UNIDO Global Mercury Project. When this project was conducted, approximately 200,000 miners were located in Brazil with 40,000 concentrated in the Tapajos River Basin. These miners extract gold using common, rudimentary processes that cause siltation and mercury contamination of streams and rivers, and deforestation. At the time, an estimated 300 to 600 pits were excavated annually with dimensions of around 10,000m<sup>3</sup> per pit resulting in a land disturbance of 12,000 ha/year.

This project aimed to identify good examples of existing ASM rehabilitation practices, to improve them where they were identified, and to promote the practices among other ASM miners and local government. Additionally, the project sought to answer the following specific questions:

- What is the extent of impacts from ASM, specifically from deforestation and water contamination?
- What are the suitable techniques for miners to reclaim their degraded areas and mitigate environmental impacts?
- What are the miner's incentives to reclaim degraded areas?

## Summary

The project team leveraged existing practices and expertise by identifying and building on existing best practices in the region. One miner was identified who had been rehabilitating his land for the previous seven years, independent of external support. The project team visited this 'role model' miner, learned about his methods and rationale for rehabilitation, and used his work as an example to share with other miners in the area. The project team did not identify any other miners engaged in rehabilitation activities.

The level of existing rehabilitation on the miner's property was found to be variable. Some pits were completely refilled and covered with vegetation (including trees that were plants 7 years prior), while others had no vegetation. Refilling of pits occurred concurrent with mining and included both physical (earth moving) and chemical (soil nutrient) components. To refill pits, sluice boxes were positioned so that tailings were drained into existing pits. To manage water quality, water was filtered through a barrier made of palm leaves positioned after the sluice boxes to filter sediments in 3 stages before returning cleaner water into the rivers. These sediment barriers were moved along the side of the pit as the pit refilled. After refilling, some pits were topped with retained topsoil to provide a medium for plant growth and expedite revegetation. The retained topsoil was stored under palm leaves to prevent erosion during mining. Pits that were not amended with topsoil had not revegetated as quickly or completely.

The miner was motivated to rehabilitate his property to cultivate a tree plantation that would generate income over a period of decades. Pits were revegetated in two ways: natural reseeding and succession and intentional planting with economically valuable tree species including African Mahogany, Neem, Teak, Brazil Nut Tree, Crabwood, Açaí Palm, Amazonian Mahogany, and Eucalyptus. He selected seeds with the help of the Brazilian Institute of Agricultural Research. The seedlings grew in a simple, nearby nursery in a mixed growth substrate of cattle manure, decomposed wood, and organic soil. Seedlings grew in plastic bags and were regularly watered and treated for pests. Seedlings were planted by hand on refilled pits and tended to by regular weeding, fertilizer application, and pest control.

The miner did not keep financial records for the cost of the rehabilitation efforts but estimated that the costs were covered by the income generated by his gold mining operation. At the end of the project, 128 mine pits were backfilled and some were revegetated. While this represents a small part of the existing and ongoing ASM disturbance, it was significant in that it showed rehabilitation was possible and could be economically feasible, depending on the resulting land use.

## Lessons Learned

- Refilling open pits was considered the most important step in rehabilitation as it made all future rehabilitation efforts much easier. However, the method only worked when pits were close together, as it was too labor intensive and costly to haul overburden to distant pits. Retaining topsoil led to faster rehabilitation but it took additional time and planning.
- Stakeholders should be involved in planning ASM interventions early on in the problem formulation phase to increase the likelihood of their support and involvement in the implementation phase. Participatory problem formulation is a way to generate collective knowledge, which generates shared opinions and more locally appropriate and realistic goals.
- External initiatives to address environmental degradation from ASM should pay the utmost consideration to economic incentives. If environmental improvements can also lead to economic improvements (e.g., improved gold recovery or reduced costs), the rehabilitation actions will likely be more accepted and implemented among miners.
- Miners were more receptive to rehabilitation and reforestation if profits could be generated from the post-mining land use. Therefore, the project promoted reforestation of rehabilitated land to provide a potential future income source.
- This project explored the potential synergies between post-mining land rehabilitation and large-scale conservation and sustainable development priorities. For example, since stemming deforestation is a priority for the government of Brazil, reforesting mined land contributes towards this goal thus it may attract some technical or financial support from the government.



Figures 13 – 17: Backfilling progression and plant propagation with native species<sup>27</sup>

<sup>27</sup> Photo credit Rodolfo Neiva de Sousa.

<sup>28</sup> Parkinson, Andrew. "Ecological Restoration and Mining Reclamation in Mongolia: Notes and Observations" (2014).



## 6.5 Seed Management

### CASE STUDY ON SEED COLLECTION FOR MINE REHABILITATION<sup>28</sup>

**Location** Mongolia  
**Parties** Andy Parkinson (Consultant)  
**Year** 2012

#### Tools

Locally made seed cleaning box, mechanical hand-held seed harvester (HSHS)

#### Summary

The goal of this project was to advise and assist on the collection of appropriate native grass seed for use in rehabilitation activities at a mine site. Appropriate seeds were native and representative of the ecological communities of the pre-disturbed site. The project involved training seed collectors from the local community in the types of seeds to collect, field trials of a mechanical HSHS, and how to dry, clean (screen and winnow), and store seeds. The project also involved a survey of plant species communities near the disturbed area. The project worked with student interns to quantify success of recently revegetated areas.

#### Results

- Seed collectors are more efficient if they carry 2-3 bags to collect more than one species at a time
- *Stipa sibirica* was selected as an additional species to collect for rehabilitation on the site as is a common grass species both locally and regionally.
- Small quantities of *Allium* species and *Lilium pumilum* seeds were collected to enhance the seed mix with forbs, thereby increasing biodiversity and forage value of the rehabilitated areas



Figures 18 and 19: Screening seeds with a box constructed by staff (left) and seed collectors collecting multiple species at once (right).

### CASE STUDY ON COLLECTING REHABILITATION SPECIES<sup>29</sup>

**Location** Mongolia, forest steppe eco-region  
**Parties** Andy Parkinson (Consultant)  
**Year** 2011

#### Tools

Mechanical HSHS

#### Summary

The goal of this project was to test the use of a mechanical HSHS and to identify candidate hand or machine harvestable grass species for use in mining rehabilitation.

<sup>29</sup> Parkinson, Andrew. "Ecological Restoration and Mining Reclamation in Mongolia: Notes and Observations" (2014).



Figures 20 and 21: Harvesting *Agropyron cristatum* adjacent to abandoned wheat fields, Rashaant Soum, Khovsgol (left) and a species rich meadow, Selenge Aimag (right).

## Results

The most common and dominant grass on the forest-steppe eco region was *Stipa krylovii*. Other widespread or sub-dominant grasses were *Stipa sibirica*, and *Koeleria macrantha*. *Agyropyron cristatum* was also fairly widespread, and occasionally found in dense stands. *Elymus*, *Bromus*, *Leymus* and *Elytrigia* species were less widespread and generally found in specific, usually more favorable conditions. *Achnatherum splendens* is also common throughout the region and is an indicator of high water table.

The mechanical HSHS has potential for smaller projects such as trial plots, for collecting seed to be used in nursery production, for harvesting from nursery plots, collecting in steep or rugged terrain, and harvesting specific species local to a site to enhance a rehabilitation seed mix. Pull type mechanical seed harvesters would collect far greater quantities of seed yet would be less selective, and specifically could be very useful in desert-steppe regions for harvesting onion grass (*Allium spp.*).

The advantages of using a mechanical HSHS over hand harvesting were not clear. Hand harvesting of grass seed with a well-organized and motivated team can be effective, and better than mechanical harvesting for collecting sorted, single species bags of seed. Mechanical harvesting would have an advantage if labor was more expensive or not readily available (i.e. a limited number of personnel). Mechanical harvesting may have an advantage for smaller hard to collect seeds. Hand harvesting is also a means to engage local communities in restoration projects.

## Challenges

There is a need for better establishment techniques as well as post-establishment management of rehabilitated areas. There is also a lack of native grass seed available in Mongolia for mining reclamation and infrastructure projects. Currently the available seed is of 'forage grass' species chosen for their productivity (ease of seed harvesting and ease of germination) rather than their ecological value or ability to establish and grow in tough conditions. Furthermore, the available species are not representative of the typical grass species composition of the Mongolian steppe. Selection of species for restoration and reclamation should not be restricted to forage grass: a much greater diversity of species could be considered for ASM rehabilitation if seed can be harvested efficiently from either wild stands or grown in nursery plots.

## Lessons Learned

- Local community labor and locally-made hand tools and equipment should be used whenever possible.
- Sheep may provide an economical way to firm a seed bed after sowing. Controlled post-establishment grazing can encourage tillering of grasses, thereby providing greater erosion control.

- *Bromus* and *Elymus* may not be ideal ground cover as they out-compete other native grasses and forbs, and do not provide optimal erosion control.
- Hand harvesting can be used as a means to engage local communities in restoration projects, either by paying a fixed price per kg of seed delivered or by hiring local casual labor to collect seed.
- Supervision of harvesting teams is important, whether collecting by hand or machine, and a botanist or ecologist should be included in the field team.
- For collecting both the quantity and diversity of seed required for rehabilitation in Mongolia, all available techniques, both hand and mechanical, wild collected and nursery grown, should be utilized and trialed further.

## 6.6 Mining Cooperatives

Due to the intense labor requirements of frugal rehabilitation, working with miner cooperatives to plan and implement land rehabilitation projects provides an efficient and inclusive way to engage mining communities in rehabilitation projects. A cooperative is an autonomous association of persons, united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise.<sup>30</sup>

Cooperatives exist in many sectors around the world, including the ASM sector. Miner cooperatives, whether formally or informally organized, can provide organizational structure to support improved communication, cooperation and coordination between miners. This interaction and organization can empower miners to improve their operations by pooling resources to purchase or lease more advanced equipment and by sharing wisdom and expertise. Cooperatives provide opportunities for shared learning experiences on a range of topics, from improved mining practices to rehabilitation methods. Because cooperatives are owned and democratically managed by their members, cooperatives also provide a potential leverage point to alleviate resource-based conflict. Assuming local representation within a cooperative, the cooperative's decisions can balance the needs of their members with the needs of the wider community.

### CASE STUDY ON COOPERATIVE LAND REHABILITATION<sup>31</sup>

|                 |  |
|-----------------|--|
| <b>Location</b> | <b><i>Kono District, Sierra Leone</i></b>  |
| <b>Parties</b>  | <b><i>Canadian International Development Agency, One Sky, and the Conservation Society of Sierra Leone</i></b> |
| <b>Type</b>     | <b><i>Alluvial Diamond Mining</i></b>  |
| <b>Year</b>     | <b><i>2006</i></b>   |

#### Tools

Bulldozer, fuel, lubricants, rice seeds, and hand-tools

#### Summary

Two local cooperatives were engaged to rehabilitate and cultivate mined-out plots of land. Each cooperative had 30–40 registered members. A Memorandum of Understanding (MOU) was signed between the local Paramount Chief and the cooperatives to give the cooperative rights to rehabilitate and cultivate former mining areas for a 10-year period.

The cooperatives rehabilitated and cultivated an area of 4.6 hectares and negotiated with a nearby mining company for the free use of their bulldozer, the costs of the driver, and fuel and lubricants for four days (a total of US \$1,167). To complete the reclamation and prepare 2.2 hectares for rice

<sup>30</sup> ILO "R193: Promotion of Cooperatives Recommendation" (2002).

<sup>31</sup> Diamond Development Initiative Policy Brief "Filling in the Holes: Policy Implications in Land Rehabilitation" (May 2009).

cultivation, 42 people (including co-operative members, miners, and others from the community) were hired for 10 days, at a rate of US \$2.61/day plus food, for a total cost of US \$1,488.

Post-rehabilitation food production included rice farming, using stored seeds. Five bushels (125 kg) of rice seed were planted on 2.2 hectares for a yield of 52 bushels (1.3 tonnes) in 2008. The cooperative kept roughly 10% of the harvest for seeds, gave about 10% to the Paramount Chief, and divided the rest to cooperative members for consumption and sale. After rice cultivation, the cooperative prepared the area for dry season vegetable production and rehabilitated the remaining 2.6 hectares.

Wages were not paid for the long-term reclamation and cultivation efforts. Rather, the donor agencies relied on the cooperative to solicit volunteers (generally one day a week). This fostered greater community participation and commitment but resulted in less rehabilitated area overall.

Roughly the same approach was used initiate land rehabilitation and cultivation with another cooperative in March 2009.

### Challenges

The small budget (e.g. US \$8,000) and staff (one intern and two staff) limited the number and size (only 2.2 hectares in 2009) of rehabilitation projects. Additionally, one of the rehabilitated plots was next to active and reportedly illicit artisanal mining. The active presence of the Town Chief near the project sites helped prevent miners' encroachment on the site, but encroachment remains a concern.

### Lessons Learned

- Strong, local leaders were needed in the cooperatives.
- Avoid dependency and ensure sustainability by giving responsibility for reclamation and cultivation work to cooperatives; donors should intervene only for training and occasional mediation.
- Communal ownership of the harvest and a long-term land lease are strong incentives for reclamation and cultivation; however, there may be limitations to the types of crops that can reasonably be planted and harvested within a 10-year period (e.g., excludes timber).
- Agricultural expertise and training are important to promoting sustainable farming.

### CASE STUDY OF GROUP MINING<sup>32</sup>

|                 |   |
|-----------------|---|
| <b>Location</b> | <b><i>Riverbed Mining Project near Filabusi, Insiza District, Zimbabwe</i></b>  |
| <b>Parties</b>  | <b><i>University of Zimbabwe Department of Mining Engineering and Metallurg and funding from GTZ (German Development Assistance Organization)</i></b> |
| <b>Type</b>     | <b><i>Artisanal Gold Mining</i></b>   |
| <b>Year</b>     | <b><i>Started in mid 1990s</i></b>  |

### Tools

Shovels, wheelbarrows, and sluice boxes

### Summary

This project demonstrated the benefits of "group mining" in which miners agreed to common mining standards and mining practices. In other locations, "group mining" is synonymous with mining cooperatives. Group mining enables miners to pool their resources, skills, and manpower to increase the efficiency and effectiveness of mining and also facilitates labor organization and diversification within mining groups. The short-term goal of the project was to transform illegal gold panning into a legal mining where land rehabilitation is integrated into the mining process. The long-term goal of this project was to build a useful model for the sustainable development of ASM that could be replicated elsewhere in Sub-Saharan Africa.

<sup>32</sup> Murangari, David E.H. "Riverbed mining at Filibusi, Insiza District, Zimbabwe: a model for sustainable development in small-scale artisanal mining" in *Industry and Environment* Vol. 25 (1) (January – March 2002).



## Description

Due to years of gold panning in the Mtshabezi River, a local reservoir and weir filled with sediments and lost water flow, causing extensive damage to the upstream and downstream riparian system. The project entailed removing sand and silt from the riverbed, while at the same time, extracting gold using sluice boxes and gravimetric methods from the removed materials. The remaining sand was used to backfill existing mine pits along the river to create a more natural riparian landscape and topography. Bank stabilization was achieved by emplacing riparian cobbles along the riverbank and planting the bank with native grasses. In this way, the reservoir and weir were excavated and water was allowed to enter the area. Stored water was then used in gold extraction processes downstream and as irrigation water for a new nearby vegetable garden. Concrete blocks, made by mixing excess sand and silt with cement, were sold to the community for use in construction. Notably, over 60% of the participants in this project were women due to the fact that women comprise a large portion of the rural alluvial mining population.

## Successes

The stated benefits of this project include:

- Gold panning and extraction activities conformed to environmental conservation and rehabilitation requirements.
- Desiltation of the weir and reservoir.
- Rehabilitation of mined-out areas and riverbanks.
- Increased local water storage-capacity for irrigation and mineral processing.
- Additional economic opportunities from using waste materials as product inputs.
- Capacity-building among local community members.

