A Guide to understanding the

LIFE CYCLE APPROACH

As applied to Artisanal and Small-scale Gold Mining

A Resource book for Local Governments and ASGM Communities in the Philippines

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Concept and Overall Editorial by:

Richard Gutierrez, Founder and Executive Director, BAN Toxics

Authors:

Arleen Honrade (Consultant)
Evelyn Cubelo, ASGM Programme Manager, BAN Toxics

Cover Photo:

Luis Liwanag

CONTENTS

About Ban Toxics

BAN Toxics is an independent non-profit environmental non-governmental organization focusing on the Southeast Asian region on issues pertaining to environmental justice, prevention of toxic trade – products, wastes and technologies, trade, human rights and sustainable development.

The organization believes that no segment of our society should suffer environmental harm by reason of poverty, belief, or race and that "the only world worth passing to our children in toxics-free".

BAN Toxics is also the Southeast Asian office of the Basel Action Network (BAN), a global organization focused on confronting the global environmental injustice and economic inefficiency of toxic trade (toxic wastes, products and technologies) and its devastating impacts. It is also an active member of the Zero Mercury Working Group (ZMWG) and the International Persistent Organic Pollutants Elimination Network (IPEN).

BAN Toxics accomplishes its objectives through bridge building with local and international groups, empowerment of local communities and advocacy at the national and global levels. Some of the notable accomplishments of BAN Toxics include assisting the Philippine government develop its National Strategic Plan on the Phase out of Mercury in the Philippine artisanal and small-scale gold mining sector, one of the first in the world.

BAN Toxics has also been involved aiding several provinces, including that of Romblon, Kalinga, Camarines Norte and South Cotabato, among others, in eliminating mercury use in ASGM in their areas. BAN Toxics was the lead organization in formulating and strategizing legal action on the issue of toxic waste dumping against the Japan Economic Partnership Agreements involving the Philippines and other Southeast Asian countries.

User's Guide

The Life Cycle Approach handbook for Artisanal and Small-scale Gold Mining Communities (ASGM) aims to provide basic principles and tools for ASGM communities, Local Government Units (LGUs), Small-scale mining organizations and civil society organizations in applying the life cycle approach in ASGM communities.

BAN Toxics and its partners believe that ASGM communities can effectively address economic, health, and environmental challenges if provided with the capacity to conduct responsible mining practices from cradle to grave

This resource guide is provided with relevant information, templates, and tools to guide the users as they make decisions and options in improving small-scale mining operations, legalizing ASGM operations, monitoring and evaluating the existing small-scale mining operations in their locality and considerations on whether to allow new ASGM mining operations, and managing this soundly and responsibly.

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Disclaimer

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Moreover, the views reflected in this resource guide are those solely of the co-authors, and are not necessarily those of the members of the expert review panel or their institutions.

LIST OF ACRONYMS

A&D	Alienable & Disposable
ASGM	Artisanal Small-scale Gold Mining
CADT	Certificate of Ancestral Domain Title
CALT	Certificate of Ancestral Land Title
DENR-CENRO	Department of Environment and Natural Resources-Community Environment and Natural Resources Office
DENR-PENRO	Department of Environment and Natural Resources-Provincial Environment and Natural Resources Office
DENR-MGB	Department of Environment and Natural Resources-Mines and Geosciences Bureau
EIA	Environmental Impact Assessment
Hg	Mercury
ISO	International Standard Organization
LCA	Life Cycle Approach
LCIA	Life Cycle Impact Assessment
LGUs	Local Government Units
PMRB	Provincial Mining Regulatory Board
PSSMA	Peoples' Small-Scale Mining Area
SETAC	Society for Environmental Toxicology and Chemistry
SSM	Small-scale Mining
UNEP	United Nations Environment Programme
WHO	World Health Organization

Introduction

The Philippines is endowed with rich mineral resources. About 30 percent of its territory has been identified to have high potential of mineral deposits. Gold is one of the most important. Based on density of deposits per one-square-kilometer land area, the country is ranked third in the world. In 2009, the Mines and Geosciences Bureau (MGB) of the Department of Environment and Natural Resources (DENR) estimated the country's [1]gold reserves at 5,080,785,289 tons, based accordingly on the bureau's consolidation of resource inventory data supplied by mining companies.

In spite of the government's attempt to improve the operation of the mining industry, a number of sectors have expressed skepticism. Their fears are not baseless as the industry continues to face decades-old challenges such as environmental degradation, public health concerns, displacement of indigenous peoples from their ancestral domains, lack of transparency and revenue-sharing issues. Amidst the heated debates on the benefits and problems brought about by mining activities, the Philippine government released Executive Order No. 79, which outlines the government's policy direction on mining.

One of the highlights of the EO is the implementation of a moratorium on the grants of new mining rights pending a new legislation that will rationalize revenue sharing schemes. It likewise reiterates that compliance with RA 7076 or the People's Small Scale Mining Act of 1991 will address issues on small-scale mining.

While numerous studies on mining have already been undertaken to guide policymakers in developing a policy framework that will shape the future of the mining industry, certain areas remain to be inadequately understood.

One of the least studied sub-sectors is artisanal and small-scale gold mining, which contributes to the Philippine economy in terms of gold production and employment generation. It is argued that artisanal and small-scale mining activities in different parts of the world, especially in developing countries, are poverty-driven.

In the Philippines, employment in small-scale gold mining is largely informal. People are lured to the sector because it offers them the only available if not the most gainful source of income. Thus, despite the safety and health risks associated with the sector, the rural poor continue to seek employment in small-scale gold mining because poverty and the lure of quick money compels them to do so.

Policy and decision makers must understand the complex nature of small-scale gold mining and development at the community level in order to identify interventions that will be responsive and relevant to the existing realities of the sector.

[1] Mines and Geosciences Bureau. (2008). Quickfacts on mining. Retrieved from http://www.mgb.gov.ph/linf.aspx. National Statistical Coordination Board. (2011).; http://ilsdole.gov.ph/wp-content/uploads/2012/12/artajo-with-edits.pdf

EXECUTIVE SUMMARY

Artisanal and small-scale gold mining plays an important economic role in the Philippines. It provides significant source of livelihood to about 300,000 miners and their families while directly and indirectly supports the livelihood of about two million people. Other than generating employment opportunities in rural areas, small-scale mining has also largely contributed to the Philippines' annual gold production. The small-scale mining sector is known to have contributed 40–50 per cent of the country's total gold production during the period from 1990 to 1999. For the last five years, the sector has been producing an average of 30 tons or about 80% of the country's annual gold supply, and which placed the Philippines in the list of top twenty gold producing countries in the world. Presently, small-scale mining activities are undertaken in 40 out of 80 provinces in the Philippines.[1]

The "informalization" of small-scale miners and the illegality of their operation restrict their access to different support mechanisms such as credit facilities and technology subsidy. Thus, most of them employ inefficient methods (i.e., use of mercury, etc.) resulting into a gamut of health and environmental problems. The lack of infrastructure and social services in remote areas where ASGM activities are undertaken further aggravates the poor health condition of small-scale miners and their families. Small-scale mining activities, especially in gold rush areas, are poverty driven. Therefore, the absence of alternative employment opportunities in rural areas is a compelling reason for people to flock to gold-rich sites.

The continuous use of mercury to separate gold from sediments using basic processing methods in ASGM is very alarming. Mercury is released into the air, where workers and their families directly inhale it. The United Nations Industrial Development Organization (UNIDO) estimates that nearly 100% of all mercury used in ASGM is released into the environment. Such practices release at least 1,000 tons of mercury per year, and account for 30% of total annual anthropogenic mercury emissions. This has been growing over the last decade along with the rise in price of gold.

According to BAN Toxics, the challenges and impacts of ASGM cut across environmental degradation, social and health problems, legal enforcement and institutional issues.

It is against this backdrop that this Life Cycle Approach (LCA) handbook for Artisanal and Small-Scale Gold Mining Communities (ASGM) has been conceived to provide basic principles and tools for ASGM communities, local government units (LGUs), small-scale mining organizations and civil society organizations in applying the life cycle approach in ASGM communities.

BAN Toxics and its partners believe that ASGM communities can effectively address economic, health, and environmental challenges if provided with relevant information, capacity and technological know-how to conduct responsible mining practices from cradle to grave. In a situation where ASGM communities are linked to numerous social and environmental problems, LCA provides ASGM with relevant framework in assessing environmental impacts of mining in all stages in the life cycle of a product.

Currently, the experience of BAN Toxics in working with a number of ASGM communities in the country has shown that mining can contribute to sustainable development by focusing on mercury-free options for gold recovery, economic, health and safety and environmentally sound outcomes.

[1] http://www.investphilippines.info/arangkada/wp-content/uploads/2014/09/1.-Arangkada-Mining-Policy-Brief-2014.09.06.compressed.pdf

LCA can be applied to ASGM and will ensure environmentally sound options in all stages when the following options are explored:

Product Development and Improvement. ASGM is poverty-driven and mostly conducted as a backyard activity in many areas. Effective steps must be explored to improve extraction of gold that is mercury-free and environmentally sustainable. BAN Toxics training on mercury gravity concentration method can be applied in this case.

Strategic Planning. LCA results can be used by ASGM groups to prioritize and decide on most effective strategies, such as pollution prevention, resource conservation and waste minimization. It can be used to lobby for government support. For example, BAN Toxics' community-based mercury-monitoring can complement in this aspect and help ASGM gather relevant data and information at the community level.

Policymaking. LCA can provide ASGM an insight into environmental problem areas and improve and guide internal environmental policy formulation. LCA can even help examine various social environmental issues considered or not considered in the current regulations governing ASGM in the country – in this case the welfare of women and children in ASGM, child labor and serious health impacts of mercury pollution in ASGM.

Marketing. LCA can also be used to support and inform customers about options for buying toxics-free and fairly traded gold. The process can be used to support and encourage ASGM to use toxics/mercury-free gold recovery in the process. LCA can also address the economic aspects and viability of mercury-free gold recovery in ASGM such as access to credit and investment.

Enhancement of Environmental Management Systems. LCA can be used to enhance environmental management systems in ASGM and minimize environmental resource use conflicts in the process. This can also be used as a tool to harmonize and integrate various aspects of resource use in all ecosystem level – upstream, midstream and downstream.

Learning. LCAs that focus on artisanal and small-scale gold mining could generate in-depth understanding on the impacts of different mining processes and provide governments and communities with important information for informed decision-making. Many ASGM communities venture into mining without enough knowledge and know-how, resulting in serious environmental degradation. This resource guide can be used to design environmentally sound options for ASGM and as well as information on other economically viable alternatives

For ASGM communities to apply LCA fully, we see further work in the following areas:

- Favorable legal environment for ASGM development in the country;
- Projects and initiatives that support women and children's right and empowerment in ASGM;
- Options for short and long-term management of mercury waste;
- Development of relevant government policies and researches addressing effective and environmentally sound rehabilitation and remediation of toxics waste in post mining phase;
- Technical support for ASGM miners in the aspect of exploration, mining and construction and post rehabilitation;
- Scaled up LGU support in eliminating mercury in the gold recovery process in ASGM; and,
- Scale up efforts to encourage participation of ASGM community such as women, children and youth in the aspect of awareness raising and decision-making.

Lastly, the LCA handbook is intended to provide its users with a better understanding of the ASGM sector.

Section I outlines the context of mining; types of small-scale mining extraction and the various aspects of mining operations.

Section II provides a deeper understanding about ASGM; facets of ASGM and the roles they play in the mining process; gold recovery practices and the problems brought about by these practices in the ASGM community.

Section III presents the legal framework of the ASGM sector as a mechanism by the Philippine Government to improve ASGM operations.

Section IV sets the context of the Life Cycle Approach (LCA) as a tool for ASGM, its development, uses, strengths and weaknesses, key principles and LCA model.

Section V outlines relevant options and guide for the miners to address environment, socio-economic and legal issues in their operations. This section also provides templates and tips on how to come up with the different requirements required in the registration of the ASGM operations as applied in the PSSMA (Peoples Small-Scale Mining Act).