## 6.7 Mercury Management

| Characteristics   | Opportunities  | Constraints  |
|---|--|--|
| <ul style="list-style-type: none"> <li>• Encourage use of improved technologies to reduce chemical use, chemical exposures, and chemical releases</li> <li>• Build demonstration plants and training centers</li> </ul> | <ul style="list-style-type: none"> <li>• Prevent chemical releases</li> <li>• Reduce health risks</li> <li>• Partner with universities</li> <li>• Minimize the need for chemical clean-up</li> </ul> | <ul style="list-style-type: none"> <li>• Lack of affordable and accessible technologies to reduce chemical use</li> <li>• Lack of training and miner awareness</li> <li>• Requires increased technical capacity and skill</li> </ul> |

In 2008, the Mongolian government banned the use of mercury in mining in response to the discovery of localized mercury intoxication and soil and water contamination from high levels of mercury use in ASM areas.<sup>33</sup> Despite this ban, mercury amalgamation still occurs and continues to pose serious health risks to ASM miners and surrounding communities. In response to the need for solutions to this problem, mercury and cyanide-free methods are being developed and tested for use in ASM. While promising, many of these methods are not as easy to use as amalgamation, are less efficient than cyanide leaching, are not widely applicable, are not used in conjunction with proper tailings disposal practices which exacerbates AMD issues, and/or are cost prohibitive, which lowers the likelihood these methods will be widely adopted.<sup>34</sup> Nevertheless, innovations in improved processing methods continue to be developed and could be considered for testing or application in Mongolia.

In 2005, the Swiss Agency for Development and Cooperation (SDC) launched the Sustainable Artisanal Mining Project (SAM) to transform ASM into an engine for local and national development in Mongolia through legal reform and capacity-building. In 2008, SDC introduced a chemical-free technology for

<sup>33</sup> UNEP, "Analysis of formalization approaches in the artisanal and small-scale gold mining sector: Mongolia Case Study" (June 2012).

<sup>34</sup> Swiss Development Agency (SDC), "SDC experiences with ASM Formalization and Responsible Environmental Practices in Latin America and Asia (Mongolia)," (2011).



ore-processing and sponsored the establishment of a mercury-free gold-processing plant in Bornuur soum, Tuv aimag. The plant is currently owned by the HAMO Company and has become the Bornuur soum's largest employer, providing permanent jobs for more than 60 people.<sup>35</sup>

Case studies on chemical-free and alternative processing methods can be found in Annex 9. Until chemical-free methods are further developed to provide for efficient metal recovery, miners are less likely to transition to using these methods. In the meantime, the choice to use mercury or cyanide is a matter of trade-offs between the beneficial properties of each chemical and its health and environmental risks. In any case, safer chemical use and handling throughout the mining process has the potential to both improve miner health and reduce chemical releases into the environment which reduces the need for more complex and costly remediation at the end the mining process.

## 6.8 AMD Management

| Characteristics   | Opportunities   | Constraints  |
|---|---|--|
| <ul style="list-style-type: none"> <li>Segregate acid-generating materials from safe materials</li> <li>Prevent or reduce contact of acid-generating material with oxygen or water</li> </ul> | <ul style="list-style-type: none"> <li>Prevent AMD before it starts</li> <li>Treat AMD, if present using passive treatment methods</li> </ul> | <ul style="list-style-type: none"> <li>Lack of awareness about nature and extent of AMD risk in ASM context</li> <li>Lack of frugal technologies to treat AMD</li> <li>Requires planning and long-term management</li> </ul> |

Acid Mine Drainage (AMD) occurs when surface or ground water and oxygen (either dissolved or airborne) come into contact with geological material rich in sulfides. Through a cycle of chemically and biologically mediated and catalysed reactions, the sulfides are oxidised to produce acidic water typically containing high concentrations of dissolved metals and other potentially toxic elements. Once begun, the process of AMD generation is normally very difficult to completely stop and resulting impacts can occur over many years or decades.

AMD can negatively impact terrestrial and freshwater ecosystems, causing harm to associated fauna and flora. The acidification of ground and surface waters and contamination with metals and other potentially toxic elements can restrict or eliminate water use options (e.g. as a potable water source or for agricultural purposes). Such impacts serve to increase the challenge and cost of post-mining land rehabilitation. Current best practice in dealing with AMD places the emphasis on prediction and prevention, planned from the outset of the operation and integrated with each phase of the mining life cycle. Prevention normally relies on minimising oxygen or water contact with sulfide-rich materials, whether these are *in-situ* or in mining and processing wastes.

The best action that can be taken in regard to AMD is to prevent contact of the acid-generating material with water. This may require physically relocating materials out of waterways and drainages or to a higher elevation. If preventative measures have not been attempted or have failed, as would be the case at most, if not all, ASM sites, and AMD is not being properly treated, the sustainability of land rehabilitation is likely to be limited.

Treatment options broadly fall into either active or passive approaches:

- *Active approaches* rely on ongoing intervention and include water treatment with a range of chemical agents to neutralise the acidity and remove dissolved metals and other potentially toxic elements. Capital and operating costs are often significant.
- *Passive approaches* were initially developed as a 'walkaway' solution to AMD – once in place the concept was that no further intervention would be required. In this context, it was hoped that while capital costs might still be significant, operating costs would be

<sup>35</sup> SDC, "Artisanal Mining – An Alternative Source of Income," accessed April 8, 2014, [www.swiss-cooperation.admin.ch/mongolia/en/Home/Other\\_projects/Sustainable\\_Artisanal\\_Mining](http://www.swiss-cooperation.admin.ch/mongolia/en/Home/Other_projects/Sustainable_Artisanal_Mining).

minimal. In reality, passive methods do not represent a 'walkaway' approach as treatment efficiency declines over time and periodic intervention is still required.

While AMD treatment can be accomplished through both active and passive methods<sup>36</sup>, passive treatment methods – despite not being the 'walkaway' solution initially targeted – are generally less expensive, require fewer chemical inputs, and require less operation and maintenance over time.<sup>37</sup> For these reasons, passive methods may be the most practical for use at ASM sites in Mongolia, where both financial and technical resources for rehabilitation are scarce. The passive treatment methods that may enable the treatment of AMD in an arid/semi-arid environment include anoxic limestone drains or open limestone channels, and vegetative filter strips,<sup>38</sup> and alkaline covers; these can be supplemented by preventative measures such as capping. If no alkaline material is locally available, then capping with normal soil and subsequent revegetation may be the only option.

*Capping:* Generally involves the construction of a low permeability cover over sulfide-bearing *in-situ* or waste materials to reduce the diffusion of oxygen and the percolation of rainfall or snowmelt. One side effect of acid soils is lack of ground cover and surface stabilization, with resulting accelerated erosion that can expose more acid generating material and exacerbate AMD generation. A vegetative cover can be part of the overall strategy to control offsite impacts. Covers can consist of locally available materials, such as clay, fly ash and seeded top-soil. Planting the cover with native plant species increases the effectiveness of the cover by stabilizing the surface soil and promoting plant transpiration which reduces water infiltration through the waste materials. Surface water should be diverted around waste piles to reduce water contact with acid-generating materials.

*Alkaline covers:* As presented above, covers reduce water flow through waste piles, but may not control AMD completely. Alkaline covers provide a way to minimize the creation of AMD. The ideal alkaline cover contains material like limestone that is slightly/moderately soluble in water. Infiltrating water first comes in contact with the neutralizing material such that it will partially dissolve. This adds alkalinity to the infiltrating water. When the alkaline water then comes in contact with acid materials (rock, soil, water), direct neutralization of acidity takes place *in situ*. If pH is increased sufficiently, metal precipitates will form. In this manner, alkalinity is added each time a wetting front passes through the cover, and alkalinity can be generated over a longer time period. Another effect of alkalinity is on reducing the activity of *Acidithiobacillus sp.* These microbes catalyze the acid generating process and their activity decreases when pH increases (i.e. with higher alkalinity / lower acidity).

*Buried (anoxic) limestone drains:* Channeling AMD through a closed drain that contains limestone. The limestone dissolves and neutralizes the effluent, causing the precipitation of dissolved metals and other potentially toxic elements. To prevent the limestone becoming coated with precipitates (and therefore becoming less effective), the drain should be designed so that precipitation occurs downstream, for example in an adjacent settling pond.

*Vegetative filter strips:* Construction of densely vegetated patches in water catchment areas is a practice used for general erosion and sediment control in and around disturbed areas. In addition to reducing erosion, naturally-occurring microbes in plant roots can extract and immobilize metals from water and soil. This can be used as either a concurrent or secondary treatment of AMD, depending on the chemistry of the effluent and its ability to sustain plant life.

A list of additional resources on treating AMD with passive systems can be found in Annex 10.

<sup>36</sup> A detailed description of the characterization and treatment of AMD is out of the scope of this report. The focus instead is on preventative and passive treatment methods for AMD that could be further evaluated and applied at Mongolian ASM sites, with an accompanying list of basic resources on this topic (see Annex 10).

<sup>37</sup> Ford, K.L., "Passive Treatment Systems for Acid Mine Drainage," *U.S. Bureau of Land Management Papers* (2003): Paper 19.

<sup>38</sup> Eric Perry (Hydrologist, PhD, US Office of Surface Mining) in discussion with the author, February 26, 2014.

**CASE STUDY ON WASTE ROCK SEGREGATION AND REVEGETATION<sup>39</sup>**

|                 |  |
|-----------------|--|
| <b>Location</b> | <b><i>Utah, United States</i></b>      |
| <b>Party</b>    | <b><i>Rio Tinto</i></b>                |
| <b>Type</b>     | <b><i>Industrial open pit mine</i></b> |
| <b>Year</b>     | <b><i>1994 - Present</i></b>           |

**Background**

The Barney's Canyon Mine was operational from 1989 to 2001 and resulted in 5 open pits and 148 million tons of waste rock and 27 million tonnes of ore. The waste rock contained 5% of non-oxidized material that posed a risk of AMD.<sup>40</sup>

**Summary**

This project involved selective handling and encapsulation of acid generating materials, in pit disposal, and infiltration limiting covers.

The waste rock segregation program was implemented in 1994 and was based on a simple visual classification of the waste (i.e., grey and black rock was sent to a sulfide repository while yellow, brown, red and orange rock was sent to oxide dumps) that was later confirmed with laboratory testing. Ultimately, six million tons of sulfide-bearing rock was placed in two repositories that cover 16 hectares out of a 230 hectare waste disposal area. Thick store and release covers were constructed on the repositories. Store and release covers are designed to allow infiltrating water to be stored within the root zone of the cover so that it can eventually be released by evapotranspiration. The store and release system is designed to prevent water from passing through into and through the waste dump itself. During final recontouring of the oxide dumps, any remaining small pockets of black or grey rock were buried beneath at least four feet of oxide.

Since the mine closed in 2001, the waste rock dumps were rehabilitated into habitat for elk and deer, and are covered thickly with grasses, wildflowers and shrubs. The waste dumps were recontoured into natural landforms and revegetated. Secure repositories for sulfide materials were capped with thick vegetated covers to reduce risk of AMD. According to the mining company, there is no evidence of acidification, saline soils, or stressed vegetation on the waste rock dump surfaces. Further investigation into the effectiveness of the store-and-release caps for preventing groundwater contamination should be considered as there is larger mine, the Bingham Canyon Mine, nearby that is discharging selenium into the Great Salt Lake through groundwater pathways.

**CASE STUDY ON PASSIVE TREATMENT OF AMD<sup>41</sup>**

|                 |  |
|-----------------|--|
| <b>Location</b> | <b><i>Black Castle Mine, Boone County, West Virginia</i></b> |
| <b>Party</b>    | <b><i>Black Castle Mining Company</i></b>                    |
| <b>Type</b>     | <b><i>Industrial Coal Mine</i></b>                           |
| <b>Year</b>     | <b><i>2008</i></b>   |

**Summary**

This project involved selective handling and encapsulation of acid generating materials, in pit disposal, and infiltration limiting covers. An AMD intervention at an industrial coal mine in Boone County, West Virginia successfully limited the production of AMD from existing waste piles. The Black Castle Mining Company covered acid-generating materials with locally-sourced alkaline sandstone to increase the pH of drainage water which decreased the metal content of the water, thus eliminating the need for costly active treatment methods.

<sup>39</sup> Rio Tinto, "Sustainable Development 2011," Copyright 2012, accessed March 1, 2014, [www.riotinto.com/sustainabledevelopment2011/environment/land.html](http://www.riotinto.com/sustainabledevelopment2011/environment/land.html).

<sup>40</sup> Rio Tinto, "Waste Factsheet," Rio Tinto Sustainability Performance Report 2011, accessed April 12, 2014, [http://www.riotinto.com/sustainabledevelopment2011/pdf/waste\\_factsheet.pdf](http://www.riotinto.com/sustainabledevelopment2011/pdf/waste_factsheet.pdf).

<sup>41</sup> Cook, Thomas et al., "Covering Pre-Existing, Acid-producing Fills with Alkaline Sandstone to Control Acid Mine Drainage" *Mine Water Environ* (2008).

## 6.9 Miner Training Centers

| Characteristics   | Opportunities   | Constraints   |
|---|---|---|
| <ul style="list-style-type: none"> <li>• Located directly within mining communities</li> <li>• Staffed by miners, geologists, engineers, and technicians</li> <li>• Contain processing and refining equipment and 'intermediate' technologies</li> <li>• Support research and demonstration projects</li> <li>• Offer miner training on various topics</li> </ul> | <ul style="list-style-type: none"> <li>• Integrate different aspects of responsible mining in training and demonstrations</li> <li>• Create centers of excellence where need is greatest</li> <li>• Global networking on ASM problem-solving</li> <li>• Encourage development of local solutions that can be tested and refined</li> <li>• Foster collaboration between miners and outside experts</li> </ul> | <ul style="list-style-type: none"> <li>• Requires significant upfront time and financial investment</li> <li>• Sphere of influence is limited by the ability of miners to access the center</li> <li>• Indefinite operation and maintenance costs (staff, supplies, etc.)</li> <li>• Community preparedness and willingness to house centers</li> </ul> |

Miner training centers are becoming an effective means to provide much needed education and technical assistance to miners. Transforming ASM miners into responsible miners requires increased knowledge, awareness, and skill in addition to new technologies and better equipment. Training centers aim to provide these resources. In the 1990s, formal training centers were created in many countries including Ghana, Zimbabwe, Venezuela, Chile, Morocco, Ecuador, and Burkina Faso.<sup>42</sup> While every training center was slightly different in its configuration and programming, they were often equipped with processing and refining equipment and technologies, and provided staff (including engineers, geologists, technicians, and local miners).

The most valuable training centers offer a range of services, including environmental education and training programs, financial support, miner registration and licensing, technology, provision of information on mineral deposits, and demonstration projects and pilot studies.<sup>43</sup> Importantly, training centers share knowledge and test ideas to improve the efficiency and profitability of mining and processing methods, which is often the 'hook' by which miners become interested in becoming involved with the concept of 'responsible ASM'. Establishing a miner training center in Mongolia could create a hub of learning, training, and demonstration for frugal ASM rehabilitation that might help in subsequent phases of the ESEC II project.

### **CASE STUDY ON THE INTERNATIONAL TRAINING CENTER FOR ARTISANAL MINERS<sup>44</sup>**

|                 |   |
|-----------------|---|
| <b>Location</b> | <b>Portovelo, Ecuador</b>   |
| <b>Parties</b>  | <b>Governments of Ecuador, Peru, and the United States; University of British Columbia National Institute of Metallurgical Geological and Mining Research; Associations of Artisanal Miners; Universidad Tecnica de Machala; and the University of São Paulo.</b> |
| <b>Type</b>     | <b>Artisanal Gold Mining</b>  |
| <b>Year</b>     | <b>2011 - Present</b>   |

#### **Summary**

The International Training Center for Artisanal Miners (ITCAM) is proposed for an ASM hotspot with over 10,000 ASM miners, different types of deposits (gold, copper, lead, and zinc), and existing processing plants. The area is also near other mining communities. ITCAM is based on the principle

<sup>42</sup> Hilson, Gavin "Small-Scale Mining in Africa: Tackling Pressing Environmental Problems With Improved Strategy" Journal of Environment and Development (11) (2002).

<sup>43</sup> Hilson, Gavin (2002).

<sup>44</sup> Veiga, Marcello M., (December 2013).

that education is the key to improving the lives of ASM miners, their communities, and the environment. When miners have access to cleaner technologies and knowledge about the benefits and negative externalities of mining, they will be more empowered to make decisions that lead to sustainable outcomes.

The stated mandate of the center is to:

- Promote global, national and local awareness of artisanal mining issues.
- Develop technological and educational programs to meet local needs.
- Help artisanal mining communities improve their quality of life.
- Help artisanal miners increase mineral recovery.
- Help the artisanal miners reduce environmental, social, and health impacts.
- Assist governmental agencies in understanding technical issues in artisanal mining.
- Assist mining companies address problems related to artisanal mining.

The facility is planned to have a pilot plant, offices, laboratories, a restaurant, and classrooms for educating miners. The pilot plant tests ores and demonstrates techniques to increase gold recovery without using more mercury. Training is planned to cover topics including, but not limited to, mining technologies, geological exploration, health and safety, environmental problems and solutions, small-business and management, policy and regulations in mining, conflict resolution and ethics, economic diversification of communities, and mine closure procedures. ITCAM has received positive attention from ASM stakeholders in Colombia, Uganda, and Indonesia who are interested in developing similar projects.

## 6.10 Integration of Sustainable Livelihoods with Rehabilitation Activities

| Characteristics   | Opportunities   | Constraints   |
|---|---|---|
| <ul style="list-style-type: none"> <li>• Integrate rehabilitation into wider policy and sustainability context</li> <li>• Convene multi-stakeholder meetings and workshops</li> <li>• Use written agreements</li> <li>• Initiate community planning</li> <li>• Alternative livelihood skills training</li> <li>• Multi-sectoral</li> <li>• Sustainable land use planning</li> </ul> | <ul style="list-style-type: none"> <li>• Address root-causes of rural poverty</li> <li>• Gain a deeper understanding of community concerns</li> <li>• Meet community needs</li> <li>• Strengthen local capacity</li> <li>• Bring together miners and non-miners</li> <li>• Provide additional income opportunities</li> <li>• Reduce the incentive to re-mine a rehabilitated site</li> </ul> | <ul style="list-style-type: none"> <li>• Time intensive, long time horizon</li> <li>• Participatory process with more parties involved</li> <li>• Outcome not as clear</li> </ul> |

The sustainable livelihoods approach draws attention to the linkages between ASM and rural economies, paying particular attention to livelihood diversity, economic resilience, and food security.<sup>45</sup> Integrating these considerations into project design and implementation increases the likelihood that development interventions will create lasting, positive change.

The sustainable livelihood approach as promoted by the UK's Department for International Development is<sup>46</sup>:

- Locally-owned and driven. Participation encourages ownership and with it, a sense of accountability for project outcomes.

<sup>45</sup> Center for Development Studies, "Livelihoods and Policy in the Artisanal and Small-Scale Mining Sector - An Overview," University of Wales, (November 2004).

<sup>46</sup> DFID, "Sustainable Livelihoods Guidance Sheets," (April 1999).



- Informed by robust research data. Research plays a valuable role in articulating the needs and aspirations of ASM miners and tying this to policy.
- Strategic and linked to other key policy initiatives/sectors. Isolated initiatives rarely have impact on deep and complex poverty issues. Projects must seek leverage and establish synergies with existing projects.
- Able to build on existing capacity. Seeking out local stakeholders or institutions that are committed to change to save duplication and help to raise capacity.

The following case studies provide examples of how this can be accomplished in an ASM context.

### **CASE STUDY ON TRANSFORMING LAND INTO PRODUCTIVE USES<sup>47,48,49</sup>**

|                 |  |
|-----------------|--|
| <b>Location</b> | <b><i>Koidu area in Kono District, Sierra Leone</i></b>  |
| <b>Parties</b>  | <b><i>Tiffany &amp; Co. Foundation's Environment Program, USAID, Foundation for Environmental Security and Sustainability (FESS)</i></b> |
| <b>Type</b>     | <b><i>Alluvial Diamond Mining</i></b>  |
| <b>Year</b>     | <b><i>2007 – 2009</i></b>  |

#### **Tools**

Shovels, pickaxes, wheelbarrows, organic and industrial fertilizers

#### **Background**

Over 50 years of intensive artisanal diamond mining with virtually no land rehabilitation resulted in large tracts of degraded land in Sierra Leone's mining areas. Degraded land has little value for Sierra Leone's citizens, exacerbates existing food insecurity, and raises the risks of disease and resource-related conflict. While land rehabilitation is required by law, the country's 120,000 to 150,000 artisanal miners lack the technical capacity and funds to rehabilitate mined areas.

#### **Summary**

The project was implemented by the Foundation for Environmental Security and Sustainability (FESS), with funding from the Tiffany & Co. Foundation and the United States Agency for International Development (USAID). The goal of this project was to empower communities to rehabilitate degraded land and return it into productive uses through a community-driven process that maximized local leadership, utilized local resources, and was highly participatory.

The project aimed to empower communities to:

- Create their own mechanisms for land reclamation and implement them in ways that are appropriate to their needs and interests;
- Reclaim land that is no longer yielding diamonds and has been rendered unusable for other purposes as a result of artisanal diamond mining; and
- Develop the agricultural potential of the land and put it to sustainable economic and social uses.

The project commenced with consultative workshops for communities in ASM districts to discuss land rehabilitation; identify the social, political, economic, cultural, and technical challenges to rehabilitation and ways to overcome these challenges; define a process for selecting sites to rehabilitate and for determining end-use; and to obtain commitments of support for undertaking reclamation. Each workshop had approximately 45 participants.

Three demonstration sites were selected based on these criteria:

<sup>47</sup> Lubovich, Kelley and Ellen Suthers. "Improving Environmental Security in Sierra Leone: The Importance of Land Reclamation," FESS Issue Brief, (June 2007).

<sup>48</sup> FESS, "Reclaiming the Land After Mining: Improving Environmental Management and Mitigating Land-Use Conflicts in Alluvia Diamond Fields in Sierra Leone," (July 2007).

<sup>49</sup> Diamond Development Initiative Policy Brief "Filling in the Holes: Policy Implications in Land Rehabilitation," (May 2009).

- Land had to be exhausted for valuable minerals and there had to be local consensus on this exhaustion;
- Rehabilitated land had to be suitable for agriculture; and
- Future economic benefits returned from the land had to be communally shared.

To the greatest extent possible, the communities made the key decisions concerning the organization of work activities. Each of the three communities, with oversight by a field representative and field assistant, coordinated the labor and supervised the rehabilitation activities. At each site, for approximately 2 months, a local group of 50 men and women worked for a small daily wage (see below), and other women voluntarily cooked food and delivered water to the workers daily. The rehabilitation consisted of draining water-filled pits, filling in holes with overburden, and levelling the topography using hand-held tools. Backfilled areas were planted with crops including rice, cassava, vegetables, and oil palm (see Figures 22 and 23). The soil conditions did not require topsoil management or importation to support crop establishment. Ultimately, 19 acres were rehabilitated.

### Inputs

#### Contributions from FESS:

- Daily wages of US \$2.61 plus food.
- Farming inputs such as tools, seeds, organic fertilizer (e.g., chicken manure and urea) and inorganic fertilizers (a total of less than US \$1,000 for all three sites).
- Agricultural expertise: Ministry of Agriculture extension agents, Farmer Field School graduates, full-time Sierra Leonean agricultural advisor hired by FESS.

#### Contributions from communities and landowners:

- Oversight, management of labour and harvests.
- Storage facilities and materials.
- Processing equipment and materials for crops.
- Labor for cooking lunches and delivering water to workers.

### Outcomes

- Three sites demonstrated the effectiveness of sound environmental practices after mining.
- Improved environmental, health and safety, and social conditions.
- Increased national and local commitments toward land reclamation.
- Enhanced governance capacity of local communities.
- Strengthened attitudes that promote gender equality.

### Challenges

- Wage payments to rehabilitation workers were unsustainable, need to explore alternative means of reimbursement.
- Uncertain long-term community buy-in.
- Questionable profitability of rehabilitation and its ability to contribute to the community development fund.
- Complex and not well-documented land rights reduce the long-term viability of rehabilitation projects.
- Need to develop more effective ways to disseminate training on rehabilitation to communities.

### Successes

Success of this project relied on an effective partnership between local communities and FESS, broad-based community participation throughout the process, formal and informal commitments of support, tangible inputs from a range of community groups, and agreements within the community that the benefits of land reclamation would be communally shared. The benefits from this project included:

- Increased local food production.
- Created local employment and assisted vulnerable women find alternative livelihoods.

- Created profits for community development projects.
- Trained community residents with knowledge of crop production, storage and marketing skills.
- Improved health and safety conditions and natural resource management.

The overall success of this project led to its adoption, adjustment, and replication in Liberia (rehabilitation of 8 hectares)<sup>50</sup>, the Central African Republic (rehabilitation of 19 hectares), and Guinea (to be determined, data are not yet available as the project commenced in 2013) by USAID and its implementing partners. Each of the subsequent projects encountered unique challenges and offered new opportunities for training miners and communities on rehabilitation practices and integrating sustainable livelihoods into rehabilitation projects.



Figures 22 and 23: Mine site in Sierra Leone before and after rehabilitation<sup>51</sup>

### **CASE STUDY ON LAND REHABILITATION AND COMPLIMENTARY LAND USE PROJECTS<sup>52</sup>**

|                 |  |
|-----------------|--|
| <b>Location</b> | <b>Liberia</b>   |
| <b>Parties</b>  | <b>USAID PRADD, Government of Liberia, Miners and Mining Communities</b> |
| <b>Type</b>     | <b>Alluvial Diamond Mining</b>   |
| <b>Year</b>     | <b>2010 - 2012</b>   |

#### **Tools**

Shovels, pickaxes, wheelbarrows, organic and industrial fertilizers, simple nurseries

#### **Background**

The goals of PRADD's land rehabilitation project were to increase the benefits of mining activities in local communities by strengthening miners' capacity to prevent and mitigate the environmental impacts of ASM and by diversifying and intensifying food production on former mine lands. PRADD sought to educate mining communities about land rehabilitation, integrate environmental and natural resources management practices into local mining activities, and motivate communities to reclaim mined-out land in the future. To this end, PRADD adopted techniques and methodologies employed in Sierra Leone (through the aforementioned USAID/FESS project) in Liberia. The project demonstrated that land rehabilitation can provide opportunities for alternative livelihoods while simultaneously addressing environmental, health and security concerns.

#### **Summary**

<sup>50</sup> Butler, Leah (2012).

<sup>51</sup> Photo credit FESS (2007).

<sup>52</sup> Butler, Leah (2012).

Stakeholder consultations were held in three communities with current ASM. The consultations provided a venue to discuss land reclamation and alternative land uses, identify specific challenges associated with land reclamation, identify land to be reclaimed, develop options for alternative economically viable land uses, and define the role of various stakeholders in implementing and sustaining the projects. The sixty participants in the consultations included miners, youth, and representatives from the Liberian Ministry of Lands Mines and Energy.

Following the consultation meetings, each community formed a land reclamation committee (LRC) consisting of 15 members. The LRCs, with support from PRADD and the government agency, drafted by-laws to define the rules and regulations for the project design, the organization and implementation of the land reclamation and the end-usage of the rehabilitated lands. The LRCs subsequently assembled community workforces of 25-35 people, based on individual interest and willingness to work for a small stipend.

PRADD drafted land tenure agreements for each community with input from the LRCs and circulated the agreements for signature by key players. The agreements specify the terms and conditions of land reclamation activities and the roles and responsibilities of each party. PRADD worked with the land reclamation committees, local leaders and the mining agents to secure official authorizations to promote land reclamation on the proposed sites.

Project design and construction took 4 months for the three sites. Throughout this time, PRADD maintained a frequent presence in the communities and held regular meetings with the community workforces, LRCs, and town leaders. PRADD led the communities through the following tasks:

- 1) Preparation of mined-out areas by removing foliage and trees, de-stumping, filling in pits, and leveling piles of overburden.
- 2) Designing and demarcating the sites for fishpond construction or cultivation of swamp rice, plantains, or seasonal vegetables.
- 3) Nursery construction, planting vegetable seeds and seed rice to allow ample time for growth before transplanting.
- 4) Excavation and construction of canals, bunds, and dykes for the fishponds and rice fields.
- 5) Gathering plantain suckers from the surrounding community for transplanting into the reclaimed area.
- 6) Liming the fishponds to prevent iron from leaching from the soils, fill the ponds with water, and stock with fingerlings.
- 7) Transplanting rice and vegetable plants into the field.
- 8) Training communities on operation and maintenance.

## Inputs

PRADD contracted a specialist from the Fishery Development Cooperative Inc. to help plan, design, and construct the fishponds and agriculture fields. The consultant was responsible for:

- Developing detailed action plans for each site, including: site design, tasks, timeline, budget, workforce structure, decision-making process, monitoring plan, and tools.
- Maintaining a constant presence at each site.
- Communicating regularly with PRADD and LRCs with updates, questions, and concerns.
- Conducting on-the-job training of local community members on design, construction, maintenance, and management skills for both fish farming and community agriculture.

Contributions from PRADD:

- Farming inputs, including tools, seeds, fingerlings, PVC pipe, first aid kits, fish food, money for procuring local plantain suckers, gas for water pump, and chain saw.
- Payment for food (from \$3 to \$5/day/person).
- Agriculture and aquaculture expertise (full-time fishery/farming expert with two field workers).
- Training and training manuals.
- Project management expertise/field work oversight (in-house environmental specialists).



#### Contribution from the Ministry of Agriculture:

- Tools.
- Chemical fertilizer and insecticide.
- 2,000 fingerlings.
- 50 kg bag of rice

#### Church Aid International:

- 14 seed varieties.

#### Other donations:

- Chemical fertilizer.
- Calcium carbonate.
- Bags of rice for food.

#### Contribution from communities:

- Manual labor.
- Cooking.
- Storage facility for tools.
- Local leadership and workforce management.
- Plan for long-term management.

### Outcomes

The project resulted in the construction of two fishponds, the cultivation of 3.2 hectares of plantains, 1 hectare of seasonal vegetables, and 4.2 hectares of swamp rice. PRADD also developed training manuals and provided 30 copies to each community.

The training manual covers aquaculture, swamp rice cultivation, seasonal vegetable production, and plantain cultivation and is meant to be a guide for both managing the completed projects and expanding the projects should the communities choose to do so. PRADD organized a three-day training for each community that consisted of classroom lectures and practical demonstrations for land reuse at each field site. The training agenda included inland fishery management, vegetable crop production, methods in swamp cultivation and the production of lowland rice, agro-forestry, and small business management skills.



**Figures 24 and 25: Former mine pits are filled in with nearby piles of overburden (left) and then converted into vegetable gardens and fish farms (right).**



## Challenges

In July 2012, PRADD held three separate town hall meetings with the LRCs and town leaders to help them plan for the long-term management of the projects. The overall purpose of these meetings was to motivate the communities to take ownership over the projects and to prepare them for PRADD's eventual withdrawal. The meetings gave participants a chance to voice concerns, ask questions, and identify key misunderstandings between those actively involved in the projects (e.g., workforce and LRCs) and the rest of the communities. The major issues raised included:

- Some community members were unwilling to participate in land reclamation altogether.
- Some workers and members of the LRCs do not feel supported by town leaders.
- Town leaders want to be more involved in the projects.
- The projects have not been thought of as community projects because of PRADD's involvement in forming the LRCs and providing daily food compensation based on worker attendance, which was seen as payment for work.

The meetings provided an opportunity for all stakeholders to talk through the issues together and develop solutions that unite the town, LRCs, and workers. While the LRCs and the workforces acquired the technical skills and knowledge to construct and operate the projects, the town has the ability to motivate volunteers (e.g., from youth or women's groups), donate food and financial resources (e.g., to buy tools), liaise with government officials to obtain outside support for the projects, and provide long-term leadership. After recognizing the contributions that each group can make, each community committed to trying their best to work together to co-manage the project.

Other challenges included:

- Wage payments to rehabilitation workers were unsustainable, meaning there is a need to explore alternative means of reimbursement.
- Uncertain long-term community buy-in.
- Questionable profitability of rehabilitation and its ability to contribute to the community development fund.
- Complex and not well-documented land rights reduce the long-term viability of rehabilitation projects.
- Need to develop more effective ways to disseminate training on rehabilitation to communities.