Section VI provides added references and resources for ASGM stakeholders.

SECTION I: MINING IN THE PHILIPPINES

1.1 What is mining?

Mining is the process of extraction (removal) of minerals and metals from the earth. In Mining Engineering practice, mining is usually taken to mean the extraction of ores, coal or stone from the earth. Ores are defined as the mineral deposits that can be worked at a profit under existing economic conditions. Stones include industrial (usually non-metallic) minerals such as calcite (limestone), quarts and other similar products.2

Minerals are generally grouped into three classes:

1) metallic minerals,
(2) non-metallic minerals, and
(3) mineral fuels.

1.2 What are the different types of small-scale mining extraction techniques?

Surface mining is a method of mining used to extract minerals and metals that are near the surface of the Earth. There are three basic types of surface mining: Open pit mining, strip mining, and quarry mining. These methods are much more economical than underground mining, yet they can have a more significant impact on the surrounding environment unless efforts are taken to reclaim the land.[3]

Several forms of small-scale mining: surface, underground and underwater.

[2]http://kids.mongabay.com/lesson_plans/lisa_algee/mining.htm
[3]http://en.wikipedia.org/wiki/Surface_mining

Open pit mining involves excavation where the ground end up looking like a terrace. Cuts are made into the ground, and the area at that depth is worked around the circumference of the mine. Once the minerals and waste have been removed from the ledge, called a bench, the excavation moves down a level and work begins again. This type of surface mining, also known as hard rock mining, is typically employed to extract metal ores, like copper, gold, iron, and aluminum, and other minerals.

Underground mining - In underground mines, the ore is extracted through a series of vertical shafts and ramps and horizontal drifts and adits (see Figure 1.1). Extraction is more selective than in open pit mining, and the ratio of waste rock to ore generated is much lower. In underground mines, waste rock is used as mine backfill to provide roof and wall support underground. Waste rock that is not used for construction or as backfill is disposed of on the surface.

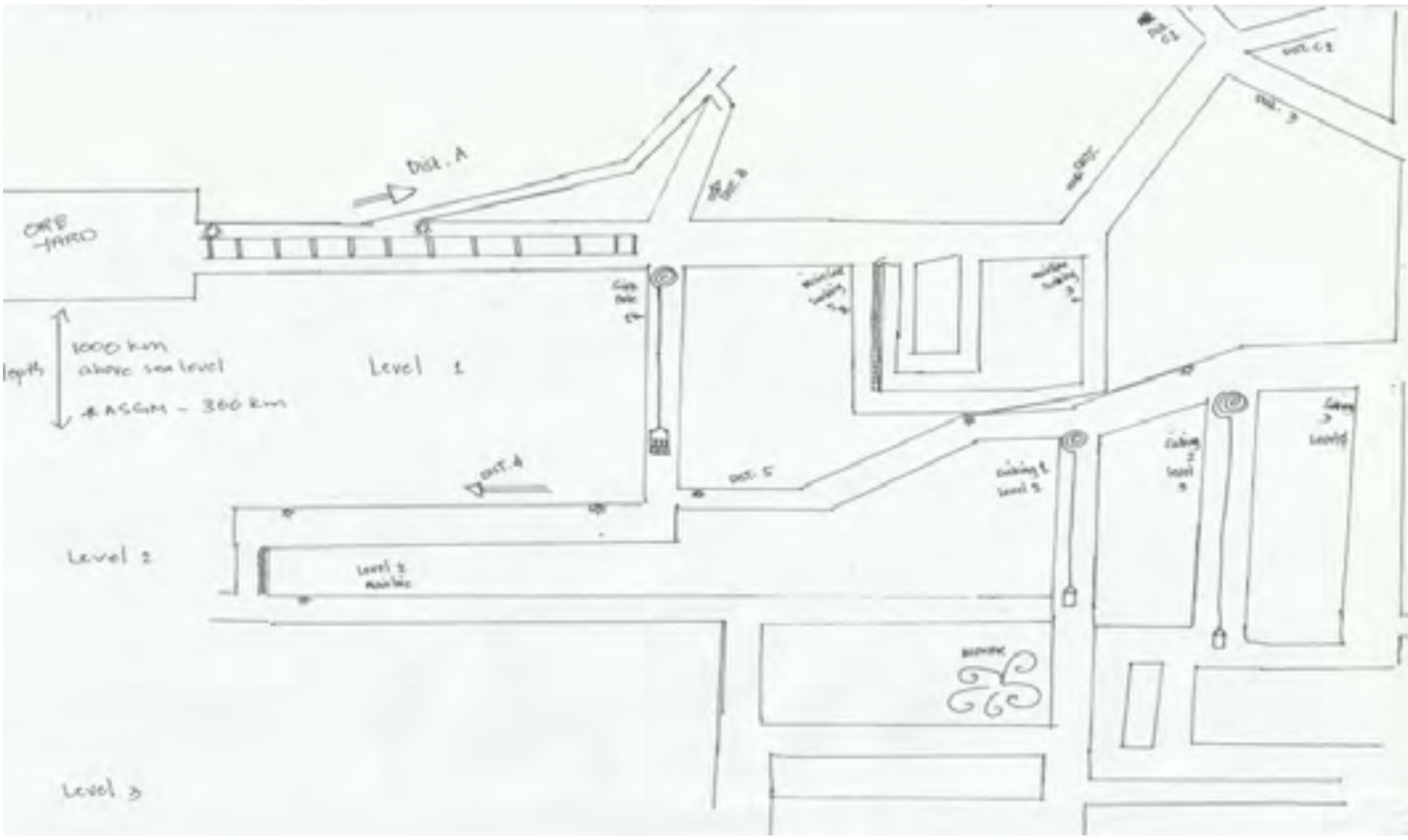
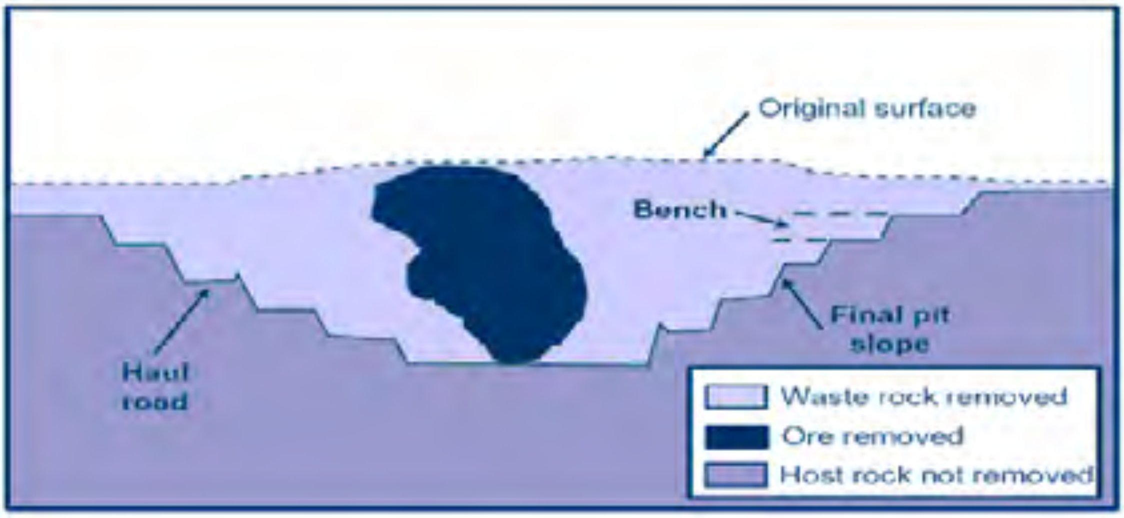


Figure 1: A Typical underground mine in Diwalwal, Compostela Valley

Illustrated by Alma Andoy, Technical Miner Trainer, Diwalwal

Cross-section of a Typical Open Pit Mine



Source: http://en.wikipedia.org/wiki/Open-pit_mining

A cross-section through a typical open pit mine is illustrated. Shown here is the large ore body below the land surface. Surrounding the ore is the waste rock. The waste rock pit walls slope up and outward from the bottom of the ore body, the angle of this being the final pit slope. Steps in the pit slope are called benches and the haul roads follow these. Surrounding the waste rock is the host rock, which is not removed.

1.3 What are the types of mining according to scale?

Defining what small-scale is, and differentiating it from what could be medium-scale and large-scale, is difficult due to the lack of a global standard. For the purpose of this study,

[5]https://www.google.com.ph; https://www.ec.gc.ca/lcpe-cepa/

Large-scale mining involves the mobilization of substantial capitalization, heavy equipment, high technology and a much bigger workforce. In terms of the volume of output, large-scale mining produces sufficient commercial quantities to satisfy the requirements of the export market and large industries on a regular basis. Large-scale is based on run-of-mine (ROM) output measured in metric tons per year: Large-scale underground mine above 500,000; and large-scale surface mine above 1,000,000.

Under the Philippine Mining Act of 1995, large-scale mining is classified into two types: The definition will rely on the current local definitions under Philippine law.6

1. Those that can be undertaken by domestic of Filipino Corporation; and

2. Those that can be undertaken by foreign-owned corporations through a Financial or Technical Assistance Agreement (FTAA)

Small-scale mining[7]. Republic Act 7076, also known as the People's Small-scale Mining Act of 1991, describes small-scale mining as mining activities that rely heavily on manual labor using simple implement and methods and do not use explosives or heavy mining equipment.

Artisanal Small-scale Gold Mining (ASGM): This informal mining activity comprises individuals, families or small cooperatives that often operate in an unregulated fashion. It has also been defined as mining conducted by individual miners or small enterprises with limited capital investment and production.8 Targets of their interest are high-value materials such as gold, although not confined to that. Section 1 of PD 1899 specifically defines the limits of ASGM operation by allowing small-scale contractors to mine up to 20 hectares per permit and extract up to 50,000 metric tons of ore per year.

[6]www.miningfacts.org/.../what-is-artisanal-and-small-scale-mining/
http://www.communitymining.org/

[7]http://www.prrm.org/publications/gmo2/annex1.htm

2.1 What is Artisanal and Small-scale Gold Mining?[9]

Artisanal Small-scale Gold Mining (ASGM) is the oldest form of mining. It is estimated that up to 20 million people in at least 30 countries are active in ASGM and a further 100 million people depend on the sector for their livelihood.

Artisanal Small-scale Gold Mining (ASGM) is a formal or informal operation with predominantly simplified forms of exploration, extraction, processing and transportation. ASGM is normally low capital intensive and uses high labor intensive technology. ASGM can include men and women working on an individual basis as well as those working in family groups, in partnership or as members of cooperatives or other types of legal associations and enterprises involving hundreds or thousands of miners.

ASGM is a production system that allows local people to earn income, however small. It provides an accessible livelihood for poor and marginalized peoples, often complementing other livelihood activities, such as agriculture, animal husbandry and hunting, and serving as a support operation in times of environmental or economic stress. The extent of activity in any particular place will wax and wane, as will the size of the ASGM population, to reflect changing local and national economic circumstances.

In the Philippines small-scale gold mining has been practiced since the 3rd Century. During this period, people from Cordillera, Camarines Norte and Masbate mined the precious metal to be used as personal adornments, hunting and farm implements and as a barter commodity, which they traded with Chinese merchants (Rovillos, et. al., 2003).

2.2 Who are the Small-scale Gold Miners?

Small-scale miners can be divided into five groups:[10]

1. Permanent miners, who conduct activities year round;
2. Modern small-scale miners, who uses the modern machineries;
3. Seasonal miners, who mine along with other activities such as farming;
4. Gold rush miners, who migrate to mining areas encouraged by newly discovered resources; and
5. Shock-pull miners, for whom the mining activities became a coping mechanism for shocks such as loss of employment, conflicts or natural disaster.

The permanent miners or traditional gold miners, usually owned by families are mostly found in the Cordilleras. Th¬ey do not operate the whole year, especially during rainy season. Processing of minerals is not mechanized and processing plants are set up in the backyard or adjacent to the location of pocket mines. Th¬e traditional processes use manual ore crushing and sluicing in separating gold. Gold is recovered using the gravity concentration technique, which involves the use of pans and sluice boxes.

Modern Small-scale Gold Miners are registered associations or cooperatives with a more complex organization than the traditional SSM. They usually have their own mechanized processing plants and have a bigger number of employees compared to the traditional ASGM. Modern ASGMs are a result of the adoption of ASGM of modern technology in mining.

[9] http://www.miningfacts.org/communities/what-is-artisanal-and-small-scale-mining/
[10] Alternate Forum for Research in Mindanao Inc. (AFRIM). 2012. A Background Study on the Small-Scale Mining Operations in Benguet and South Cotabato and their Impact on the Economy, the Environment, and the Community. Bantay Kita. https://www.scribd.com/doc/210981746/Small-Scale-Mining

Gold rush miners

A rush typically begins with the discovery of placer gold made by an individual. At first, the gold may be washed from the sand and gravel by individual miners, using a gold pan or similar simple instrument. Once it is clear that the volume of gold-bearing sediment is larger than a few cubic meters, the miners will build rockers or sluice boxes, with which a small group can wash gold from the sediment many times faster than using gold pans. Winning the gold in this manner requires almost no capital investment, only a simple pan or equipment that may be built on the spot.

2.3 Traditional Practices in Small - Scale Gold Mining

1. Prospecting. In prospecting, the ore quality, "vein" geologic formation, and ore assaying are examined. An area with a good ore quality is prepared for tunneling. Tunneling, holing and drilling are done using pick and shovel. Others, who can afford it, use electric hammer jacks.

2. Hydraulic mining, which was locally known as "banlas", was a popular way of surface mining using hydraulic hose and sluice boxes. It is operated by three or more persons in an open area positive for gold. ¬It is done next to creeks or rivers to easily drain the water that will wash the ores with gold. Th¬is practice destroys vegetation, causes soil erosion, exposes tree roots, silts and pollutes through the use of mercury. Furthermore, this operation involves illegal cutting of trees that are used to assemble sluice boxes.

2.4 Gold Recovery Practices in ASGM in the Philippines

Gravity Concentration or Panning is the traditional manual process of physical separation of gold particles from the crushed ore that has been continually practiced by the small-scale mining operators in Benguet province. Gold is recovered using the gravity concentration technique, which involves the use of pans and sluice boxes. A sluice box is made of wood covered with jute, which captures the gold grains when the ore and water mixture passes the sluice. Afterwards, the cloth is washed to collect the grains. It is panned to further separate the gold from other particles. Th¬is zero-chemical process recovers 60% of gold prior to the modern heap-leaching process that further subjects the tailings from the sluicing process into a cyanide solution. In this process, 90% gold recovery can be achieved.[12]

Sluicing

[12] http://bantoxics.org/download/The_Price_of_Gold.pdf

Panning

Rodmilling/ballmilling with or without mercy

Amalgamation is a technique that involves the use of mercury which is either fed into the ball mill/rod mill with the slurry (whole-ore amalgamation) or applied to the gold concentrates during panning. Mercury is mistakenly believed to enhance gold recovery.[13]

[13]http://bantoxics.org/download/The_Price_of_Gold.pdf

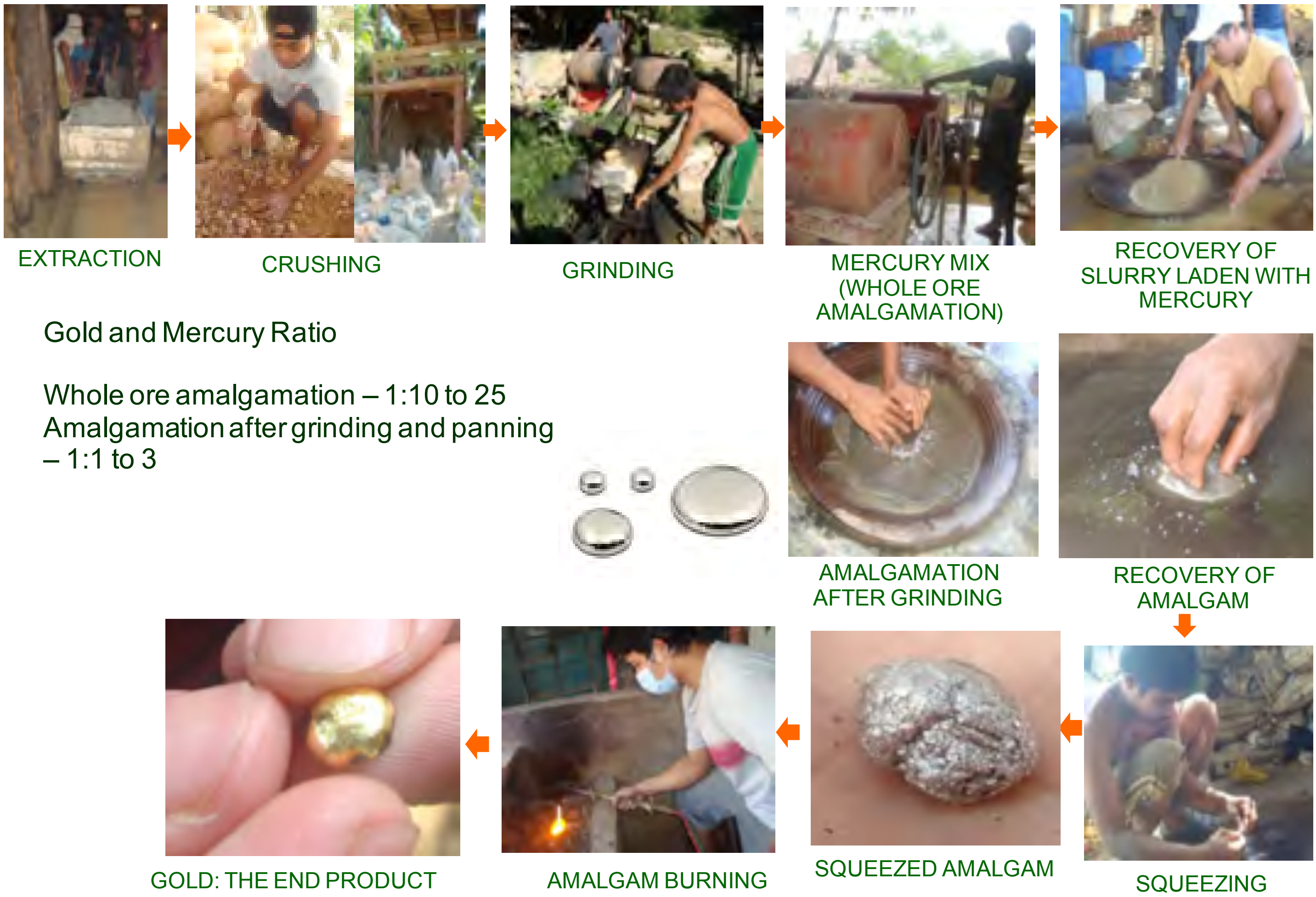


Figure 2 Whole Ore Amalgamation ; Photo Credit: BAN Toxics!

Cyanidation (i.e., carbon-in-pulp and heap leaching) is the process where gold ore or the tailings are processed with the use of cyanide solution followed by precipitation with zinc dust or activated carbon. While this method is faster, it requires a minimum volume of gold ore for it to be economical and practical. The final output undergoes blowtorching or smelting.[14]

[14]http://bantoxics.org/download/The_Price_of_Gold.pdf

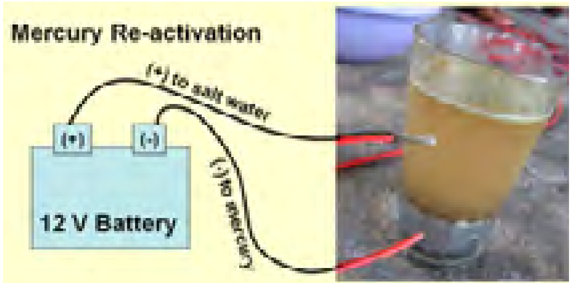
Cyanidation

2.5 Alternative gold processing techniques[15]

1. Mercury reduction methods
    a. Retort
    b. Use of fume hood (with water box condenser)
    c. Mercury reactivation via electrolysis

2. Mercury-free techniques
    a. Centrifugal method
    b. Magnetic sluice
    c. Shaking sluice
    d. Gravity concentration
    e. Cyanidation

3. Refining
    a. Direct smelting
    b. Use of borax



[15]http://bantoxics.org/download/The_Price_of_Gold.pdf

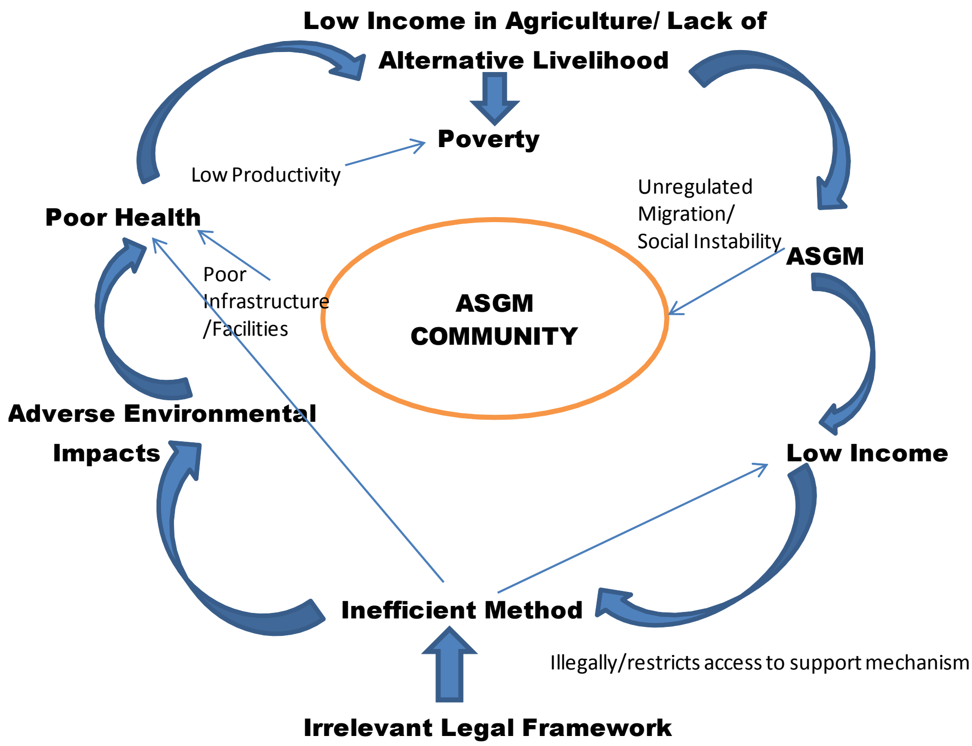
2.6 Why is Artisanal Small-scale Gold Mining important?

Artisanal Small-scale gold mining plays an important economic role in the Philippines. It provides significant source of livelihood to about 300,000 miners and their families while directly and indirectly supports the livelihood of about two million people. Other than generating employment opportunities in rural areas, small-scale mining has also largely contributed to the Philippines' annual gold. The small-scale mining sector is known to have contributed 40–50% of the country's total gold production during the period from 1990 to 1999. For the last five years, the sector has been producing an average of 30 tons or about 80% of the country's annual gold supply, and which placed the Philippines in the list of top twenty gold producing countries in the world. Presently, small-scale mining activities are undertaken in 40 out of 80 provinces in the Philippines.[16]

2.7 What are the problems/issues confronting ASGM in the Philippines?

The figure illustrates the problem cycle confronting small-scale gold mining communities in the Philippines. Conflicts and other social problems usually arise from an irresponsive and irrelevant legal framework. Various stakeholders claimed that several provisions under RA 7076 are already outdated and does not provide for the expansion of the production of small-scale miners. Other laws, while not directly governing small-scale mining are also conflict with RA 7076. These contribute to the "informalization" of small-scale miners. Illegality restricts their access to different support mechanisms such as credit facilities and technology subsidy. Thus, most of them employ inefficient methods (i.e., use of mercury, etc.) resulting in health and environmental problems. Likewise, inefficient methods diminish their productivity and prospects for better incomes.