## Successes

Community benefits from reclamation of mined-out land included:

- Transformation of formerly unused land (mined-out pits) into productive land for fish and crop farming.
- Increased food security (defined as food availability, food access, and food nutrition).
- New sources of revenue for community development projects.
- Establishment of seed banks.
- Knowledge and skills in environmental management/land rehabilitation, agriculture and aquaculture development, operation, and maintenance that can be developed and shared.
- New infrastructure (raised nursery, fish ponds, storage facilities).
- Stock of tools for future community projects (tools can be borrowed for a fee to cover tool management and maintenance costs).

## CASE STUDY ON POST-MINING INCOME GENERATING ENVIRONMENTAL REHABILITATION<sup>53</sup>

|                 |  |
|-----------------|--|
| <b>Location</b> | <b>Central African Republic</b>        |
| <b>Parties</b>  | <b>USAID PRADD, Mining Communities</b> |
| <b>Type</b>     | <b>Alluvial Diamond Mining</b>         |
| <b>Year</b>     | <b>2008 – 2013</b>                     |

<sup>53</sup> DeJong, Terah J. "PRADD Environmental Rehabilitation and Artisanal Diamond Mining: A Case Study of Land and Livelihoods in the Central African Republic." (March 2012).

## Summary

The Post-Mining Income-Generating Environmental Rehabilitation (POMIGER) Program combined income diversification and food security strengthening with environmental rehabilitation of mined-out areas. Land rehabilitation became an avenue through which the project team could address rural poverty by converting old mining pits into fishponds, vegetable gardens, and fruit orchards. This increases livelihood diversity in mining communities and provided additional revenue sources that could balance out the sporadic and unreliable income from mining. As revenue from ASM declined or stagnated, miners were forced to turn to other available livelihood options. This project provided these options through constructing demonstration projects and then training miners and community members on alternative ways to earn income.

The program led to the rehabilitation of 381 sites for agricultural uses. These sites had a collective footprint of 48.28 hectares and supported 264 individuals.



Figure 26 – 28: Miners in the Central African Republic transform mined land into agriculture plots and fish farms<sup>54</sup>

## 6.11 Site Reuse Assessment

| Characteristics  | Opportunities  | Constraints  |
|--|--|--|
| <ul style="list-style-type: none"> <li>• Medium- and long-term land use planning based on local community input</li> <li>• Convene multi-stakeholder meetings and workshops</li> <li>• Multi-sectoral</li> </ul> | <ul style="list-style-type: none"> <li>• Meet community needs</li> <li>• Improve long-term management</li> <li>• Align remediation with future land uses</li> <li>• Foster more sustainable rehabilitation projects</li> <li>• Bring together miners and non-miners</li> </ul> | <ul style="list-style-type: none"> <li>• Time intensive</li> <li>• Participatory process with more parties involved</li> <li>• Property right/use restrictions</li> <li>• Long-term uses may change</li> </ul> |

Because mineral resources are finite and exhaustible, mining land uses are temporary in nature and will eventually be replaced by different uses. To the extent that formerly mined land can be repurposed, this land holds value for other users and future generations by providing opportunities for alternative human uses or biodiversity preservation. Incorporating long-term land use thinking into both the mining and land rehabilitation processes increases the chance that these values can be realized.

<sup>54</sup> Photo credit Terah Deiong (2012).

A range of post-ASM land uses may be possible and desirable in Mongolia, including natural habitat, pasture, forestry, or crop land. Future land use goals will inform the nature and extent (and therefore cost and level of effort) of rehabilitation activities for each site. Accordingly, identifying and understanding the reasonably anticipated and practical future land uses is an important consideration for rehabilitation planning.

Stakeholder input in reuse planning can strengthen local capacity to prevent misuse of the land over the long-term, which increases the benefits of rehabilitation investments. Participatory site reuse assessments are useful tools to engage stakeholders in reuse planning. A reuse assessment involves collecting and evaluating information at the site level to develop assumptions about reasonably anticipated future land uses. It can involve a review of historic land uses, visual inspections of the mine, and discussions with stakeholders. Reuse assessments can be conducted at different spatial scales and will be shaped by the resources available, stakeholders' needs, the size of the mine(s), and the intended outcomes. For example, one reuse assessment could be conducted for each mine, for a cluster of mines (e.g. a mining district), or for all mines within a particular soum. The decision on if and how to conduct reuse assessments could be made through the planned multi-stakeholder collaboration process envisioned by TAF.

### **CASE STUDY ON REUSE ASSESSMENTS<sup>55</sup>**

|                 |  |
|-----------------|--|
| <b>Location</b> | <b>United States</b>                             |
| <b>Parties</b>  | <b>USEPA, Local Communities, Property Owners</b> |
| <b>Type</b>     | <b>Any Rehabilitation Project</b>                |
| <b>Year</b>     | <b>1999 - Present</b>                            |

### **Summary**

In 1999, the U.S. Environmental Protection Agency (USEPA) launched the Superfund Redevelopment Initiative (SRI) to assist government agencies, communities, and private companies transform contaminated sites, including mining sites, into productive uses. The SRI is intended to encourage stakeholders to consider future land uses when making decisions about site clean-up and rehabilitation plans. The SRI promotes a participatory process where stakeholders are encouraged to voice their preferences and expectations for long-term land uses. These preferences are then considered in conjunction with other factors including land tenure status and clean-up constraints. To facilitate this process, the USEPA developed reuse assessment guidelines.

The USEPA document "Reuse Assessments: A Tool to Implement the Superfund Land Use Directive" contains guidance for conducting reuse assessments, including an outline for the assessment and steps for collecting information about the site and nearby community. While these guidelines were designed for large and complex hazardous waste sites, the guidelines are flexible and can be adjusted and scaled-down to fit the ASM context in Mongolia. The concepts and methods of reuse planning are similar enough such that they can apply to any type (e.g., mining, infrastructure, commercial development) or size of site. As an example, Table 2 contains an outline for a reuse assessment applicable to Mongolia that has been adapted from the USEPA guidance document.

<sup>55</sup> USEPA, "Reuse Assessments: A Tool to Implement the Superfund Land Use Directive" Office of Solid Waste and Emergency Response (2001).

**Table 2: Outline for ASM Reuse Assessment in Mongolia****Stakeholders**

- Identify stakeholders and their connection to the site (ASM miners, citizens of impacted soum, soum governments, civil society, mining companies, local entrepreneurs, and central government)
- Determine which stakeholders are responsible for local land use determinations
- Document the stakeholders who wish to participate in the reuse assessment

**Site Description**

- Physical features: size and topography [% undisturbed habitat/vegetation]
- Site location in relation to other land uses, i.e. residential, commercial, industrial, and agricultural areas, areas with significant biodiversity, and water resources
- Current and past uses
- Neighboring land uses
- Nearby public infrastructure

**Environmental Considerations**

- Size and nature of areas that have been excavated or used for waste dumping
- Contaminants and their locations (to the extent this information is known)
- Potential restrictions resulting from the environmental contamination
- Areas that are "clean" and potentially available for immediate reuse
- Ground water use
- Other site characteristics (e.g., presence of surface waters, critical habitats, endangered species, etc.)

**Site Ownership**

- Person or entity that holds title to the land and/or who controls access
- Site owner(s) preferences and plans

**Land Use Considerations and Environmental Regulations**

- National, provincial, local regulations impacting reuse
- Institutional controls (e.g., easements, covenants) already in place
- Historical and cultural resources present

**Community Input**

- Future reuses that community members support
- Future reuses that community members oppose
- Cultural factors that may create barriers or assets to future reuse
- Environmental justice issues

**Public Initiatives**

- Infrastructure plans that may influence the site uses
- Funds available for the rehabilitation and reuse
- Other resources available for the rehabilitation and reuse (e.g. human capital & voluntary labour)

**Most Likely Future Uses**

- Analyse and synthesise the information as the basis for concluding the most likely future use or uses

## 6.12 Grazing Management

| Characteristics  | Opportunities  | Constraints  |
|--|--|--|
| <ul style="list-style-type: none"> <li>• Active herd management</li> <li>• Use of rotational grazing plans</li> <li>• Creation of grazing exclusion zones</li> <li>• Fencing rehabilitated areas to encourage and protect plant establishment</li> </ul> | <ul style="list-style-type: none"> <li>• Reduce stress on newly rehabilitated lands</li> <li>• Create environment suitable for revegetation</li> <li>• Increase chance of long-term revegetation success</li> <li>• Minimize land degradation</li> </ul> | <ul style="list-style-type: none"> <li>• Can require coordination among many stakeholders</li> <li>• Physical barriers (e.g., fences) may disrupt other wildlife</li> <li>• Requires planning assistance on grazing/rangelands management</li> </ul> |

Understanding the most probable future land use can improve land management decisions during and after rehabilitation activities. For example, livestock grazing has been identified as a desirable land use for some rehabilitated ASM sites in Mongolia (other uses may include agriculture or habitat restored for biodiversity values, for example). With this knowledge, local land managers can develop and enact local land use restrictions for the rehabilitated area immediately following rehabilitation activities that foster the sustainable (gradual or tiered) conversion to this land use. Working towards a long-term goal of livestock grazing necessitates temporary postponement of this use until the new plant communities become sufficiently established such that they can sustain the increased pressures.



Figures 29 and 30: Herds of goats and horses grazing on the Mongolian Steppe<sup>56</sup>

### CASE STUDY ON MITIGATING GRAZING PRESSURES<sup>57</sup>

|                 |  |
|-----------------|--|
| <b>Location</b> | <i>Ulziit River, Bumbugur soum, Bayankhongor aimag, Mongolia</i> |
| <b>Party</b>    | <i>Odod Gold LLC (formerly Cold Gold Mongolia)</i>               |
| <b>Type</b>     | <i>Open Pit and Placer Gold Mine</i>                             |
| <b>Year</b>     | <i>2009</i>  |

#### Summary

During and after rehabilitation activities, the mining company realized that, while physical rehabilitation was proceeding as planned, ecological rehabilitation was more challenging due to low rainfall, overgrazing of newly restored ground by livestock, and poor soils. In response, the company initiated a pilot project to reduce overgrazing by enclosing a 2.5 hectare plot in a livestock-proof fence.

#### Results

The vegetation growth greatly improved in the fence area, as compared to the unfenced areas,

<sup>56</sup> Photo credit Estelle Levin, CASM workshop Mongolia, 2007

<sup>57</sup> The Asia Foundation. "Land Reclamation: A Mongolian Citizens Guide." (2009).



indicating that the success of rehabilitation is enhanced if livestock are excluded from rehabilitated areas for a period of two years. Though fencing increased the long-term success of the rehabilitation project, this management strategy required multi-party collaboration to secure the consent and participation of herders, miners, and their communities.

This finding is consistent with other literature on landscape restoration in arid and semi-arid lands. A study on desertification and restoration of grasslands in Inner Mongolia provides the following recommendations for grazing management in relation to land rehabilitation that could be applicable in Mongolia:<sup>58</sup>

- *Herding management*: Develop and implement strategies to improve herding practices. This could involve excluding livestock for a period of 2-5 years from rehabilitated lands, which would significantly improve soil properties and help restore soil fertility.
- *Range grazing*: In cases where fencing is not feasible or desirable, range grazing offers an alternative. Range grazing consists of closely managing the size and location of grazing herd by using a rotational grazing system, which can help ecosystem recovery.
- *Capacity assessment*: Develop recommendations for herd size, location, and rotations by assessing the existing impacts of grazing. Use available information to guide best practice on managing grazing on rehabilitated landscapes.
- *Supportive livelihoods*: Alternative (non-pastoral) sustainable livelihood options may be available. These options could include grassland restoration or range assessment jobs and agricultural and agricultural processing jobs. Training could be provided for these alternative livelihoods.

While exclusion of grazing allows for natural revegetation in many cases, studies of grassland restoration in China's pastoral lands<sup>59,60</sup> and in arid ecosystems of the western United States<sup>61</sup> show that grazing exclusion alone will not necessarily lead to optimal recovery and may even have undesirable socioeconomic consequences for excluded grazers. Thus any plans to exclude or limit grazing should take into account additional fundamental processes (e.g. climate, fire, and other human pressures) that influence the ecological and economic health of the area. The following measures offer options for encouraging grassland recovery:<sup>62</sup>

- Policy measures and government interventions
- Ecological resettlement for herders and farmers are displaced by land degradation
- Encouraging people to maintain timber, brush, and grass with native, site-adapted shrubs
- Use of "spatially heterogeneous" integrated management that encourages natural recovery<sup>63</sup>
- Improved management schemes, such as delayed grazing or rotated grazing
- Demonstration projects (e.g., alternative energy generation or high yield grass plantation)

### 6.13 Site Monitoring

Frugal rehabilitation approaches require the use of monitoring activities that miners and local communities can use to evaluate the success of rehabilitation projects. Appropriate monitoring methods will vary depending on the nature of the site, extent of environmental disturbances, including chemical contamination, and the type of rehabilitation. Without mechanisms to evaluate the effectiveness of rehabilitation projects, it is difficult to determine if projects reached their intended goals and which methods were the most effective.

<sup>58</sup> Meyer, Natalie. "Desertification and restoration of Grasslands in Inner Mongolia," *Journal of Forestry* (2006).

<sup>59</sup> CAB International. "Rangeland Degradation and Recovery in China's Pastoral Lands," Eds. Victor R. Squires et al. (2009).

<sup>60</sup> Akiyama, Tsuyoshi and Kensuke Kawamura. "Grassland degradation in China: methods for monitoring, management, and restoration," *Grassland Science* Vol. 53 (1) (2007).

<sup>61</sup> Curtin, Charles G. "Grazing, Rest, and Restoration in Arid Landscapes," *Conservation Biology* Vol. 16 (3) (2002).

<sup>62</sup> Zhang, Guogang et al. "How to restore the degraded grassland in Inner Mongolia of China?" *Journal of Food, Agriculture, and Environment* Vol. 11 (2) (2013).

<sup>63</sup> Bradshaw A., "The use of natural processes in reclamation—advantages and difficulties." *Landscape and Urban Planning* (51) (2000).

Because rehabilitation for ASM is a relatively new activity in Mongolia, collecting, tracking, and evaluating project success will be key to establishing baseline conditions and continually improving rehabilitation programs. Site monitoring allows managers to identify problems as they arise, empowering them to adaptively manage the project. Basic project monitoring and data collection will enable ASM stakeholders to evaluate project success and make future recommendations based on evidence. The benefits of establishing monitoring programs for ASM in Mongolia include:<sup>64</sup>

- Use of local knowledge (on environment, biodiversity and cultural issues).
- Improved reporting for government, regulators, and stakeholders.
- Local monitoring employment opportunities.
- Ability to measure rehabilitation success.
- Ability to document, refine, and disseminate best practices.

Basic monitoring programs could be established for ASM rehabilitation that assess the success of rehabilitation projects in terms of both technical effectiveness, cost effectiveness and outcomes (relative to objectives as set). Site-level monitoring could include:

- Baseline surveys before rehabilitation starts.
- Documenting measures taken during rehabilitation.
- Documentation of cost, inputs, and labor required.
- Monitoring short, medium, and long-term outcomes.
- Evaluating outcomes based on stated goals and objectives.

### **CASE STUDY ON REVEGETATION AND MONITORING**<sup>65,66</sup>

|                 |                                      |
|-----------------|--------------------------------------|
| <b>Location</b> | <b>North Central Mongolia</b>        |
| <b>Party</b>    | <b>Peabody Energy</b>                |
| <b>Type</b>     | <b>Industrial Open Cut Coal Mine</b> |
| <b>Year</b>     | <b>2009 – Present</b>                |

#### **Site Preparation**

The company first collected baseline information on the available topsoil, topography, native vegetation, and soil quality. The rehabilitated topography was designed to establish a drainage path, ensure slope stability, and blend the recontoured surface into the surrounding topography. During the earth-moving activities, any potentially acid-generating material was placed into the bottom of the pit to reduce the risk of AMD and covered with suitable overburden. Stockpiled topsoil was spread over the surface of the waste to a depth of 20cm and was then ripped and contoured to establish optimal seedbed conditions.

#### **Revegetation and Monitoring**

The mine is within the steppe zone (grassland) and is dominated by grasses, sedges, and low growing forbs and sub-shrubs. The company worked with Professor Davganamdal Tumenjargal, a revegetation expert from the Mongolian University of Agriculture, to identify the appropriate types of species for revegetation. These included alfalfa, smooth brome, crested wheatgrass, and Siberian needlegrass.