PROBLEM CYCLE IN ASGM



Adapted from Hinton (2005)

[15]http://www.investphilippines.info/arangkada/wp-content/uploads/2014/09/1.-Arangkada-Mining-Policy-Brief-2014.09.06.compressed.pdf

The lack of infrastructure and social services in remote areas, where ASGM activities are undertaken, further aggravates the poor health condition of small-scale miners and their families. Small-scale mining activities, especially in gold rush areas, are poverty driven. Therefore, the absence of alternative employment opportunities in rural areas is a compelling reason for people to flock to gold-rich sites. Consequently, unregulated migration usually brings a host of social problems (i.e., security issues, etc.) in small-scale mining communities. Decent work also remains to be a challenge in small-scale gold mining.

As cited by BAN Toxics, the challenges and impacts of ASGM cut across environmental degradation, social and health problems, legal enforcement and institutional issues.

- Deforestation and landscape destruction
- Contamination of water bodies due to cyanide and mercury pollution
- Soil erosion and siltation
- Biodiversity loss
- Loss of soil productivity

Environmental impacts of ASGM

Photo Credit: BAN Toxics!

Social and health Problems

- Unregulated migration in mining areas especially in "gold rush areas"
- Land tenure and resource use conflicts
- Limited access to health and basic services
- Exposure of miners to occupational health and safety hazards
- Exploitation of workers especially minors
- Absence of social security benefits for miner-labourers
- Cases of mercury poisoning and high levels of mercury among miners and

Legal, enforcement and institutional problems

- Weak and non-operational mining regulatory boards
- Costly and difficult permitting and li censing process
- Ineffectual enforcement of small-scale mining and other related laws
- Small-scale mining companies undertaking large-scale operations
- Lack of capacity of LGUs
- Uncontrolled ASGM activities in protected and watershed reservation areas

2.8 Why Continuous Use of Mercury and Cyanidation in ASGM is a serious concern?

Mercury is a constituent element of the earth, a heavy metal. In pure form it is known as "elemental" or "metallic" mercury. Mercury is rarely found in nature as a pure liquid metal, but rather with compounds.

ASGM is one of the most significant sources of mercury release into the environment in the developing world. It accounts for about 15% of the world's annual gold production.

In ASGM, mercury use is the conventional way to separate gold from sediments using basic processing methods. Mercury is released into the air, where workers and their families directly inhale it.

The United Nations Industrial Development Organization (UNIDO) estimates that nearly 100% of all mercury used in ASGM is released into the environment. Such practices release at least 1,000 tons of mercury per year, and account for 30% of total annual anthropogenic mercury

A cause for concern

As cited by UNEP and WHO, mercury is a toxin and is harmful to humans and wildlife. Significant adverse impacts on human health and the environment have been documented around the world.[18 19 17]

[17]UNEP. Mercury Use in Artisanal and Small Scale Gold Mining. Retrieved from http://www.unep.org/chemicalsandwaste/Mercury/MercuryPublications/ReportsPublications/AwarenessRaisingPackage/tabid/4022/language/en-US/Default.aspx

According to WHO, exposure to mercury at even small amounts may cause serious health problems, and is a threat to the development of the child in utero and early in life. As noted further, elemental and methylmercury are toxic to the central and peripheral nervous systems. The inhalation of mercury vapor can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may be fatal. The inorganic salts of mercury are corrosive to the skin, eyes and gastrointestinal tract, and may induce kidney toxicity if ingested. Neurological and behavioral disorders may be observed after inhalation, ingestion or dermal exposure of different mercury compounds.[20]

Mercury is present throughout the environment. As an element, mercury cannot be created nor destroyed by any chemical means. Mercury levels in the environment have increased considerably since the on-set of the industrial age. Mercury is now present in various environmental media and food. Mercury is persistent and cycles globally. Once mercury is released into the environment, it persists and cycles through various media like air, water and soil. The emissions from ASGM can also travel long distances beyond the mining community, widening the impact of contamination to downstream communities and contributing to the to global mercury pollution and contaminating the world's fisheries. In the aquatic ecosystem, under certain conditions in sediment deposits, bacteria can transform elemental mercury into methyl mercury, a far more toxic form. Methylmercury has the propensity to bioaccumulate up the food chain. Primary exposure of mercury to humans is through diet. However, people can also be exposed to mercury by breathing in air or drinking water contaminated with mercury or mercury compounds.[21]

Cyanide Leaching of Gold

Cyanide leaching has been the main industrial process used to extract gold from ores since it was invented in 1887. However, the use of cyanide has been controversial due to its potential toxic effects on workers and the environment. There have been several accidents involving cyanide spills during transport or the accidental release of cyanide-contaminated tailings that have resulted in fishkills and deaths of birds and other animals.[22]

[18]http://www.who.int/mediacentre/factsheets/fs361/en/
[19]UNEP Mercury Use in Artisanal and Small Scale Gold Mining.
[20]Note: Symptoms include tremors, insomnia, memory loss, neuromuscular effects, headaches and cognitive and motor dysfunction. Mild, subclinical signs of central nervous system toxicity can be seen in workers exposed to an elemental mercury level in the air of 20 μg/m3 or more for several years. Kidney effects have been reported, ranging from increased protein in the urine to kidney failure (WHO).

[21]UNEP. Ibid.
[22]http://bantoxics.org/v2/images/downloads/BanToxics_The_Price_of_Gold.pdf.

For miners, the advantages of using cyanide are:

- Only a relatively small amount of cyanide is needed to recover gold, usually less one kg of cyanide per ton of rock.
- Cyanide is very selective in leaching gold and only minor amounts of other minerals in the ore.
- Cyanide leaches coarse and very fine gold as well as gold that are attached to the rock.
- The process is quick; tank leaching normally takes less than one day.
- Cyanide remaining in the waste (tailings) product can be destroyed to minimize the environmental impact.
- Cyanide degrades naturally in the environment, primarily from exposure to the sun's ultraviolet light, to less toxic forms and ultimately to nontoxic carbon dioxide and nitrates.
- If used responsibly, the risk of cyanide poisoning can be minimized.
- Cyanide does not accumulate in animals or plant life.

The disadvantages of cyanide leaching are:

- Cyanide is highly toxic, and at high concentrations it will kill fish, birds and mammals (including humans).
- Cyanide reacts with mercury to produce soluble chemical compounds that are easily transported with water, thereby spreading mercury contamination to large areas.
- When cyanide reacts with mercury, it converts the mercury to a form in which it more easily enters the food chain and becomes more harmful.
- Free cyanide is very toxic and is readily absorbed through inhalation, ingestion or skin contact and is distributed throughout the body via blood. Cyanide stops cells from absorbing oxygen, so death results from the depression of the central nervous system
- Cyanide is highly toxic, and at high concentrations it will kill fish, birds and mammals (including humans).
- Again, if the leach is discharged in to a stream, there is a risk that it will kill fish, contaminate wells, poison drinking water and possibly kill people.
- Cyanide reacts with mercury to produce soluble chemical compounds that are easily transported with water, thereby spreading mercury contamination to large areas.
- When cyanide reacts with mercury, it converts the mercury to a form in which it more easily enters the food chain and becomes more harmful.
- Cyanide remaining in the waste (tailings) product can be destroyed to minimize the environmental impact.

Toxicity of cyanide[23]

Cyanide is very toxic and is readily absorbed through inhalation, ingestion or skin contact and is distributed throughout the body via blood. It induces tissue anoxia so that oxygen cannot be utilized and death results from the depression of the central nervous system. The greatest source of cyanide exposure to humans and some animals is cyanogenic food plants and forage crops, not mining operations.

SECTION III- ASGM LEGAL FRAMEWORK

The current legal framework[24] of the Philippines covers four main regulations concerning small-scale mining:

1) Presidential Decree no. 1899 established small-scale mining as a new dimension in mineral development.

2) People's Small Scale Mining Act of 1991 resulted in the creation of a people's small scale mining program.

3) Philippine Mining Act of 1995 instituted a system of mineral resources exploration, development, utilization and conservation; and

4) E.O 79 s. 2012 covered the institutionalization and implementation of reforms in the Philippine Mining Sector, providing policies and guidelines to ensure environmental protection and responsible mining in the utilization of mineral resources.

Presidential Decree no. 1899, issued in 1984, governs small-scale mining operations for areas not declared as Peoples' Small-Scale Mining Area (PSSMA). According to this act, small-scale mining refers to any single unit mining operation, with the annual production less than 50,000 metric tons of ore.

[23]http://www.miningfacts.org/environment/what-is-the-role-of-cyanide-in-mining/

[24]http://www.tseatc.com/smf/index.php

In addition, the act requires that small-scale mining activities:

1. Should be conducted in artisanal way, without the use of sophisticated mining equipment;

2. Shouldbekepttheminimalinvestment on infrastructures and processing plant;

3. Should rely on manual labor; and

4. Should be owned, managed or controlled by an individual or entity qualified under existing mining laws, rules and regulations.

The People's Small-scale Mining Act of 1991, established a people's small-scale mining program, which includes the identification, segregation and reservation of certain mineral lands as People's Small-scale Mining Area. This act is governed by the following

1. Recognition of prior existing rights and productivity;

2. Formation of cooperatives;

3. Provision on technical and financial assistance, and other social services;

4. Access to processing and marketing;

5. Regulation of small-scale mining industry in the aspect of growth and productivity and as well as efficient collection of government revenue.

The Philippine Mining Act of 1995 requires the holder of small-scale mining contract to strictly comply with its environmental, safety, health and social provisions. The law requires small-scale mining operators to complete the following procedures:

1) Registration of activities and secure governmental permits,

2) Registration of mining workers through organization of cooperatives,

3) Compliance with the required safety, health and environmental conditions, and

4) Submission of production reports and payment of taxes and other royalties.

[25]www.mgb.gov.ph/Files/Policies/RA%207076.pdf; philippinemining.imaginet.com.ph/mining.../ra-7076-small-scale-mining.; www.mgb10.com/news/clarificatory%20guidlines%20ssm.html

Finally, the small-scale mining activities are subject to safety rules and regulations. These rules provide technical requirements for the legal operation of mining sites and regulate different stages of the mining process. The legal framework provides a sound basis for the operation of ASGM, but not many small-scale miners comply with established requirements.

Executive Order No. 79 provides for the full enforcement of environmental standards in mining as prescribed by the various mining and environmental laws, rules and regulations. Only those who are able to strictly comply with all the pertinent requirements shall be eligible for the grant of mining rights. EO 79 further outlines the following provisions:

1) Small-scale mining should be under taken only within the declared " Minahang Bayan" by the LGU;

2) Comply with Environmental Impact Statement System under Presidential Decree (PD) No. 1586 ;

3) Not applicable for metallic minerals except gold, silver, and chromite, as provided for in RA 7076;

4) Use of mercury in small-scale mining shall be strictly prohibited; training and capacity building measures in the form of technical assistance for small-scale mining cooperatives and associations shall be conducted by the concerned government agencies.