After revegetation was completed, a site monitoring program was developed and initiated to evaluate the long-term success of the project. Students from the Mongolian State University of Agriculture are implementing the monitoring program. The project expects that revegetation should be successfully established five years after the final seeding. Plant monitoring after two years indicated successful establishment of perennial vegetation. During mining operations, a shallow groundwater source was discovered that was developed into a drinking water well, pond, and livestock tank during the rehabilitation process.

<sup>64</sup> The Asia Foundation (2009).

<sup>65</sup> WCA Case Study "Peabody Energy completes Mongolia's first coal mine restoration project," (November 2011).

<sup>66</sup> Pfannenstiel, V.R. and Davganamdal Tumenjargal "Achieving Reclamation Success Globally – Peabody Energy's Experience in Mongolia" Journal of American Society of Mining and Reclamation, Vol.1(1), (2012).



Figure 31: Ereen Mine, end of operations, 2009<sup>67</sup>



Figure 32: Ereen Mine, one year after rehabilitation, 2011<sup>68</sup>

#### 6.14 ASM/LSM Cooperation

ASM miners are mostly operating with narrow profit margins that may provide just enough for them and their families. They are also operating with little to no awareness about the benefits and practice of rehabilitation. Without the resources and knowledge to engage in rehabilitation, miners are unlikely to allocate their scarce resources towards this end.

Large-scale mining companies can help fill this resource and knowledge gap. Mining companies are valuable sources of expertise that can play a role in raising the skill and technology level of ASM operations to a more sustainable status. Large-scale companies have vast expertise in prospecting, mining, processing, refining, and chemical management, have access to new technologies, and are more informed of relevant environmental and health issues. Increasing the exchange of information and ideas between LSM and ASM brings critical improvements to ASM operations and offers additional opportunities to specifically promote ASM rehabilitation, including:

*Synergistic Rehabilitation.* Opportunities may exist for companies to work towards required biodiversity targets by rehabilitating ASM sites in areas with high biodiversity values. Increasingly, local and national governments are including language referring to biodiversity offsets in their policies, guidance, and legislation as a tool to balance development with environmental protection. Additionally, the IFC PS6, which focuses on biodiversity conservation, requires a net gain for impacts on critical habitat and no net loss, where possible, for impacts to natural habitat. Thus a mining company's ability to access capital from the World Bank and Equator Principles Financial Institutions and secure approvals from governments is requiring an increasing level of commitment to ambitious

<sup>67</sup> Photo credit Pfannenstiel and Tumenjargal (2012).

<sup>68</sup> Photo credit Pfannenstiel and Tumenjargal (2012).

conservation goals. Rehabilitating existing degraded ASM land may be one avenue through which mining companies can reach these goals.

*Improve miner access to finance and credit.* LSM companies could serve as financial partners that are able to provide low-interest or interest-free loans. With this capital, miners could purchase new equipment, invest in better management practices (including land rehabilitation), legally acquire new mineral deposits, and improve their livelihoods overall which all may result in both increased profits and the capacity to repay loans.

*Rehabilitation training programs.* LSM companies are typically much more experienced in land rehabilitation and are responsible for larger land rehabilitation projects. Collaborating on ASM rehabilitation training programs is one avenue through which this expertise can be shared. This collaboration could occur as part of a miner training center's programming.

*Employment.* Industrial mines require labor to conduct rehabilitation activities. These mines could employ local ASM miners. In rehabilitating industrial mines, ASM miners can learn the principles and processes of rehabilitation in an experiential, hands-on environment and then later apply the principles and processes to their small-scale operations.

*Buying from ASM.* Buying product from artisanal miners operating on or near an LSM concession gives LSM a stake in helping the ASM manage their environmental impacts. There are a number of companies working with ASM in this way, and this is especially facilitated through responsible mining and sourcing programmes such as the Fairmined Standard<sup>69</sup>, and the FairTrade Gold Standard.<sup>70</sup>

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<sup>69</sup> Alliance for Responsible Mining, "Fairmined Standard for Gold from Artisanal and Small-Scale Mining, Including Associated Precious Metals," current version May 1, 2013.

<sup>70</sup> Fairtrade International, "Fairtrade Standard for Gold and Associated Precious Metals for Artisanal and Small-Scale Mining," current version August 11, 2013.



## 7 SUMMARY OF BEST PRACTICES

| Best Practice           | Key Characteristics   |
|-------------------------|---|
| Biodiversity Management | <ul style="list-style-type: none"> <li>• Encourage best management practices for reducing mine footprint, disturbance, sedimentation and chemical use; identifying and avoiding the most sensitive areas; and managing wastes effectively.</li> <li>• If conservation of key biodiversity values is desired, restore degraded areas to functional ecosystems for conservation of key biodiversity values and then annex restored land to existing protected areas.</li> <li>• Invest in miner training programs that increase awareness of biodiversity attributes, values, and best practices.</li> <li>• Discourage prospecting and mining in areas with high biodiversity values.</li> </ul> |
| Rehabilitation Planning | <ul style="list-style-type: none"> <li>• Encourage the methodical planning of site-specific rehabilitation activities.</li> <li>• Think ahead to define the rehabilitation goals, objectives, strategy, procedures, inputs, budget, timeline, risks / threats to success, and roles / responsibilities of key actors.</li> </ul>  |
| Systematic Exploration  | <ul style="list-style-type: none"> <li>• Prospect in a systematic manner.</li> <li>• Refill prospecting holes.</li> <li>• Divert surface water, if necessary.</li> </ul>  |
| Concurrent Backfilling  | <ul style="list-style-type: none"> <li>• Restore a more natural topography of mined areas by backfilling pits and trenches with overburden as mining progresses.</li> <li>• Divert surface water, if needed.</li> </ul>   |
| Soil Management         | <ul style="list-style-type: none"> <li>• Salvage, store, and use topsoil for rehabilitation.</li> <li>• Keep topsoil separate from overburden.</li> <li>• Store topsoil near areas where it will be used.</li> <li>• Minimise soil dump height (to avoid compacting and maintain aerobic soil conditions).</li> <li>• Use sediment barriers or temporary seeding to reduce erosion while soil is being stored.</li> </ul>   |
| Seed Management         | <ul style="list-style-type: none"> <li>• Collect appropriate native seed mixes for revegetation that are representative of natural ecological communities.</li> <li>• Provide training to rehabilitation teams on correct seed collection, cleaning, and storage techniques.</li> </ul>   |
| Mining Cooperatives     | <ul style="list-style-type: none"> <li>• Engage with organized groups of miners and recruit them to take an active role in rehabilitation projects.</li> <li>• Foster improved communication, cooperation and coordination between miners and with external organizations.</li> <li>• Encourage shared-learning experiences with miner cooperatives on a range of topics, from improved mining practices to rehabilitation methods.</li> <li>• Alleviate resource-based conflict by using cooperatives as a potential leverage point.</li> </ul>  |
| Mercury Management      | <ul style="list-style-type: none"> <li>• Encourage use of improved technologies to reduce chemical use, chemical exposures, and chemical releases.</li> <li>• Build demonstration plants and training centres.</li> </ul>   |
| AMD Management          | <ul style="list-style-type: none"> <li>• Segregate acid-generating materials from safe materials.</li> <li>• Prevent or reduce contact of acid-generating material with oxygen or water.</li> </ul>   |
| Miner Training Centers  | <ul style="list-style-type: none"> <li>• Locate centers within mining communities.</li> <li>• Staff centres with local miners, geologists, engineers, and technicians.</li> <li>• Improve technology by hosting improved processing and refining equipment and 'intermediate' technologies.</li> </ul>  |



|  |   |
|--|---|
|  | <ul style="list-style-type: none"> <li>• Support research and demonstration projects.</li> <li>• Offer miner training on various environmental and ecological topics.</li> </ul>  |
| Integration of Sustainable Livelihoods | <ul style="list-style-type: none"> <li>• Integrate rehabilitation into wider policy and sustainability context.</li> <li>• Convene multi-stakeholder meetings and workshops.</li> <li>• Use written agreements.</li> <li>• Initiate community planning.</li> <li>• Implement alternative livelihood skills training.</li> <li>• Use a multi-sectoral approach.</li> <li>• Adopt sustainable land use planning.</li> </ul> |
| Site Reuse Assessment                  | <ul style="list-style-type: none"> <li>• Engage in medium- and long-term land use planning based on local community input.</li> <li>• Convene multi-stakeholder meetings and workshops.</li> <li>• Gain multi-sectoral and diverse viewpoint on long-term land uses.</li> </ul>   |
| Grazing Management                     | <ul style="list-style-type: none"> <li>• Promote intentional and active herd management.</li> <li>• Use rotational grazing plans.</li> <li>• Create grazing exclusion zones.</li> <li>• Fence rehabilitated areas to encourage and protect plant establishment.</li> </ul>  |
| Site Monitoring                        | <ul style="list-style-type: none"> <li>• Conduct baseline surveys before rehabilitation starts.</li> <li>• Document measures taken during rehabilitation.</li> <li>• Document costs, inputs, and labor required.</li> <li>• Monitor short, medium, and long-term outcomes.</li> <li>• Evaluate outcomes based on stated goals and objectives.</li> </ul>  |
| ASM/LSM Cooperation                    | <ul style="list-style-type: none"> <li>• Identify employment opportunities for LSM rehabilitation.</li> <li>• Improve access to finance and credit.</li> <li>• Achieve biodiversity conservation through synergistic rehabilitation with large mining companies.</li> <li>• Consider potential of LSM as a source of funds and expertise for miner training programs.</li> </ul>  |

## 8 OBSERVATIONS

### *Lack of examples of frugal ASM rehabilitation*

A key finding of this research is that, while examples of frugal rehabilitation in an ASM exist around the world, they are limited in number and are not well-documented overall. The limited number of successful, self-sustaining ASM rehabilitation examples as well as the lack of detail is a product of the fact that the application of environmental rehabilitation to ASM is not widespread and is a nascent but growing practice. In many ways, ESEC II is pioneering this practice and is bringing together, for the first time, an array of heretofore disparate approaches to ASM rehabilitation. While the research provided in this report identifies a range of both theoretical and practical approaches and short-term, small-scale pilot projects, there is a relative lack of experience in successfully implementing long-term, self-sustaining rehabilitation projects at the ASM scale. From the perspective of ESEC II and ASM stakeholders in Mongolia, this means that successful planning and implementation of these projects will require continued innovation, adaptive approaches, and a long-term investment. ESEC II has an opportunity to lead this practice and bring value to the international community by documenting and communicating its progress, successes, and lessons learned.

### *Role of local government and support structures*

In reviewing the case studies and rehabilitation methods, it becomes clear that instilling rehabilitation practices within an ASM context takes time and requires significant oversight and direct assistance to miners and nearby communities. External organizations and local government can play a key role here. Communities and governments need to recognize the political, institutional as well as economic incentives for their commitment to the rehabilitated areas in order to prevent re-mining and maintain the long-term benefits of the rehabilitation project. The importance of local government and civil

society in implementing long-term interventions cannot be overstated.

Building norms around ASM rehabilitation requires building the knowledge and skills of miners in the areas of physical and ecological rehabilitation and identifying and communicating the long-term economic incentives. The economic incentives to miners for rehabilitation should be identified in consultation with ASM miners and thoroughly communicated throughout the training and demonstration process.

Additionally, social factors—such as community acceptance, cooperation, and monitoring—are also critical to the long-term success of rehabilitation projects. While the technical and ecological components are critical to successful rehabilitation, resources should also be invested in providing consistent, long-term, and responsive assistance to mining communities so that the post-mining land use can be sustainable. This is the only way to avoid sponsoring poorly-planned and fleeting rehabilitation projects that leave no lasting benefit to communities or the environment. Successful ASM rehabilitation cannot be accomplished by ASM miners alone but can be accomplished with the sustained interest and support of the full array of local stakeholders.

#### *Additional observations*

- **Establish a clear process.** Identify and include the right stakeholders, including land users, landowners, community members, governments, etc. to get consensus on the approach and desired outcomes for ASM rehabilitation. The process should include approaches for designing, prioritizing, implementing, and monitoring rehabilitation projects.
- **Land Use.** Local stakeholders are important to ensuring that mining does not encroach on rehabilitated areas. Before rehabilitation proceeds, firm commitments should be made by all appropriate entities to agree on foreseeable future land uses that do not threaten rehabilitation.
- **Economic linkages.** Adoption of frugal rehabilitation practices will be more successful if the linkages between rehabilitation and economic security are communicated and demonstrated.
- **Local expertise.** Build on the knowledge and expertise already present in communities. Training in frugal rehabilitation techniques will be more effective if local miners are incorporated into the development of training materials and the method of instruction. This builds trust among the miners and increases the chance of long-term adoption of best practices.
- **Experiential learning.** Frugal rehabilitation training should demonstrate positive outcomes in a field-based setting where benefits can be easily recognized by miners. Experiential learning is important to capacity-building and to the facilitation of a healthy exchange of ideas where best practices are taught to miners and then adjusted to fit site conditions based on local knowledge and needs. Providing opportunities for hands-on practice with rehabilitation methods also facilitates the learning process.
- **Presence of field staff.** Supporting organizations should be present and actively involved to promote workforce motivation, project vision, commitment, and effective coordination.
- **Communication.** Encourage regular communication between trainers, miners, and communities to foster cooperation on rehabilitation projects from the outset. Provide conflict resolution and facilitation support.
- **Manage expectations.** Be realistic about what is achievable when planning the scope and scale of rehabilitation projects.

- **Local champions.** Identify local champions and leaders at the outset. These individuals will help resolve problems, move the project forward, and will sustain the projects after the supporting agencies leave.

## 9 FURTHER RECOMMENDATIONS

### 9.1 Additional Areas of Interest

These following topics are also important for rehabilitation but were not included in this report, and could be explored during subsequent phases of the project.

- The role of property rights in the long-term success of ASM rehabilitation,
- The use of rehabilitation funds to finance ASM rehabilitation practices.

### 9.2 ASM Typology

Due to the sheer number and geographic dispersion of ASM sites in Mongolia, it will be useful to develop and implement rehabilitation projects in a systematic manner during the demonstration phase of ESEC II. To facilitate the practical application of best practices in frugal rehabilitation, it may be advantageous to develop a framework for ASM rehabilitation planning based on a typology of ASM sites and known rehabilitation methods. The typology would build on the ASM classification scheme introduced by The World Bank in 2002 that was confirmed in Mongolia through surveys conducted by the Sustainable Artisanal Mining Project in 2009.

The typology would characterize and cluster different types of ASM sites in Mongolia according to factors known to influence rehabilitation. The following parameters might be most appropriate for characterising ASM sites in Mongolia.

**Table 3. Suggested ASM Typology Parameters**

| Parameter  | Potential Value(s)                                |
|--|---|
| Mining and Processing  |   |
| <b>Geometry of mineral deposit</b>   | coal bed or seam, fluorspar vein, gold placer     |
| <b>Depth of workings</b>   | shallow to deep                                   |
| <b>Mine disturbance footprint</b>  | small for fluorspar vein, large for coal          |
| <b>Waste to ore ratio</b>  | low for coal, medium for fluorspar, high for gold |
| <b>Overburden to ore ratio</b>   | low for fluorspar and high for coal               |
| <b>Presence of sulfides in the ore</b>   | low to high                                       |
| <b>Presence of other natural contaminants that can be mobilized by mining / processing</b> | low to high                                       |
| <b>Use of chemicals with potential to contaminate water or land</b>                        | low to high                                       |
| <b>Processing methods and separation of waste into coarse and fine fractions</b>           | range of values                                   |
| <b>Likelihood of unmined resource still being present below or adjacent to mined areas</b> | low to high                                       |
| Biophysical  |   |
| <b>Proximity to areas of high biodiversity value</b>                                       | near to far                                       |
| <b>Impacts to areas of high biodiversity value</b>   | low to high                                       |
| <b>Hydrology/presence of water</b>   | range of values                                   |
| Social   |   |
| <b>Proximity to community</b>  | near to far                                       |
| <b>Potential appropriate land uses</b>   | range of values                                   |

Basic on the characterization and clustering, the sites could then be paired with a range of established land rehabilitation approaches. Since certain types of ASM sites have similar characteristics (e.g., size of disturbance, type of contaminants, etc.), these sites often require similar rehabilitation approaches. For example, a site with chemical contamination will likely require some type of containment system where the contaminated soils can be consolidated and capped.