SECTION IV: Life Cycle Approach

4.1 LCA Application to ASGM

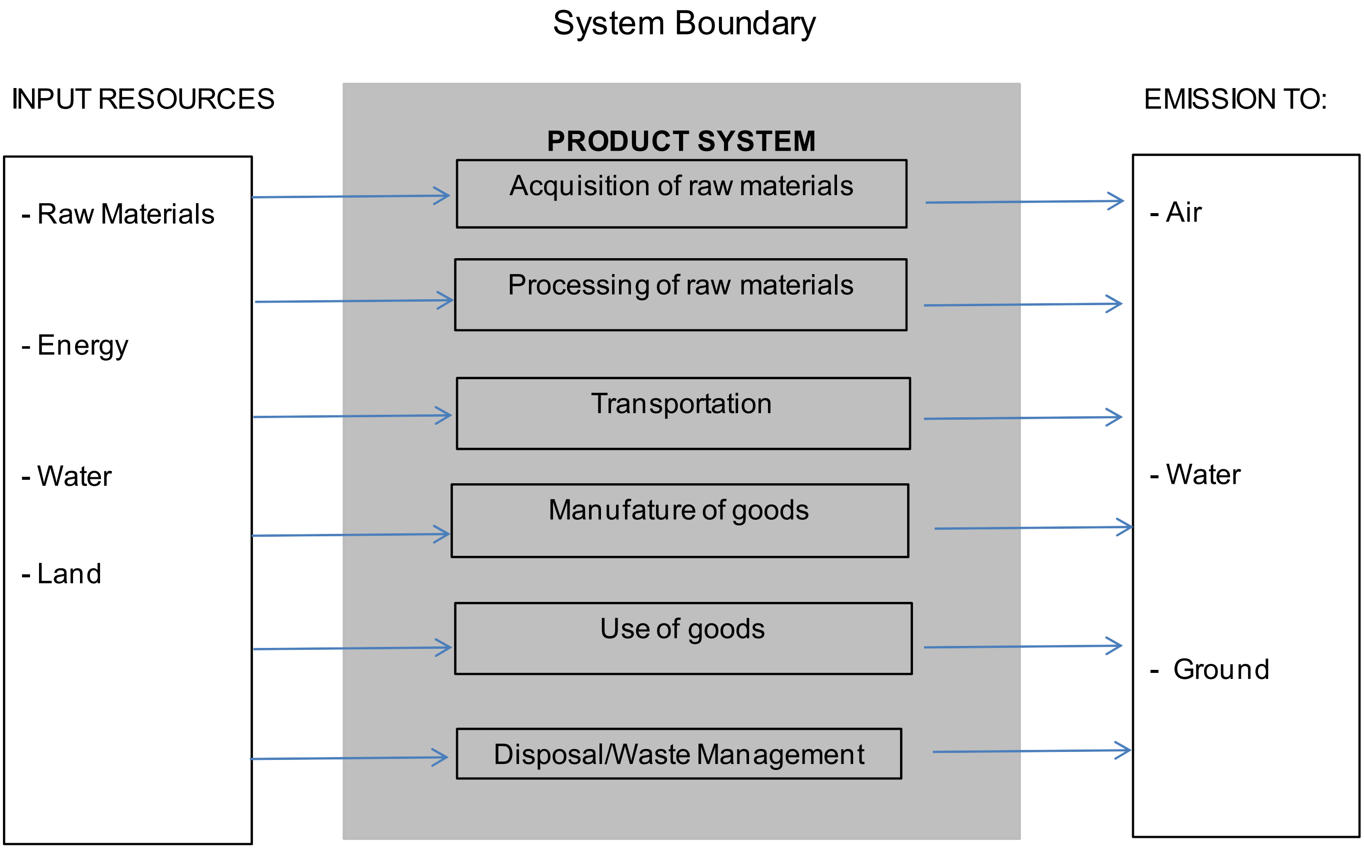
Life cycle assessment (LCA) of a product or service is the assessment of environmental burdens of a product or service across its life cycle (Bauman and Tillman, 2004). This is a comprehensive tool for quantifying and interpreting environmental impacts of a product or service from the cradle to the grave. The LCA technique has been used to assess environmental impacts associated with various products. Unfortunately, its use in assessing mining products and processes has been limited, as evidenced by limited published literature on LCA applications especially in ASGM.[26]

4.2 Life Cycle Assessment Framework

The ISO[27] 14040 standard defines life cycle assessment (LCA) as the compilation and evaluation of the material and energy flows, and of the potential environmental impacts of the life cycle of a product (ISO, 1997). Thus, LCA assesses the potential environmental impacts and resources used for a product, from the point of raw material acquisition, through production of product parts and the product itself and the use of the product, to ultimate disposal of product and its waste management. A characteristic central to LCA is its holistic approach (Guinée, 2002; Muga, 2009), in that it covers potential environmental impacts through all the stages in the life cycle of a product.

[26]Use of LCA in the Mining Industry and Research Challenges . www.enviro-geremi.polymtl.ca/pdf/articles/G3-P_Lesage-paper_(II).pd

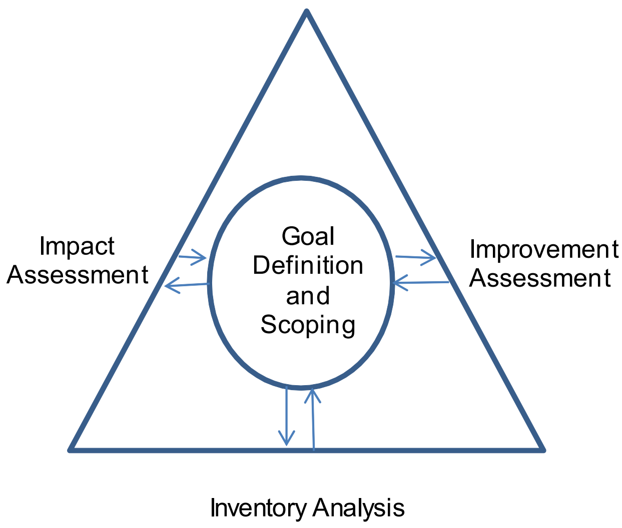
[27]SO (International Organization for Standardization) is an independent, non-governmental membership organization and the world's largest developer of voluntary International Standards. International Standards make things work. They give world-class specifications for products, services and systems, to ensure quality, safety and efficiency. They are instrumental in facilitating international trade. ISO has published more than 19 500 International Standards covering almost every industry, from technology, to food safety, to agriculture and healthcare. ISO International Standards impact everyone, everywhere.



A generalized Life Cycle Assessment Model
(Adapted from Owens, 1997

4.3.1 Phases of LCA[28]

The LCA model, as put forward by SETAC[29] in the 1993 code of practice, has four main components (Figure 2.3 below). These are: Goal Definition and Scoping, Inventory Analysis, Impact Assessment, and Improvement Assessment. Over time, Improvement Assessment came to be viewed as one of the possible uses of LCA, rather than a step in the methodology (Baumann and Tillman, 2004). Figure 2.3. SETAC 1993 LCA framework (Adapted from Curran, 1996)



SETAC 1993 LCA framework
(Adapted from Curran, 1996)

[28] Ditsele, Ofentse, " Application of life cycle assessment to estimate environmental impacts of surface coal mining" (2010). Masters Theses. www.scholarsmine.mst.edu/cgi/viewcontent.cgi?article=5800

[29] SETAC is a not-for-profit, global professional organization comprised of some 6,000 individual members and institutions from academia, business and government. Since 1979, the Society has provided a forum where scientists, managers and other professionals exchange information and ideas on the study, analysis and solution of environmental problems, the management and regulation of natural resources, research and development, and environmental education. SETAC's founding principles are:

- Multidisciplinary approaches to solving environmental problems
- Tripartite balance among academia, business and government
- Science-based objectivity

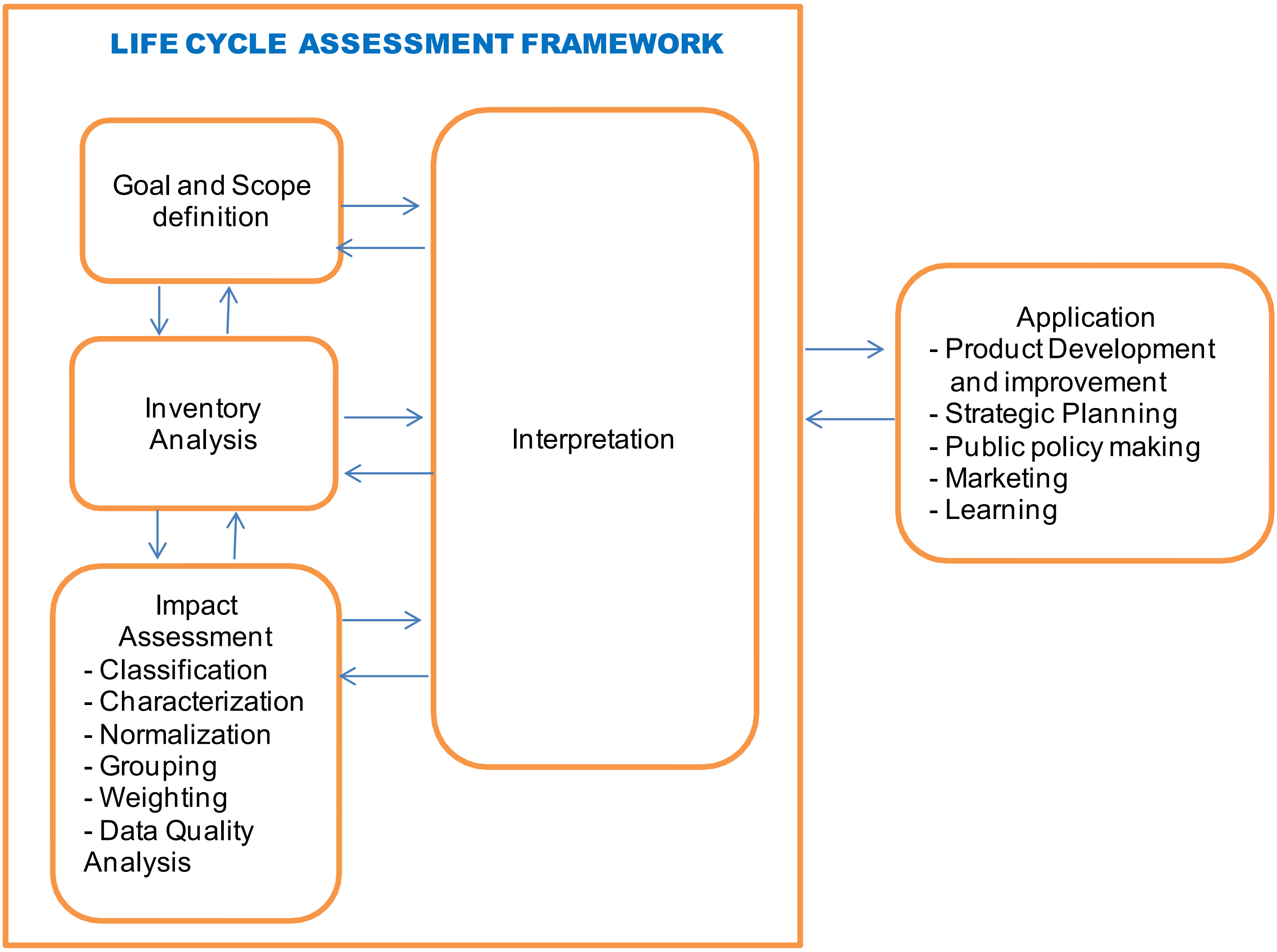


Figure 2.4. LCA framework according to ISO 14041:1998
(Adapted from Baumann and Tillman, 2004)

Goal and Scope Definition.

An LCA study is carried out to answer specific questions, and these are the questions that guide the goal and scope of an LCA study (Curran, 1996). Aspects of this phase are defined and described in the ISO 14041: 1998 and ISO/TR 14049: 2000. In the goal definition, the purpose of the study or the context in which the LCA study is to be conducted is established, as well as the anticipated audience.[30]

As part of the goal and scope definition, it is important to explain the nature of the study, i.e. whether it involves a prospective or retrospective LCA (Ekvall, 2005; Finnveden et al., 2009). A retrospective LCA study (also known as descriptive, accounting or attributional) describes the environmental flows to and from a life cycle and its subsystems (Höjer et al., 2008). Retrospective LCAs are useful for comparing existing products in marketing (Weidema, 2001), though some do not necessarily involve any comparisons, such as those for learning purposes (Ekvall, Tillman and Molander, 2005; Finnveden et al. 2009). On the other hand, a prospective (or change-oriented, effect-oriented or consequential) LCA aims to describe the consequences of changes made within the technological system investigated (Ekvall et al., 2005; Höjer et al., 2008), and is useful for decision-making (Tillman, 2000).

The type of LCA has a bearing on the type, specificity and hence quality of data that is necessary to achieve results of some significance (Tillman, 2000). For retrospective LCAs, average data (which represents average environmental burdens for producing a unit of the product from the system) may suffice, while prospective LCAs typically require marginal data, which corresponds to the effects on the environmental burdens of the system due to a small change in the output of a product (Tillman, 2000; Ekvall et al., 2005; Finnveden, 2008).

In the goal and scope definition phase, the LCA practitioner defines the product, process system boundaries, impact categories of interest, as well as the format for presenting results. The functional unit, which is a quantified performance measure of a product system used as a reference unit in an LCA study, must be defined. The determination of the boundaries of an LCA project is critical to the completeness of the LCA (Raynolds, Fraser and Checkel, 2000), and it is based on a number of factors, including, the goal and scope of the project, the availability of data, and the time and resources available (Ahmadi et al, 2003; Rebitzer et al., 2004).

[30]Ditsele, Ofentse, " Application of life cycle assessment to estimate environmental impacts of surface coal mining" (2010). Masters Theses. scholarsmine.mst.edu/cgi/viewcontent.cgi?article=5800...masters_theses

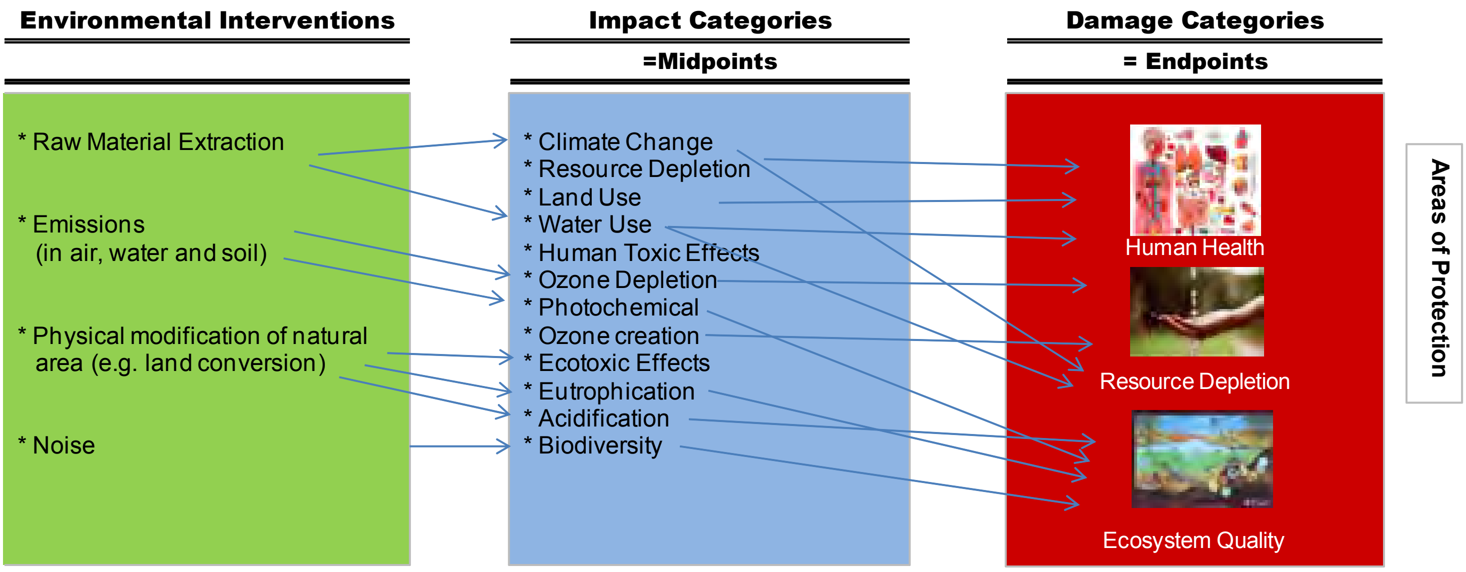
Inventory Analysis

The inventory analysis phase is described in the ISO 14041:1998 and ISO/TR 14049:2000. In this phase, relevant energy, material and other resource inputs, as well as environmental releases to air, water, and land, and other environmental burdens throughout the life cycle of a product are identified and quantified. The life cycle inventory (LCI) items are calculated as the functional unit's proportional share of the full environmental flows from each process (Finnveden et al. 2009).

4.5 Life Cycle Impact Assessment[31]

In this phase, potential impacts are assessed based on impact categories defined in the goal and scope definition and the environment flows identified in the inventory analysis. The LCIA phase has several steps, which include classification, characterization, normalization, grouping, weighting and data quality analysis.

Life Cycle Impact Assessment – A framework



Source: Based on Jolliet O, muller-Wenk R, Bare J. Brent A, GoedKoop M. Heipings R. Itsubo N. Pena C. Pennington D, Potting J. Rebitzer G. Stewart M. Udo de Haes H. Weidema B. 2004. The LCIA midpoint - damage framework of the UNEP/SETAC Life Cycle Initiative. Int. J LCA. 9(6):3:94-404

[31]Ditsele, Ofentse, " Application of life cycle assessment to estimate environmental impacts of surface coal mining" (2010). Masters Theses.

1. Classification

Classification involves the assignment of the emissions from the inventory into impact categories according to the substances' ability to contribute to different environmental problems (Baumann and Tillman, 2004). For example, sulfur dioxide (SO_2) can be assigned to acidification and photochemical ozone creation potential, and carbon dioxide (CO_2) and methane (CH_4) can be assigned to global warming potential.

2. Characterization

Following classification, characterization models are selected to model the impact of each emission quantitatively, according to the environmental mechanism (cause-effect chains) of the pollutants in order to give an impact score expressed in a common unit for the impact category (Pennington, et al., 2004). Characterization methods model the fate of pollutants in the environment to different extents: Some modeling may be problem-oriented (midpoint modeling) or damage-oriented (endpoint modeling) (Mangena and Brent, 2006; Finnveden et al., 2009).

3. Normalization

In normalization, the results from characterization are related to reference values, which express the relative magnitude of the impact scores on a scale, which is common to all the impact categories (Bauman and Tillman, 2004). Normalization puts the significance of the characterization results in context, by relating the environmental burdens of a product (or service) to the overall burden in its surroundings, and typically this is done at a national level and on an annual basis (Bare, Gloria and Norris, 2006; Mangena and Brent, 2006).

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4. Grouping

Grouping involves sorting and ranking of indicators after characterization. This usually is a qualitative process in which indicators are grouped together and ranked based on level of importance, i.e. from high importance, medium importance to low priority (Pennington et al., 2004). The level of importance placed on indicators during ranking is usually based on social, political and ethical values, and thus, there is an element of subjectivity in grouping (Finnveden et al., 2009).

5. Weighting

Weighting allows different impact categories to be measured on a single scale so that the relative importance of the different environmental impact categories and resource consumptions can be evaluated (EPA, 1996; Finnveden et al., 2009). When weighting is used, the relative significance assigned to the impact categories depends on the goal of the study. Weighting may be necessary when trade-off situations occur, (e.g., where an improvement in one impact score results in a deterioration of another impact score). There are no set weighting factors that are considered correct and this makes weighting subjective (González, Adenso-Díaz and González-Torre, 2002; Pennington et al., 2004; Finnveden et al., 2009).

6. Data Quality Analysis

The final step in the LCIA phase is data quality analysis, which involves an analysis of the LCI or LCIA results to give an understanding of their reliability (Baumann and Tillman, 2004). When interpreting the results of an LCA, it is important to have an idea of the quality and uncertainty of the data (Finnveden and Lindfors, 1998), because that helps in judging the significance of the LCA results (Huijbregts et al., 2001; Basset-Mens et al., 2003).

The use of quantitative uncertainty analysis methods does not guarantee reliable LCA results (Lloyd and Ries, 2007). Thus, a quantitative analysis that is undertaken using poor information on the distribution of uncertainty is likely to be misleading. When quantitative uncertainty analysis is not possible, at least a qualitative assessment of the reliability of the data should be done (Ross et al., 2002). Qualitative analysis approach may not be as precise as quantitative methods, but it is still able to explain the sources of uncertainties to enable appropriate interpretation of the LCA results.

4.6 What are the uses of LCA[32]

LCA is receiving more attention from industry and regulatory authorities as an important tool for environmental systems analysis. LCA can be used in a number of ways to aid in decision-making on environmental issues by the public, government and businesses.

1. Product Development and Improvement. One application of LCA that is gaining importance is eco-design. LCA has been identified as a key tool in implementing Design for Environment or Green Design programs in industries. LCA is used to identify opportunities for improving the environmental performance of products at various points in their life cycle. For instance, the German automotive industry uses LCA in the design of new cars (Guinée, 2002; Finkbeiner et al., 2003).

2. Strategic Planning. LCA can be used for strategic planning, either internally within a business, or within an industry or at a national level by government. LCA results can be used to set priorities and decide on product or process design or redesign as a part of strategic planning. When used this way, LCA can provide information that serves as the basis for company, industry or government strategies on pollution prevention, resource conservation and waste minimization.

3. Policymaking. LCA can provide insight into environmental problem areas and improvement opportunities that could guide internal environmental policy formulation. LCA can help in broadening the range of environmental issues considered in developing regulations or setting public policies

4. Marketing. Marketing was the driver for the development of LCA methodology in general, particularly its standardization. The now standardized LCA can be used to support product certifications or marketing declarations. Environmental product declarations are meant for environmentally conscious customers to make choices among several products and the choice ideally is based on environmental consequences of the products.

[32]Ditsele, Ofentse, " Application of life cycle assessment to estimate environmental impacts of surface coal mining" (2010). Masters Theses.

5. Enhancement of Environmental Management Systems. LCA can be used to enhance environmental management systems for businesses. LCA has been used successfully in pollution prevention by reducing hazardous wastes and increasing recycling in some manufacturing industries. Alcan, one of the leading producers of aluminum materials and products, has employed LCA to expand the scope of its environmental management system to address their products' upstream and downstream impacts associated with suppliers and customers (Rebitzer and Buxmann, 2005). The unique capabilities make LCA an ideal tool to consider as part of a small-scale mining environmental management system.

6. Learning. Another important application of LCA is that of learning about environmental issues in general and about the relationships of product systems (Tillman, 2000; Ekvall et al., 2005). Many LCAs may be conducted with goals relating to product marketing, product improvement or policymaking. However, there are LCAs that are carried out solely for learning purposes, with no specific action in mind (Finnveden et al., 2009). Also, irrespective of the intended goals, all LCAs provide a body of knowledge from which learning points may be derived (Baumann and Tillman, 2004). Given the limited use of LCA in the small-scale mining industry, LCAs that focus on artisanal small-scale gold mining could offer industry players an opportunity to learn and appreciate the impacts of different mining processes.

4.7 Strengths and Weaknesses of LCA[33]

The strength of the LCA technique lies in its holistic approach to evaluating the environmental burdens of a product or service (Guinée, 2002) and its quantitative nature (Muga, 2009). LCA considers aspects of the natural environment, human health, and resources use (Finnveden et al., 2009), and it incorporates a broad array of environmental elements and impact categories (Owens, 1997), compared to other environmental evaluation methods such as ecological footprint (which focuses only on land area) and chemical risk assessment (which only covers toxicity of chemicals). The comprehensive scope of LCA is useful in avoiding problem-shifting (Guinée, 2002; Finnveden et al., 2009).

The cradle-to-grave approach and the wide array of impact categories, enables tracking and capture of any transfers of environmental problems between stages of the life cycle of a product, from one place to another, and from one media to another, which could inadvertently happen as a result of changes in processes.

[33]Ditsele, Ofentse, " Application of life cycle assessment to estimate environmental impacts of surface coal mining" (2010).

The holistic approach of LCA, which is its strength, is at the same time its limitation (Guinée, 2002). The approach leads to requirements for lots of data, which is often not readily available (Ayres, 1995; Tan, Culaba, Purvis, 2002; Ahmadi et al., 2003; Durucan, Korre and Munoz-Melendez, 2006). The success of any given study is driven by the availability of good data, and the lack of readily accessible and credible data has limited the number of LCA studies (Curran, Mann and Norris, 2005). This problem of data availability may be addressed to some extent by streamlining the scope on an LCA study to take into account the data that can reasonably be acquired given the time and other resource constraints.