These “off the shelf” or “presumptive” rehabilitation approaches are beneficial in that they can accelerate the site assessment and rehabilitation process, thus reducing the cost and time required for rehabilitation on the whole. Presumptive approaches promote focused data collection during the rehabilitation planning process and foster consistency in the application of rehabilitation approaches, yet they are also flexible and adaptable to unique site conditions. In unique or particularly challenging circumstances, presumptive approaches can be altered or used with other rehabilitation approaches.<sup>71</sup>

### 9.3 Site Screening

Understanding the range of ASM sites and the factors that influence rehabilitation will help TAF and ASM stakeholders assess and categorize sites to prioritize responses in the most efficient and effective way possible. Site screening is one way to prioritize rehabilitation projects and TAF could apply a screening method, like the one included below, to the vast number of ASM sites in Mongolia.

#### **CASE STUDY ON SCREENING ABANDONED MINES<sup>72,73</sup>**

|                 |  |
|-----------------|--|
| <b>Location</b> | <b><i>Navajo and Hopi Land, United States</i></b>  |
| <b>Party</b>    | <b><i>United States government agencies, Hopi and Navajo government agencies, University researchers</i></b> |
| <b>Type</b>     | <b><i>Abandoned Small to Medium Mines</i></b>  |
| <b>Year</b>     | <b><i>2007 - Present</i></b>   |

#### **Background**

The Navajo Nation spans 69.9 km<sup>2</sup> in the southwest United States. The climate in this region is arid to semi-arid with less than 25.4 cm of rain annually. In the mid-20<sup>th</sup> century, these lands were extensively mined for uranium for Cold War weapons and nuclear energy production. While most uranium mining ceased by the late 1960s, a legacy of over 500 abandoned uranium mines remains that poses continued health risks to the Navajo people.

#### **Summary**

In August 2007, the USEPA conducted a comprehensive assessment of all known uranium mines on the Navajo Nation. This assessment revealed the scope of the abandoned mine problem and provided a solid foundation for planning future mine remediation work. The goal of the comprehensive assessment was to give the agencies the data it needed to identify and address the most urgent risks first. To date, the agencies have screened 521 mine sites to more fully understand the risks of each site and the associated needs for remediation. The USEPA focused their remediation work on mines with high levels of contamination that are near people as those present the highest health risks.

An example remediation action for one of these mines includes excavating and consolidating waste, disposing waste in covered stockpiles that are stabilized with a soil sealant and then enclosed by a

<sup>71</sup> While application of presumptive approaches may accelerate technological decisions around site rehabilitation, use of presumptive approaches does not obviate the need for appropriate community outreach, participatory planning, and serious consideration of confounding, site-specific factors.

<sup>72</sup> USEPA, “Addressing Uranium Contamination on the Navajo Nation,” last updated February 19, 2013, accessed March 2, 2014, [www.epa.gov/region09/superfund/navajo-nation/abandoned-uranium.html](http://www.epa.gov/region09/superfund/navajo-nation/abandoned-uranium.html).

<sup>73</sup> TerraSpectra Geomatics, “Abandoned Uranium Mines and the Navajo Nation. Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data,” Prepared for the USEPA, (August 2007).

fence. The areas are revegetated with a drought-tolerant seed mix that contain species typically found in the southwestern United States and warning signs are posted as needed.<sup>74</sup>



Figure 33 and 34: Map of Abandoned Uranium Mines (left)<sup>75</sup> and the Section 32 Mine Clean-up<sup>76</sup>

<sup>74</sup> USEPA (2013).

<sup>75</sup> USEPA (2013).

<sup>76</sup> Terra Spectra (2007).



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## ANNEX 1: List of Best Practices and Case Studies

| Best Practice   | Case Study   | Location                           |
|---|--|------------------------------------|
| Rehabilitation Planning   | NO CASE STUDY, KEY OPPORTUNITIES IDENTIFIED                              | N/A                                |
| Systematic Prospecting  | CASE STUDY ON SYSTEMATIC PROSPECTING                                     | Liberia, Central African Republic  |
| Concurrent Backfilling  | CASE STUDY ON THE SMERTER MINING METHOD                                  | Liberia                            |
| Soil Management   | CASE STUDY ON SOIL MANAGEMENT IN MEDIUM-SCALE MINING                     | Mongolia                           |
|   | CASE STUDY OF SOIL MANAGEMENT IN ASM                                     | Brazil                             |
| Seed Selection  | CASE STUDY ON SEED COLLECTION FOR MINE REHABILITATION                    | Mongolia                           |
|   | CASE STUDY ON COLLECTING REHABILITATION SPECIES                          | Mongolia                           |
| Miner Cooperatives  | CASE STUDY ON COOPERATIVE LAND REHABILITATION                            | Mozambique                         |
|   | CASE STUDY ON GROUP MINING   | Sierra Leone                       |
| Mercury Management  | CASE STUDIES INCLUDED IN ANNEX   | Brazil, Burkina Faso, Andes Region |
| AMD Management  | CASE STUDY ON WASTE ROCK SEGREGATION AND REVEGETATION                    | United States                      |
|   | CASE STUDY ON PASSIVE TREATMENT OF AMD                                   | United States                      |
| Miner Training Centers  | CASE STUDY ON THE INTERNATIONAL TRAINING CENTER FOR ARTISANAL MINERS     | Ecuador                            |
| Integration of Sustainable Livelihoods with Rehabilitation Activities | CASE STUDY ON TRANSFORMING LAND INTO PRODUCTIVE USES                     | Sierra Leone                       |
|   | CASE STUDY ON LAND REHABILITATION AND COMPLIMENTARY LAND USE PROJECTS    | Liberia                            |
|   | CASE STUDY ON POST-MINING INCOME GENERATING ENVIRONMENTAL REHABILITATION | Central African Republic           |
| Site Reuse Assessment   | CASE STUDY ON REUSE ASSESSMENTS  | United States                      |
| Grazing Management  | CASE STUDY ON MITIGATING GRAZING PRESSURES                               | Mongolia                           |
| Biodiversity Management   | NO CASE STUDY, KEY OPPORTUNITIES IDENTIFIED                              | N/A                                |
| Site Monitoring   | CASE STUDY ON REVEGETATION AND MONITORING                                | Mongolia                           |
| LSM/ASM Cooperation   | NO CASE STUDY, KEY OPPORTUNITIES IDENTIFIED                              | N/A                                |
| Site Screening  | CASE STUDY ON SCREENING ABANDONED MINES                                  | United States                      |

## ANNEX 2: Additional Resources Relevant to ASM Rehabilitation in Mongolia

| Topic                            | Location   | Resource   |
|----------------------------------|--|--|
| Impact Avoidance                 | China  | Harmonious Mines Program <sup>77</sup>   |
| Mercury Management               | Kalimantan   | UNIDO Global Mercury Project <sup>78</sup>   |
|                                  | Ghana  | Lessons learned on deployment of retorts and community-based approaches <sup>79,80,81</sup>  |
|                                  | Burkina Faso, Peru, Ecuador, Colombia, and Bolivia | Mercury Free Processing and Mercury Management Training for ASM <sup>82,83</sup>   |
|                                  | Brazil   | Reducing Chemical Use in ASM <sup>84</sup>   |
| Mine Rehabilitation              | Guyana   | WWF Guianas Conservation Program <sup>85</sup>   |
|                                  | India  | Mine Spoil Restoration: A strategy combining rainwater harvesting and adaptation to random recurrence of droughts in Rajasthan <sup>86</sup> |
| Rehabilitation of Degraded Lands | India  | Rehabilitation of degraded rangelands and stabilization of production in arable arid land of Thar Desert, India <sup>87</sup>                |
|                                  | China  | Lessons learned from large-scale reforestation efforts (general) <sup>88</sup>   |
|                                  | Sub-Saharan Africa                                 | Rehabilitation of Degraded Lands: Lessons Learned from Selected Case Studies <sup>89</sup>   |
|                                  | Mongolia   | The Control of Land Degradation in Inner Mongolia, Hunshandak Sandland Case  |

<sup>77</sup> Wuebbeke, Josh. "Green vs. Black: How Coal Mining is Changing Inner Mongolia and the Hulunbei'er Grasslands," in Heinrich Boell Foundation (ed): Copper Coal, and Conflicts. Resources and Resource Extraction in Asia (June 2013).

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<sup>88</sup> Huang, Lin et al. "Effects of grassland restoration programs on ecosystems in arid and semiarid China" *Journal of Environmental Management* 117 (2013).

<sup>89</sup> Blay, Dominic et al. "Rehabilitation of Degraded Lands in Sub-Saharan Africa: Lessons Learned from Selected Case Studies" FORNESSA. 2004.



|   |               |  |
|---|---------------|--|
|   |               | Study <sup>90</sup>  |
|   |               | Desertification and Restoration of Grassland in Inner Mongolia <sup>91</sup>                               |
| ASM Cooperatives                            | China         | Duyun ASM Owners Association Case Study <sup>92</sup>  |
| Responsible Mining Standards and Incentives | Peru          | Sotrami Mining Organization <sup>93</sup><br>Macdesa Mining Organization<br>Españolita Mining Organization |
|   | Bolivia       | Cotapata Mining Cooperative <sup>94</sup>  |
|   | Colombia      | Corpoación Oro Verde <sup>95</sup>   |
|   | South America | Fairtrade Gold Standard <sup>96</sup><br>Fairmined Standard <sup>97</sup>                                  |
| Rehabilitation Funds                        | Mongolia      | Mongolia Rehabilitation Fund <sup>98</sup>   |
|   | South Africa  | Rehabilitation Trust Fund <sup>99</sup>  |
|   | Tanzania      | Geita Gold Mine, provided safety training and technical assistance <sup>100,101</sup>                      |
|   | Ghana         | Goldfields Damang Mine, ASM property sharing <sup>102</sup>  |
|   |               | Newmont forfeiture of area near Ahafo Mine for ASM <sup>103</sup>  |
|   | Philippines   | Benguet Corporation, ASM property sharing <sup>104</sup>   |
|   | Indonesia     | Rio Tinto's Kelian Equatorial Mining project, co-mining <sup>105</sup>                                     |
|   | Peru          | Solidaridad Minera Yanaquihua S.A.C. Project <sup>106</sup>  |
|   | Bolivia       | San Bartolome Mine, COEUR JV with ASM Cooperatives <sup>107</sup>  |

<sup>90</sup> Liu, Meizhen et al. "The Control of Land Degradation in Inner Mongolia: A Case Study in Huushandak Sandland" Chinese Academy of Sciences.

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<sup>94</sup> ARM, "Fairmined Gold," copyright 2013, accessed February 28, 2014, [www.communitymining.org/en/fairmined-gold](http://www.communitymining.org/en/fairmined-gold).

<sup>95</sup> Oro Verde, "Green Gold – Oro Verde," accessed March 5, 2014, [www.greengold-oro Verde.org/loved\\_gold/](http://www.greengold-oro Verde.org/loved_gold/)

<sup>96</sup> Fairtrade International, "Fairtrade Standard for Gold and Associated Precious Metals for Artisanal and Small-Scale Mining," current version August 11, 2013.

<sup>97</sup> Alliance for Responsible Mining, "Fairmined Standard for Gold from Artisanal and Small-Scale Mining, Including Associated Precious Metals," current version May 1, 2013.

<sup>98</sup> UNEP "Analysis of formalization approaches in the artisanal and small-scale gold mining sector based on experiences in Ecuador, Mongolia, Peru, Tanzania, and Uganda: Mongolia Case Study" (June 2012).

<sup>99</sup> Guidelines on Small Scale Mining in South Africa

<sup>100</sup> Barrick, "Barrick Gold Artisanal Mining," copyright 2011, accessed March 1, 2014, <http://barrickresponsibility.com/2010/en/society/artisanalmining.html>.

<sup>101</sup> CASM "Mining Together: Large-Scale Mining Meets Artisanal Mining" (2009).

<sup>102</sup> CASM and ICMM "Working Together: How large-scale mining can engage with artisanal and small-scale miners"

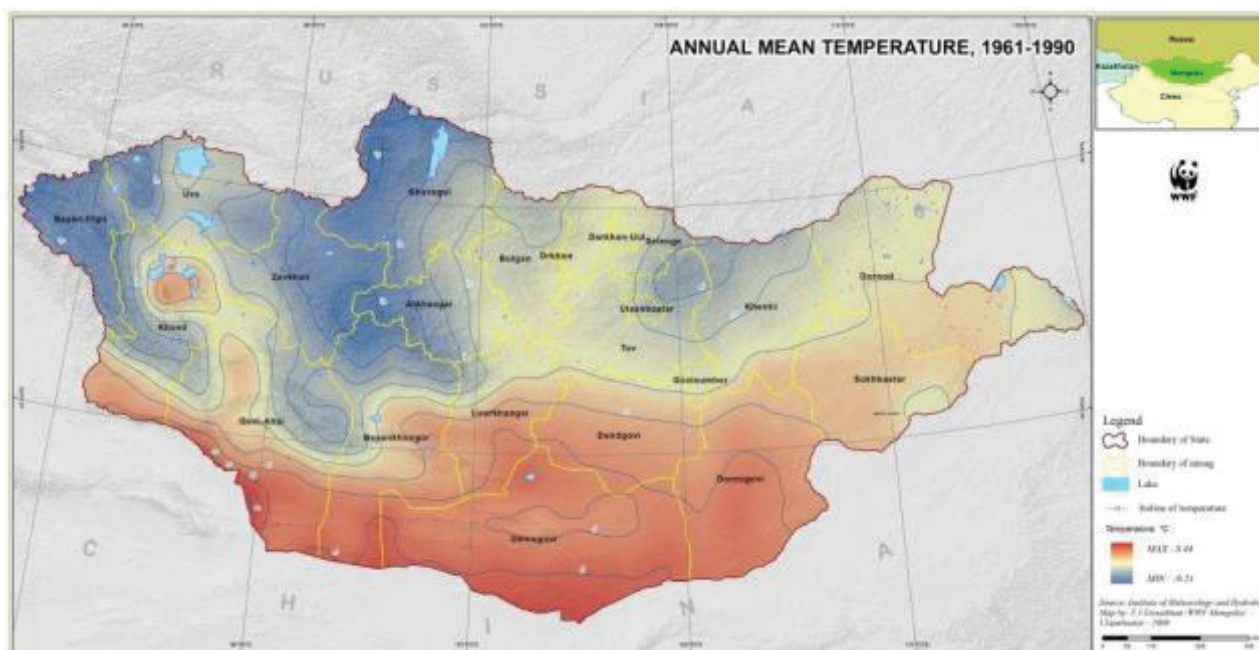
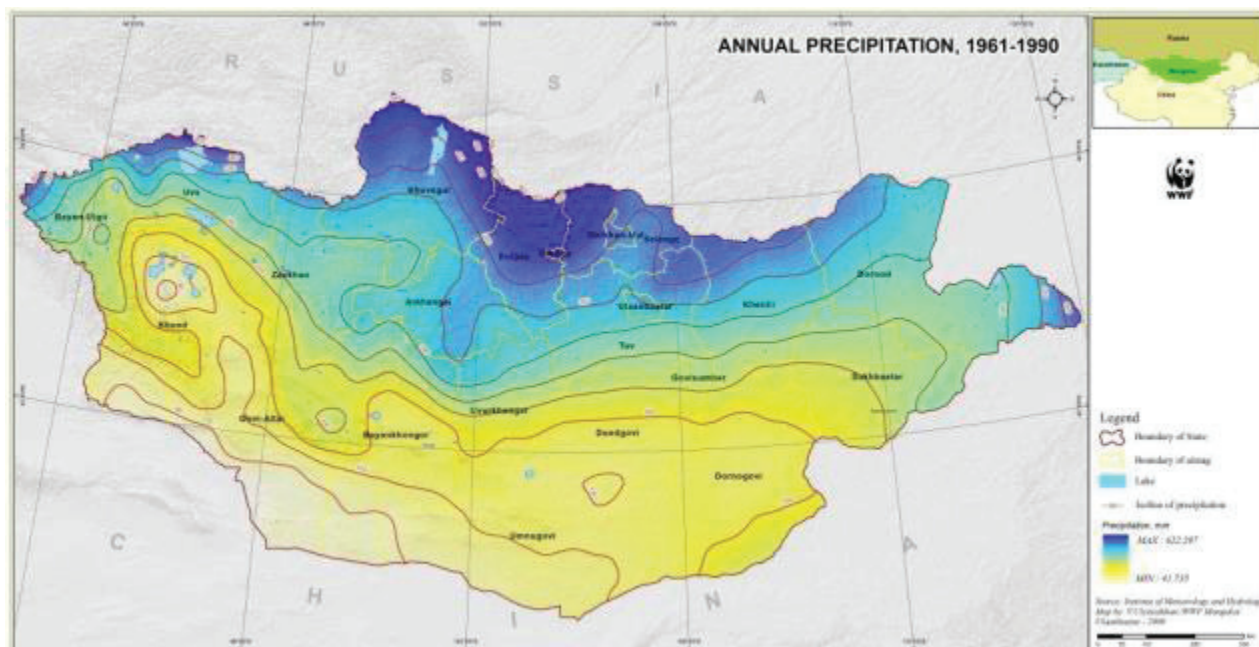
<sup>103</sup> Newmont, "Beyond the Mine," copyright 2013, accessed February 26, 2014, [www.beyondthemine.com/2012/](http://www.beyondthemine.com/2012/).