Another shortfall that has been cited with LCA is that the potential impacts are presented in the form of aggregated environmental loads or impacts, without considering their distribution over time and space (Owens, 1997; Zhang et al., 2006).

In the context of ASGM, this limitation is apparent in the lack of analytical framework in LCA to capture and measure the impacts of mining to the vulnerable sector of the community such as women and children.[34] The World Health Organization (WHO) pointed out that exposure to toxic chemicals being used in mining affects women and children the most.

4.8 Challenges in Applying LCA to ASGM[35]

There are some challenges in applying LCA to mining processes that could perhaps be hampering acceptance and use of LCA in the mining industry. These include a lack of data, shortfalls in the current LCA framework to address issues peculiar to ASGM, and possible limited awareness of the LCA methodology in the ASGM industry.

1. Lack of Data

Many LCA practitioners have cited the scarcity of data as a major challenge in conducting LCAs (Curran, 1996; González, Adenso-Díaz and González-Torre, 2002; Durucan et al., 2006).

[34]A statement from Richard Gutierrez, Executive Director of BAN Toxics!

[35]Ditsele, Ofentse, " Application of life cycle assessment to estimate environmental impacts of surface coal mining" (2010). Masters Theses; www.isa.utl.pt/der/ASAmb/DocumentosAulas/Recipe/Handbook%20on%...

2. Limited Specificity to Mineral Products

Lindeijer (2005) pointed out that the current LCA framework does not address mining issues adequately, citing the lack of specificity to mineral products. Traditional LCA impact categories defined by SETAC include global warming, ozone depletion, human toxicity, ecotoxicity, photo-oxidant formation, acidification, eutrophication, odor, noise, and radiation potential impacts (Baumann and Tillman, 2004).

These impact categories do not sufficiently address all potential impacts that are important in mining (Stewart, 2005; Bovea et al., 2007). Various LCA practitioners have argued for land use, water use, energy use and resource depletion as impact categories that need attention in mining LCAs. Bourassa (2005); Lindeijer (2005) and Bovea et al. (2007) suggested that land use impacts in mining are a dominant ¬

Water consumption has been identified as one of the important considerations in evaluating the environmental performance of mining operations (Baur and Zapp, 2005). Water is a resource whose availability varies from site to site, and mining uses compete with other uses (Baur and Zapp, 2005; Mangena and Brent, 2006). According to Baur and Zapp (2005), water consumption could be considered under LCIA category of extraction of abiotic resource. However, the challenge in this characterization of water depletion is that, water is a renewable resource that continues to be replenished as it is consumed. Another problem is that characterizing water consumption in mining may tend to be value-based because concerns over scarcity of water may vary from site to site. So, to deal with water consumption in LCAs of mining products, it may suffice to include it as part of resource inputs in the inventory, as characterizing it in the LCIA phase can only be justified within the context of a particular area or region.

3. Ambiguity of Results Due to Aggregation

The problem of ambiguity and concealment of site specific impacts due to aggregation of data in life cycle impact assessment has been put forward by various LCA practitioners (Owens, 1997; van Zyl, 2002; Lindeijer, 2005; Durucan, etal., 2006). Due to the unique situation of each mine, there is usually interest in site-specific information (van Zyl, 2002; Durucan, et al., 2006). Site-specific impacts are relevant for ensuring that effective measures are developed to address environmental problems for a particular site (McLellan, 2009). One level of aggregation of results occurs in the mandatory steps of LCIA, specifically in the classification and characterization. To prevent total concealment of site-specific environmental flows in LCA results, the inventory data for different life cycle stages could be presented separately so that it is available in non-aggregated form to allow for assessment of impacts for any life cycle stage of interest.

4. Arbitrariness in Selection of Functional Unit

One aspect of LCA that causes problems in LCA studies is the selection of functional unit. Other than the requirement for a functional unit to be expressed in quantitative terms, the ISO 14041 (1998) standard does not prescribe values for functional units. With LCA practitioners left to make their own choices of functional units, the result is arbitrariness (Olsen et al, 2001). The lack of standardized common functional units allows for flexibility in order to cater for the myriad of possible functions that LCA practitioners may wish to investigate, but it also makes the comparison of LCA results of similar products cumbersome. While the constraints that could result from standardizing functional units are appreciated, there is a need to at least have some recommended common functional units to allow for easily comparable results and to enable easy borrowing of data from other studies.

5. Arbitrariness in Selection of System Boundaries

One of the problems that have been identified in the application of LCA to mineral products is the different definition of boundaries for some mining processes in some studies (Stewart, 2005). Typically, system boundaries are selected using some qualitative criteria decided on by individual LCA practitioners, and this leads to inconsistent results for products and processes that are supposed to be similar

6. Limited Awareness of LCA Methodology

LCA developed with a relatively small circle of academics and consultants and many, including mining engineers, are still coming to grips with it as it is being rolled out to different industries (Middleton and McKean, 2005). Thus, LCA is generally not yet well understood and appreciated within the mining industry. It is only a few leading mining corporations that appreciate its benefits. It is through exposure of industry players to the tool through LCA studies of mining products that perhaps interest in the tool could be generated.

7. Lack of Expertise and Resources.

LCAs are not simple, nor are they cheap, and this inhibits their use by small companies (Hoskins, 2005). Given the limited expertise on LCA in the mining industry, the industry has had to rely on expensive consultants to carry out LCAs to satisfactory standards (Middleton and McKean, 2005). The lack of adequate resources, including knowledgeable personnel, is likely to limit the use of LCA for the many small-scale mining industry.

4.10 Key Principles Under LCA

Sustainable Development and the Mining Industry[36]

The most widely accepted definition of sustainable development is provided in the World Commission of Environment and Development in its landmark report Our Common Future (the Brundtland Report) – 'development that meets the needs of the

[36]https://restaurantsustainability.wordpress.com/.../pillars-of-sustainability-a... www.circularecology.com/sustainability-and-sustainable-development.html; abourassa@nrcan-rncan.gc.ca/ Mining and Sustainable Development managing one to advance the other

present without compromising the ability of future generations to meet their own needs'. A core principle in sustainable development is the 'precautionary principle', which is simply stated in the 1992 Intergovernmental Agreement on the Environment as when there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (DEWHA 1992).

In the minerals sector, sustainable development means that investments in minerals projects should be financially profitable, technically appropriate, environmentally sound and socially responsible. Businesses involved in extracting non-renewable resources have come under mounting pressure to embed the concept of sustainability into strategic decision-making processes and operations. Economic development, environmental impact and social responsibilities must be well managed, and productive relationships must exist between governments, industry and stakeholders. Achieving such a situation is simply a 'good way to do business'.

4.11 Responsible Mining Practices

What is the Principle of Responsible Mining?

There is no standard definition of sustainability that has been universally adopted by the mining industry. Some descriptions cite that miners can achieve sustainable develop mentby embracing the following concepts[38]:

- Social, environment and economic pillars (James 1999).

- Offsetting or reinvesting the benefits from the depleting mineral asset (Labonne 1999).

- The simultaneous pursuit of sustained or enhanced: Environmental quality, economic growth, and social justice (Eggert 2006)

A body of literature exists suggesting that mining can contribute to sustainable development by focusing on successful economic, environmental and community outcomes. However, in a mining context, these pillars (the triple bottom-line) fail to adequately account for two important areas, essential for a sustainable mining operation. One "missing" dimension is safety, which receives more attention in the mining sector than arguably any other industry.

The second missing dimension is a focus on extraction practices of the mineral resource itself. There is a need to focus on the micro level, at the individual mine site, where the resource is managed sustainably or unsustainably. This element or dimension can be termed 'resource efficiency' or simply 'efficiency'. It differentiates mining from other industries and is the basis or platform for any sustainable benefit to flow to the community. In the Philippines, the mineral resource is "owned" by the State on behalf of the community, therefore, there is an immediate link to the triple bottom-line. Too often, an ore body is mined without any regard for the long term, resulting in a reduced mine life.
Laurence (2011) outlined 5 tenets of responsible mining that artisanal and small-scale miners need to abide such as safety, environment, economy, efficiency and the community.

[37]www.industry.gov.au/resource/Documents/LPSDP/guideLPSD.pdf/ A GUIDE TO LEADING PRACTICE SUSTAINABLE DEVELOPMENT IN MINING

Figure 3: Elements of Responsible Mining

Safety

For both ethical and business reasons, a mining operation should aim to prioritize safety. Characteristics of safe mines include a commitment to risk management, appropriate attitudes and behaviors, reporting systems need to be in place, a focus on education and training, and a focus on processes and equipment (Laurence 2005).

Economy

Unless a mine is profitable, it cannot be sustainable. The aim for ASGM is while maximizing revenue is also to maximize the equitable benefits to all stakeholders, including shareholders, employees, local communities and businesses, which depend on the mine, as well as the governments that benefit by means of taxes and royalties.

which will extend the mine life and thus, stakeholder benefits, without compromising the revenue stream.

Resource Efficiency

A mine also has to be efficient in the way the resource is managed and extracted. Everybody must collaborate to optimize resource extraction. Examples of non-sustainable mining practices include "high grading" the ore body, which entails mining only the highest grade material for short-term gain. This is a practice used by individuals with a short time frame. This, in turn, is a symptom of the high turnover at many mine sites and the drive to "make one's name" as quickly as possible without regard for the longer-term extraction of the deposits. Particularly in these times of high commodity prices, it makes sense to consider mining lower grades, , which will extend the mine life and thus, stakeholder benefits, without compromising the revenue stream.

Environment

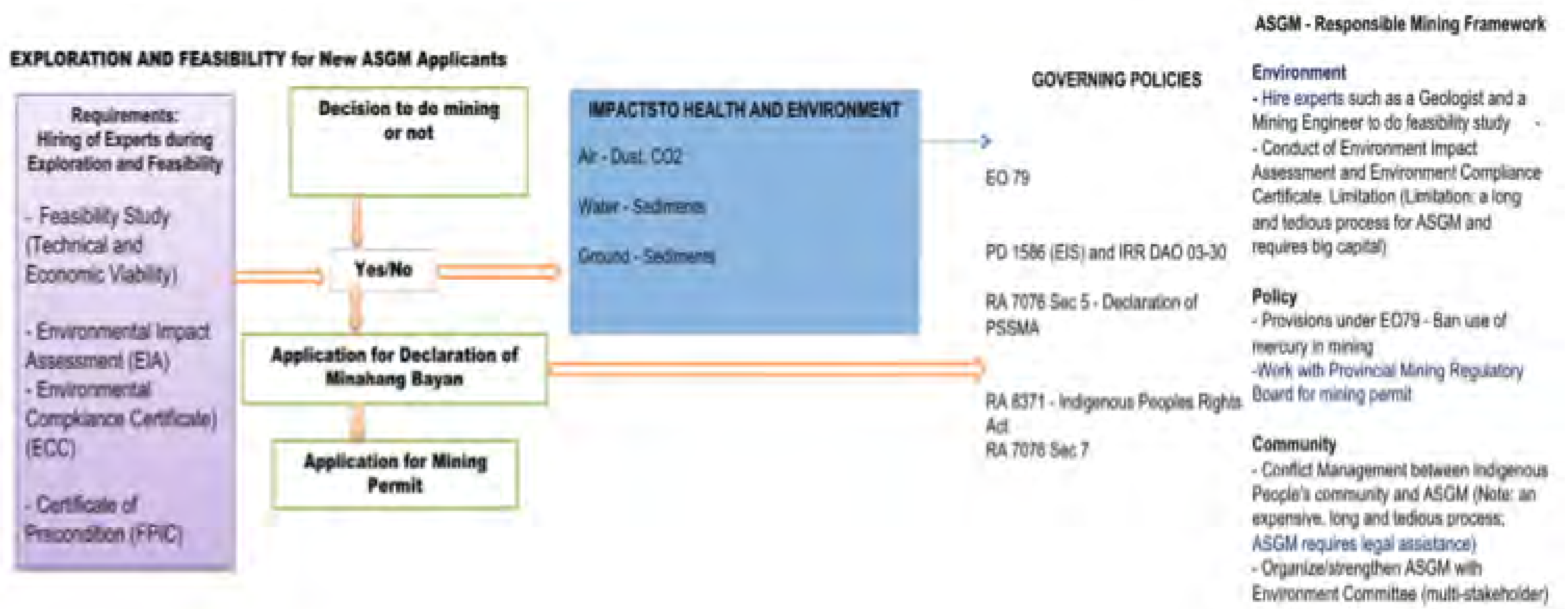
Adopting leading environmental management practices on mine sites makes excellent business sense. Unless steps are taken in the planning and operational stages to protect environmental values, long-term liabilities such as acid mine drainage may result.