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<sup>105</sup> CASM (2009).

<sup>106</sup> Solidaridad, "Solidaridad Change That Matters," accessed March 4, 2014, <http://solidaridadnetwork.org/>.

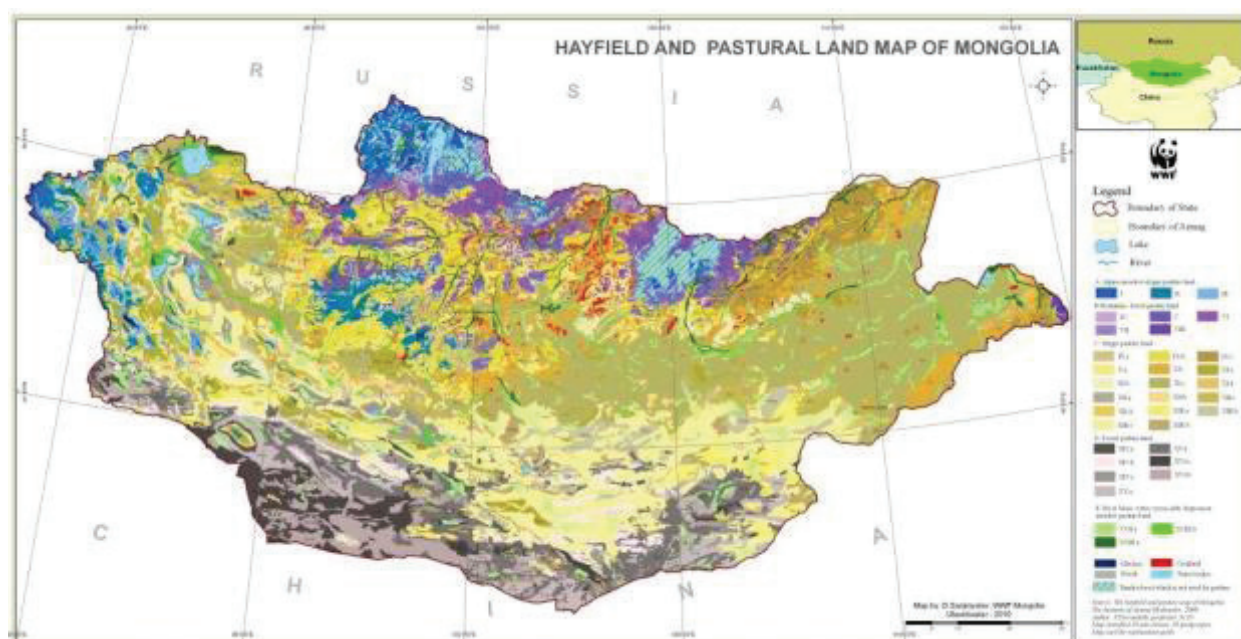
## ANNEX 3: Mean Precipitation and Temperatures in Mongolia



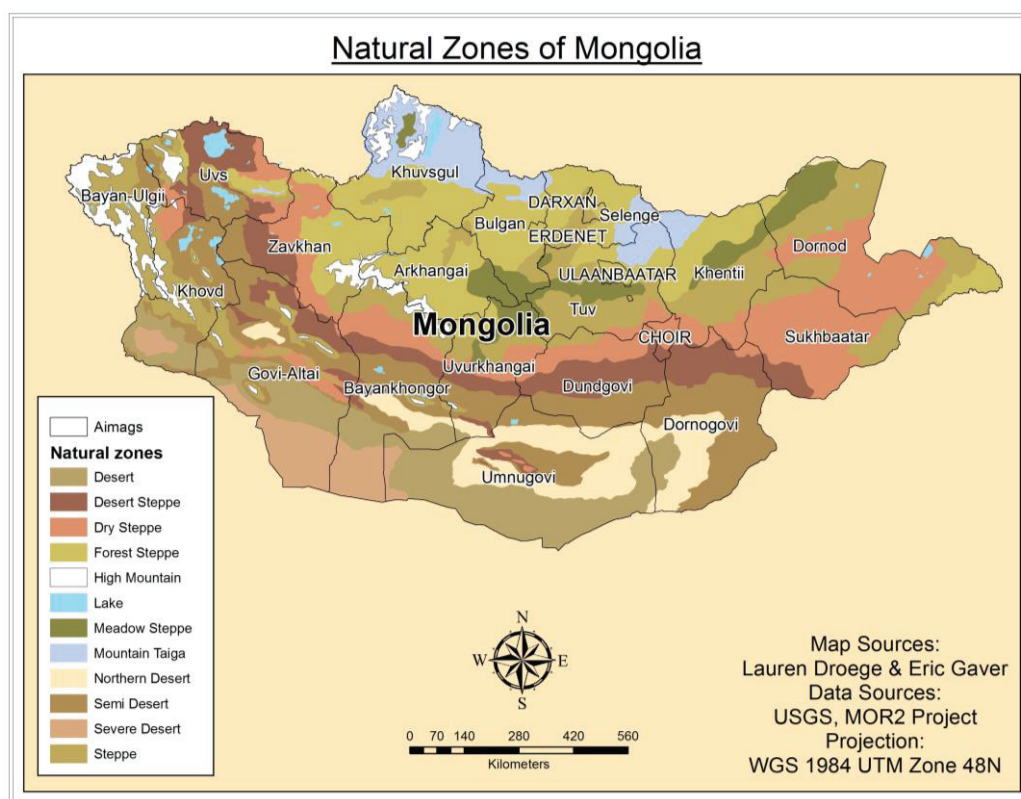
Data Source: UNDP Mongolia Web-Based GIS Database on Biodiversity in Mongolia

<sup>107</sup> Coeur D'Alene Mines Corporation, "Reducing Operational Risk Through Strategic Alliances: A Case Study-San Bartolome Mine, Bolivia."

## ANNEX 4: Ecosystems of Mongolia



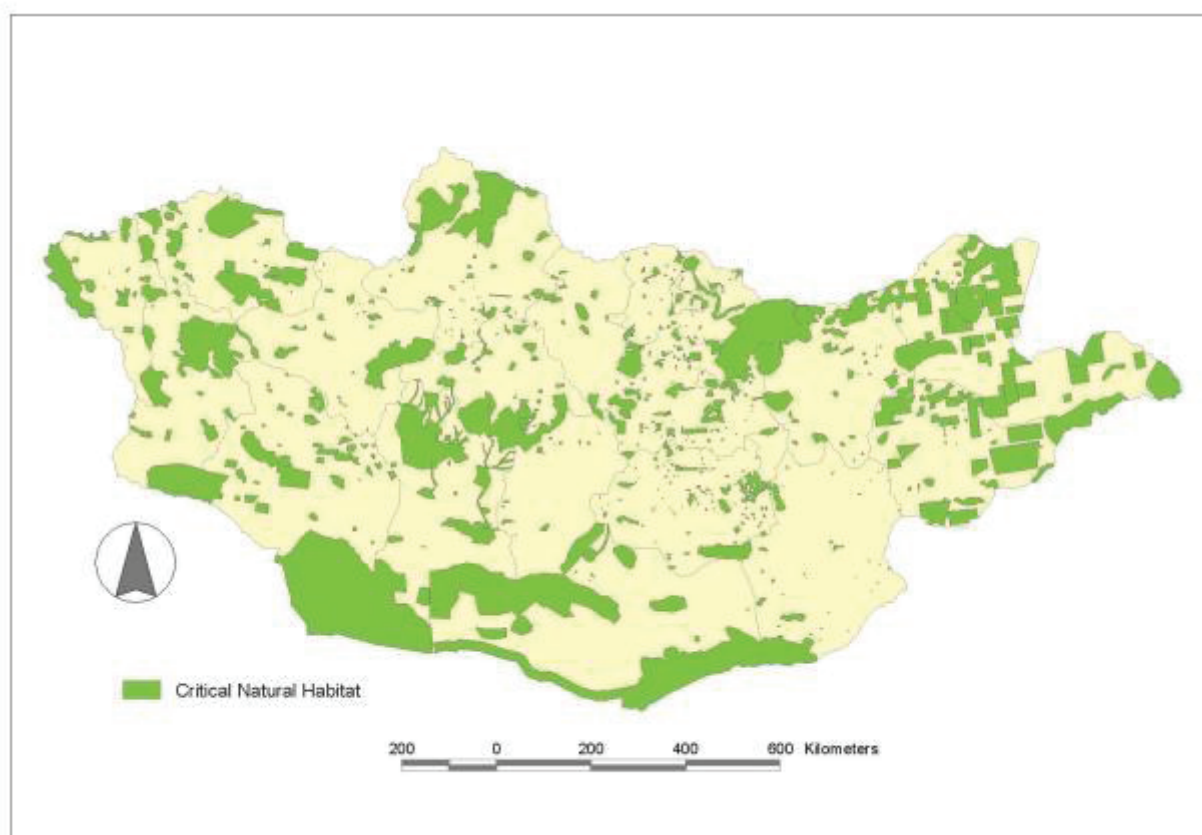
Data Source: UNDP Mongolia Web-Based GIS Database on Biodiversity in Mongolia



Data Source: Colorado State University, <http://gisedu.colostate.edu>



## ANNEX 5: Composite Map of Critical Natural Habitat in Mongolia



Data Source: BirdLife International, January 2009

## ANNEX 6: Biodiversity Assessment Resources

Biodiversity assessments use spatial analysis to identify the habitats and species near a particular project and determine whether important biodiversity resources may be affected by the project. Areas with “important biodiversity” are those that<sup>108</sup>:

- Support endemic, rare, declining habitats/species/genotypes.
- Support genotypes and species whose presence is a prerequisite for the persistence of other species.
- Act as a buffer, linking habitat or ecological corridor, or play an important part in maintaining environmental quality.
- Have important seasonal uses or are critical for migration.
- Support habitats, species populations, ecosystems that are vulnerable, threatened throughout their range and slow to recover.
- Support particularly large or continuous areas of previously undisturbed habitat.
- Act as refugia for biodiversity during climate change, enabling persistence and continuation of evolutionary processes.
- Support biodiversity for which mitigation is difficult or its effectiveness unproven including habitats that take a long time to develop characteristic biodiversity.

A range of online tools exist to help with Biodiversity Assessments:

[Integrated Biodiversity Assessment Tool \(IBAT\) \(www.ibatforbusiness.org\)](http://www.ibatforbusiness.org): A for-fee web-based tool that provides access to accurate and up-to-date spatial and descriptive information for Protected Areas, Key Biodiversity Areas, Alliance for Zero Extinction sites, IUCN Red List of Threatened Species, Biodiversity Hotspots, Endemic Bird Areas, and High Biodiversity Wilderness Areas.

[World Database on Protected Areas \(WDPA\) \(www.wdpa.org\)](http://www.wdpa.org): A free database that is the only comprehensive inventory of the world’s protected areas. It has technical and financial support of the Proteus 2012 Partnership, involving 17 private sector partners, and was re-launched in 2008.

[Key Biodiversity Areas \(KBAs\)](http://www.iucn.org/about/union/secretariat/offices/iucnmed/iucn_med_programme/species/key_biodiversity_areas/)

[\(www.iucn.org/about/union/secretariat/offices/iucnmed/iucn\\_med\\_programme/species/key\\_biodiversity\\_areas/\)](http://www.iucn.org/about/union/secretariat/offices/iucnmed/iucn_med_programme/species/key_biodiversity_areas/): Key Biodiversity Areas represent the most important sites for biodiversity conservation worldwide.

[Proteus \(www.proteuspartners.org/\)](http://www.proteuspartners.org/) is a partnership between businesses and UNEP World Conservation Monitoring Centre (UNEP-WCMC) to make available global information on biodiversity. It aims to improve the accuracy of information available on protected areas, by providing access to information on sites important for biodiversity, and increasing access to information on the distribution and status of coastal and marine ecosystems.

[Global Biodiversity Information Facility \(GBIF\) \(www.gbif.org/\)](http://www.gbif.org/): GBIF enables free and open access to biodiversity data online, and is an international government-initiated and funded initiative focused on making biodiversity data available to all and anyone, for scientific research, conservation and sustainable development.

<sup>108</sup> IAIA, “Biodiversity in Impact Assessment,” Special Publication No. 3. (July 2005).



## Annex 7: Rehabilitation Planning Resources

A Guide for Desert and Dryland Restoration: New Hope for Arid Lands (2007), David A. Bainbridge, discusses the ecology of desert plants, explores the causes of desertification and land abuse, and outlines the processes and procedures needed to evaluate, plan, implement, and monitor desert restoration projects.

Arid Southwest Lands Habitat Restoration Conference (2003), Desert Managers Group, contains proceedings and powerpoints that address many aspects of restoration in the Southwest United States.

Conserving and Managing Biodiversity in Dryland Ecosystems, The World Bank,

<http://siteresources.worldbank.org/INTBIODIVERSITY/214574-1110975789669/20612766/Biodiversity%20in%20Drylands.pdf>.

Extractive Industries in Arid and Semi-Arid Zones: Environmental Planning and Management (2003), IUCN, Joachim Gratzfeld, contributes planning and management approaches that minimise land degradation and desertification in arid and semi-arid zones as a result of extractive industry operations.

Handbook of Ecological Restoration: Principles of Restoration. Vol. 1. (2002), M. R. Perrow and A.J. Davy, summarizes a diversity of current restoration practices and covers the philosophy behind restoration, current paradigms, policy, and some of the theories that guide practice.

Handbook of Ecological Restoration: Restoration in Practice. Vol. 2. (2002), M. R. Perrow and A.J. Davy, concerned with practical applications for specific ecosystem types and contains detailed case studies.

Restoration and Rehabilitation of Arid and Semiarid Mediterranean Ecosystems in North Africa and West Asia: A Review (2000), Henry N. Le Houerou,

[www.ingentaconnect.com/content/tandf/uasrold/2000/00000014/00000001/art00002](http://www.ingentaconnect.com/content/tandf/uasrold/2000/00000014/00000001/art00002)

Restoration and Rehabilitation of the Desert Environment (1996), edited by Al-Awadhi et al, contains technical papers presented at the Kuwait-Japan Symposium on Restoration and Rehabilitation of the Desert Environment on the remediation of the polluted soil; enhancement of the visual impact of greenery; and recycling of wastewater for rehabilitation purposes.

Riparian Corridors in Semi-Arid and Arid Environments (2005), GSA, presentation abstracts on the Results and Approaches of Integrative Studies in Support of Scientifically Based Management and Restoration, with Emphasis on the Great Basin.

Riparian Ecosystem Recovery in Arid Lands: Strategies and References (1996), by Briggs, takes a holistic approach to riparian recovery that will enable users to better judge whether recovery expenditures are likely to produce desired results.

Wildland Shrub and Arid Land Restoration Symposium (1995), edited by Roundy et al, includes 62 papers dealing with wildland shrubs and restoration of arid lands including restoration and revegetation, ecology, genetic integrity, and management options.

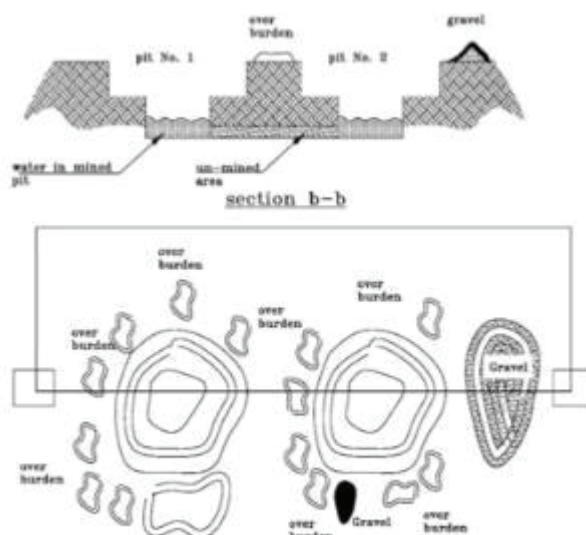
## ANNEX 8: SMARTER Mining Method

### CURRENT MINING METHOD<sup>109, 110</sup>

The current ASM mining method in Liberia uses pitting where holes are randomly dug and overburden is placed in scattered piles around a mining claim (see Figure A1). Random pits and piles are difficult to reuse for other purposes. Some disadvantages of the pitting method include:

- No exploration work done to determine deposits and grades.
- Bottom of pit is narrow so gravel is extracted from only a small area.
- 40 - 50% of ore left un-mined.
- Pits are not backfilled.
- Land cannot be easily reused.
- Open pits collect water and serve as breeding grounds for mosquitos/malaria.
- Dumping gravel and soil in rivers damages downstream drinking water and fish habitat.
- Leaving pits open leads to deforestation and loss of shelter, shade, protection from wind and rain, protection for animals, and food.

FIGURE A1: Pitting Method



### THE SMARTER METHOD

The SMARTER method is simple and involves little additional cost. The method involves digging trenches and backfilling as the trenches are completed. Benefits include:

- Increased gravel recovery and can declare areas as mined-out (empty).
- Reduced handling of soil.
- Improved safety and health conditions.
- Land can be used after mining is completed.

### SMARTER MINING STEPS

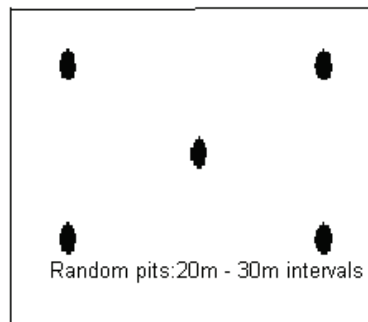
<sup>109</sup> Adapted from Jeigula, Sallia, "SMARTER Mining Training Module for PRADD Liberia," (March 2012).

<sup>110</sup> CEMMATS, a consulting firm in Sierra Leone, developed and tested the method in Sierra Leone in 2006. Based on initial success, the method was replicated in Liberia and in the Central African Republic.

### Step 1: Prospecting

- Helps determine where to dig further
- Select evenly spaced pits for prospecting in the mining claim
- Dig prospecting holes using the pitting method to determine the grade of the gravel
- Backfill the prospecting pits with soil and oversized gravel
- If deposits are found, use trenching method to mine the area near the pit

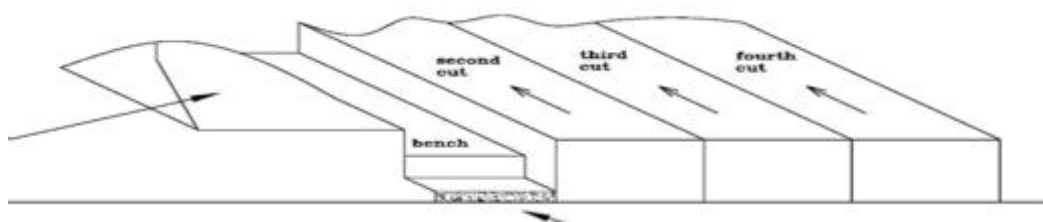
**FIGURE A2: Prospecting Pits**



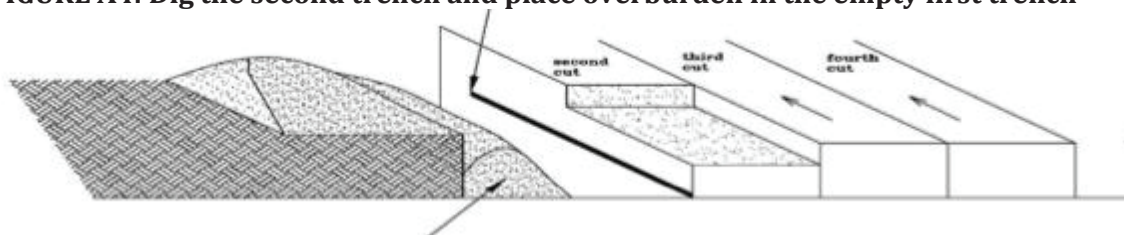
### Step 2: Trenching and backfilling

- Brush and clear the mining claim.
- Divide area into equal sized rectangles and identify the first, second, and third trenches
- Identify areas to place overburden and gravel
- Dig first trench and pile overburden on virgin soil. Dig out gravel and place in a secure area for washing.
- Move to second trench. Dig second trench and place overburden in the mined-out (empty) first trench.
- Move to third trench and so on. Dig trenches one at a time, using benches if needed to prevent mudslides and caving in.
- Once the area has been fully mined, use remaining overburden to fill the trenches, make sure the peaks are struck and the valleys are filled in, level the ground, and restore the area for future uses.

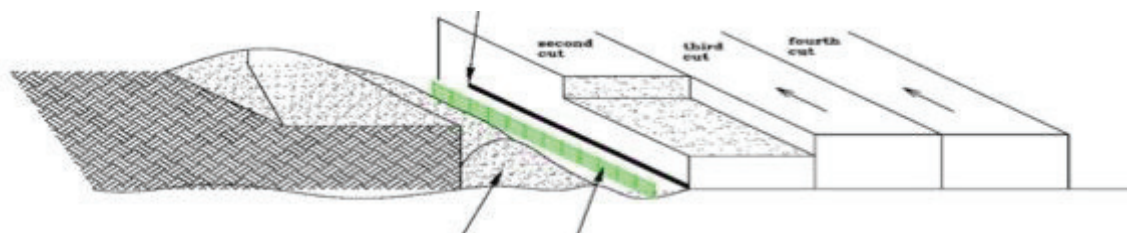
**FIGURE A3: Dig the first trench and place the overburden to the side of first trench. Set gravel aside for washing**



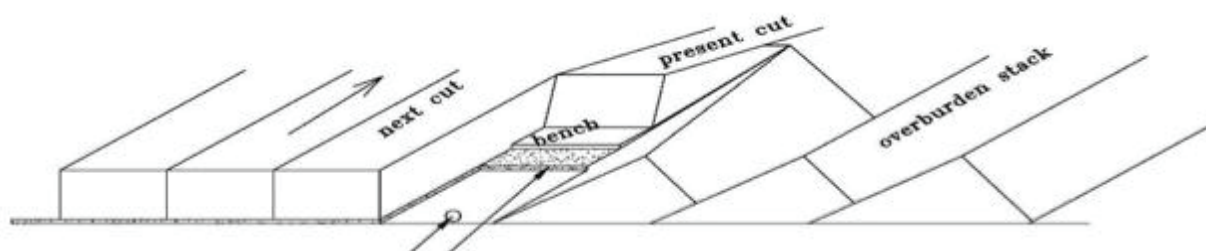
**FIGURE A4: Dig the second trench and place overburden in the empty first trench**



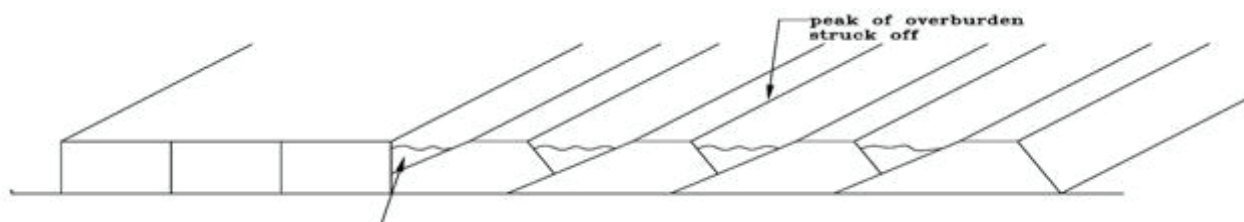
**FIGURE A5: Mining in a swamp: build a fence using wooden pegs and palm branches to prevent overburden from sliding into the trench being mined**



**FIGURE A6:** Continue digging trenches, backfilling empty trenches, and stockpiling gravel for washing, until the area has been fully worked



**FIGURE A7:** Reclaim the mined out area with overburden from the first trench



## ANNEX 9: Approaches to Mercury Management

### **CASE STUDY ON MERCURY-FREE PROCESSING AND TRAINING<sup>111</sup>**

|                 |  |
|-----------------|--|
| <b>Location</b> | <b>Dano, Burkina Faso</b>  |
| <b>Parties</b>  | <b>Artisanal Gold Council, Burkina Faso Miners Syndicate, Local Miner Organizations, Government of Burkina Faso, UNDOS, GEF, UNIDO</b> |
| <b>Type</b>     | <b>Artisanal Gold Mining</b>   |
| <b>Year</b>     | <b>2013</b>  |

#### **Background**

There are currently 200,000 people directly employed by ASM in Burkina Faso with over 1 million people dependent on the sector. In 2012, 600 artisanal gold mining sites produced 27 tonnes of gold, all of which was processed using mercury. While providing a much needed income source for rural populations, ASM has resulted in widespread mercury contamination and increased health risks for nearby communities.

#### **Summary**

The goal of the project was to install a mercury-free processing system with a training center that focuses on raising health and environmental awareness. The plant is designed to provide improved milling which reduces the need for mercury. The components of the plant include a crusher, mill, and a shaking table. Use of a wet pan mill reduces dust, uses less energy, and is intended to be intuitive to operate. Gold from the mill is concentrated in sluices, and flows to a shaking table where it is further concentrated to a level that eliminates need to use mercury. The portion that comes off the shaking table is directly smelted. Tailings are discharged into a collection area, creating a potential to install a secondary processing system that is cyanide-based. This area can also be used for waste disposal. It is unclear what, if any, proactive steps are being taken to reduce the potential for AMD creation within the tailings disposal area. While not all tailings are sources for AMD, if these tailings have an acid-generating potential, the tailings disposal area should be lined and capped upon closure.

The plant was made with two goals in mind: to be as inexpensive as possible to increase its replicability and to be more effective than existing technology. This particular plant cost \$20,000. The physical installation of the plant generated positive attention from miners, resulting in increased demand for additional plants in other mining communities.



**Figure A8: Wet pan mill being installed in Burkina Faso<sup>112</sup>**

<sup>111</sup> Artisanal Gold Council, "Artisanal Gold Council," Copyright 2011, accessed March 3, 2014, <http://www.artisanalgold.org/>.

<sup>112</sup> Photo credit Kevin Telmer.



**CASE STUDY ON REDUCING MERCURY USE AND RELEASE IN THE ANDES<sup>113</sup>**

|                 |  |
|-----------------|--|
| <b>Location</b> | <b>Peru, Ecuador, Bolivia, Colombia</b>              |
| <b>Parties</b>  | <b>USDOS, Marcello Viega as Principal Researcher</b> |
| <b>Type</b>     | <b>Artisanal Gold Mining</b>                         |
| <b>Year</b>     | <b>2010 - Present</b>                                |

**Summary**

This project demonstrated ways to reduce or eliminate mercury in ASM operations where mercury loss comes from the amalgamation of whole ore in copper-plates, in grinding circuits, or in sluice boxes. Intensive cyanide leaching of concentrates in a small ball mill was found to be a simple and efficient method that has potential to replace amalgamation, so long as more efficient concentration methods can be developed. An important component to this project was the inclusion of comprehensive training for 200 miners. The training included lectures and hands-on laboratory exercises about methods to reduce mercury emissions and to increase gold production using the equipment in the new demonstration plant.

The training touched on the following technologies: gravity concentration using centrifuges, cyanidation and use of activated carbon to extract gold from solution, elution method to extract gold associated with electrowinning, flotation of gold and copper minerals, gold refining with nitric acid, grinding processes for ultra-fine gold liberation, oxidation processes for sulfides, cyanide destruction with peroxide, chemical analyses of gold and cyanide, and methods to remove mercury before cyanidation.

**Challenges**

The level of training required to teach miners to safely handle and use cyanide compounds would be incredibly challenging to roll out to the thousands of miners in Mongolia. Use of cyanide in the ASM context may also receive resistance from the LSM community where cyanide use is tightly regulated and controlled.



**Figure A9: Plant in Portovelo, Ecuador used to demonstrate mercury-free technologies<sup>114</sup>**

<sup>113</sup> Veiga, Marcello M., "Reducing Mercury Use and Release in Andean Artisanal and Small-Scale Gold Mining," for United States Department of State (December 2013).

<sup>114</sup> Photo credit Marcello Veiga.

### **CASE STUDY ON REDUCING CHEMICAL USE IN BRAZIL<sup>115</sup>**

|                 |  |
|-----------------|--|
| <b>Location</b> | <b>Garimpo Ouro Roxo, Tapajos River Basin, Brazil</b>                                  |
| <b>Parties</b>  | <b>GEF/UNDP/UNIDO Global Mercury Project with Rodolfo Nieva (principal researcher)</b> |
| <b>Type</b>     | <b>Artisanal Gold Mining</b>   |
| <b>Year</b>     | <b>2009</b>  |

#### **Summary**

In the Tapajos River Basin, the predominant ASM gold processing methods include manual methods and dredging for alluvial ores, using hydraulic monitors and sluice boxes with carpets for colluvial ores, and/or using hammermills and amalgamating copper plates for primary ores. During gold processing, mercury is used to extract gold from concentrates and whole ores. At least 6 tonnes of mercury escape into the environment annually from these processing methods.

This project involved constructing a pilot plant to prevent mercury releases into the environment by offering an alternative to the mercury amalgamation process. The alternative process uses gravity pre-concentration followed by intensive cyanidation. The stated advantages of the new process include reduction of processing time, reduction of chemical use, potentially less tailings to be treated, lower operating costs, and reduced environmental impacts.

#### **Drawbacks**

The tailings generated from this process may be laced with cyanide and require treatment prior to disposal of entrained water. There is the potential for inadvertent cyanide spills in nearby waterways.



**Figure A10: Pilot cyanidation plant in the Tapajos Region<sup>116</sup>**

<sup>115</sup> Nieva de Sousa, Rodolfo (September 2010).

<sup>116</sup> Photo credit Rodolfo Nieva de Sousa.

## ANNEX 10: Passive Treatment of AMD Resources

A West Virginia University Acid Mine Drainage Website

[http://anr.ext.wvu.edu/land\\_reclamation/acid-mine-drainage](http://anr.ext.wvu.edu/land_reclamation/acid-mine-drainage)

Report on Passive In-Situ Remediation of Acidic Mine Drainage

<http://imwa.info/piramid/>

International Network for Acid Prevention Acid Drainage Guide

[http://www.gardguide.com/index.php/Main\\_Page](http://www.gardguide.com/index.php/Main_Page)

Technologies for Avoidance and Remediation of Acid Mine Drainage Handbook

<http://www.techtransfer.osmre.gov/NTTMainSite/Library/hbmanual/hbtechavoid.shtm>

Report on Prediction of Water Quality at Surface Coal Mines

<http://www.techtransfer.osmre.gov/NTTMainSite/Library/hbmanual/predictH2O.shtm>

Abandoned Mine Site Characterization and Cleanup Handbook

<http://www.techtransfer.osmre.gov/NTTMainSite/Library/hbmanual/epa530c.shtm>

Report on Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania

<http://www.techtransfer.osmre.gov/NTTMainSite/Library/pub/cmdpppp.shtm>







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