Community

Finally, a mine needs a 'social license' to operate. Unless the community, especially in areas that are covered by ancestral domain claim/title, is engaged and supportive of a mining operation, opposition and confrontation may ensue. Dysfunctional community interaction will ultimately distract management from its main focus of efficiently running the mine.

[39]www.industry.gov.au/resource/Documents/LPSDP/guideLPSD. A GUIDE TO LEADING PRACTICE SUSTAINABLE DEVELOPMENT IN MINING

SECTION V- APPLICATION OF LCA MODEL IN THE ASGM CONTEXT
5. 1 Pre-Mining (Applies to new ASGM Applications)



6. 5. 1.1 Mineral Exploration: How to find gold deposits

Simple methods can be used to find gold deposits. The particular approach depends on the local geology. For example, soils in tropical environments that have evolved from gold bearing greenstones can become slowly enriched in gold as the bedrock weathers. In the Tapajós region in the Brazilian Amazon, miners systematically pan this type of weathered soil to locate and define the size of deposits. The process is semi-quantitative, and is based on a grid of 200m x 40m. Samples at each intersection of the grid are collected and panned, and visually inspected to determine the amount of gold in the sample. In areas where more gold specks are recovered, the miners establish a finer grid, (for example, a 5m x 5m grid), and attempt to identify the presence of quartz fragments or flaky grains of hematite (an iron mineral which is an indication of pyrite oxidation) using a magnifying lens. Further sampling is undertaken by digging 2-meter deep trenches. In the Tapajós sampling process, a 10L or 20L bucket of sampled soil is collected at each intersection of the grid. The material is panned with water, and if the concentrate shows some gold specks, they are counted and examined. If a scale is available, the gold is weighed; but if a scale is not available, the weight of the specks is determined by comparing the grains with pictures of specks of different weights on a plastic card, allowing the miner to make a good estimate of the grade of gold in the sample.[40]

It is sometimes also recommended to analyze the samples using the fire-assay method wherein a 30g sample is melted in a furnace with borax and lead nitrate allowing all gold in the sample to be captured by the lead forming a nice button which can be visually sized to estimate weight. The shape of the gold specks can indicate if the gold is from a vein, or is recrystallized (i.e., supergenic). Primary gold is usually less round and dendritic (tree-shape). It also contains more impurities such as copper, silver, etc. than recrystallized gold. The systematic panning method is very inexpensive and allows immediate results. In general, this approach allows miners to detect large gold bearing quartz veins, but often misses small veins less than 1 m.[41][42]

[40] www.globalmercury.org/ Lifted from Manual for Training Artisanal and Small-Scale Gold Miners, Marcello M. Veiga

[41] Ibid

[42] Note: According to Mr. Alain Lestra, a French geologist and independent consultant living in the Brazilian Amazon for more than 20 years

BASIC TIPS ON HOW TO FIND GOLD

Veiga (2006) outlines basic knowledge for miners on how to find gold:

- Gold is deposited in rocks in a number of ways, usually when hot gold-rich fluids cool inside cracks or in zones of reactive bedrock deep inside the earth. This has happened millions of years ago.

  + Pyrite can be distinguished from gold by mixing it with vinegar and water.

  + Red rusting pyrite stains in bed rock can be a sign that there might be gold nearby.

- Free gold found near rivers comes from bedrock that has been broken up over very long time and usually carried by rain water to the streams.

- Free gold can also be found in crumbled weathered bedrock near where it was de posited.

- Gold often has other metals mixed with it -- silver is the most common.

- The particles of gold in rocks can be both big and small.

  + Miners recover more gold when the gold particles are liberated from other minerals.

  + Gold particles become liberated by efficient grinding.

  + The degree of liberation must be tested.

  + Poor liberation causes the loss of gold in sluices and centri fuges, during amalgamation, and during cyanide leaching.

5. 1.2 Feasibility Study

Feasibility is an integral element of the mine evaluation process and can be defined as an assessment of the economic, environmental and social impacts of the potential mining project. Feasibility studies are required in the pre-production stages to justify the continued investment of money in the project and declaration of the area as "Minahang Bayan". Feasibility study usually consists of a scoping study, a pre-feasibility study and final or bankable feasibility study. At this stage, the project should commission an expert EIA preparer which will provide valuable information on the baseline conditions.[43]

[43]www.industry.gov.au/resource/Documents/LPSDP/guideLPSD.pdf A GUIDE TO LEADING PRACTICE SUSTAINABLE DEVELOPMENT IN MINING

ASGM tip #1- during the mining exploration activities take note of the following:

- Get a map of the area from NAMRIA (The National Mapping and Resource Information Authority) to have a clear view of the land you are applying for mining permit like elevation and slope. Slope more than 25% means the area is public land, therefore you go to the nearest DENR office (CENRO/PENRO) to see the different land tenure options (if there are) issued in that particular area. You may as well find out if there are projects (foreign funded or locally funded) implemented in the area.

- Go to the nearest NCIP office and inquire if the area is part of an ancestral domain claim or if there is already an issued CADT or CALT.

- If the area is ancestral domain secure certificate of precondition from NCIP.

- Go to the nearest MGB office and inquire if the area has an existing mining claim by large scale mining companies or any mining operations.

- If the area you plan to apply is A&D go to the nearest DAR office and inquire if the area is under CARP.

- If the A&D area is full of coconuts, visit the nearest CDA (Coconut Dev't. Authority) office and inquire if there is a prohibition to cut the coconuts.

- Get the socio-economic profile of the area from the BLGU office to get the critical mass of the population for your Information dissemination activity regarding your proposed project.

- Once you got the go signal from the different government authorities, engage the local community through a walk through mapping activity to determine the lay of the land and the natural landmarks like rivers, streams, historical sites that will be directly affected of the mining project you plan to do.

5.1. 3 Environmental Impact Assessment

EIA is a mandatory process by the Department of Environment and Natural Resources (DENR) under Administrative Order (DAO 2003-30).

The environmental impact assessment (EIA) process is an interdisciplinary and multi-step procedure to ensure that environmental considerations are included in decisions regarding projects that may impact the environment. Simply defined, the EIA process helps identify the possible environmental effects of a proposed activity and how those impacts can be mitigated. The purpose of the EIA process is to inform decision-makers and the public of the environmental consequences of implementing a proposed project. The EIA document itself is a technical tool that identifies, predicts, and analyzes impacts on the physical environment, as well as social, cultural, and health impacts. If the EIA process is successful, it identifies alternatives and mitigation measures to reduce the environmental impact of a proposed project. The EIA process also serves an important procedural role in the overall decision-making process by promoting transparency and public involvement. It is important to note that the EIA process does not guarantee that a project will be modified or rejected if the process reveals that there will be serious environmental impacts.[44]

[44]www.industry.gov.au/resource/Documents/LPSDP/guideLPSD.pdf/ A GUIDE TO LEADING PRACTICE SUSTAINABLE DEVELOPMENT IN MINING

Small-scale miner tip #2- EIA Study is a requirement prior to the declaration of “Minahang Bayan”.

1. EIA is a document that requires a number of technical inputs, therefore PMRB and DENR require that this is done by experts certified by DENR-EMB.

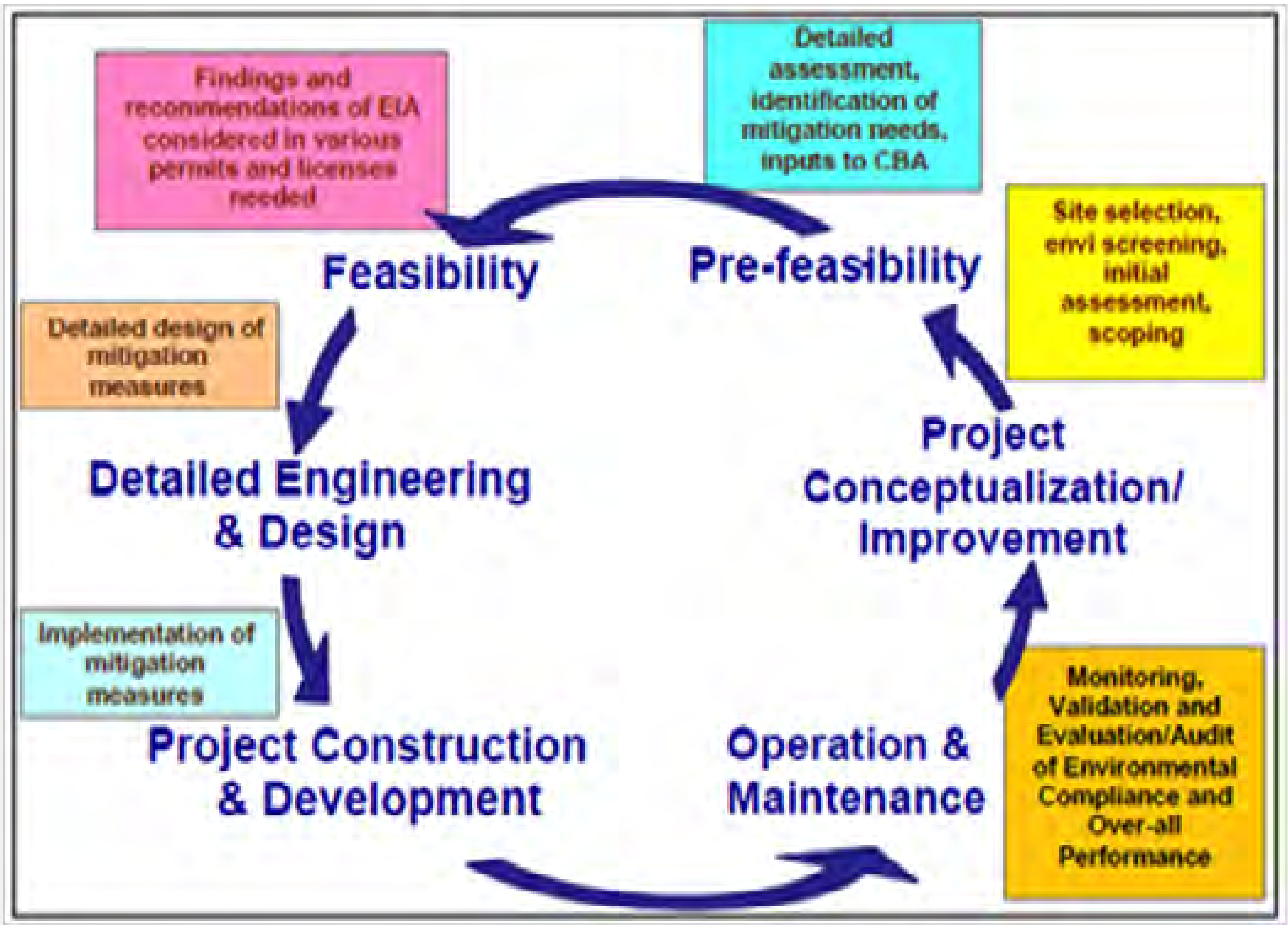
2. In cases where ASGM miners do not have access to EIA experts, a simple initial Environmental Examination can be done, such as listing of flora and fauna found in the area etc. You may contact any environmental NGOs for support and training on this method.

3. Get a base map from your Barangay Hall, use this during your walk through to illustrate settlement areas, mining areas, gold processing zones, schools, hospitals and other landmarks in your community.

4. Make a plan on how you propose to mitigate the damage of the ASGM operations to the plants and wildlife (flora and fauna) and other natural resources that will be affected in the proposed Minahang Bayan.

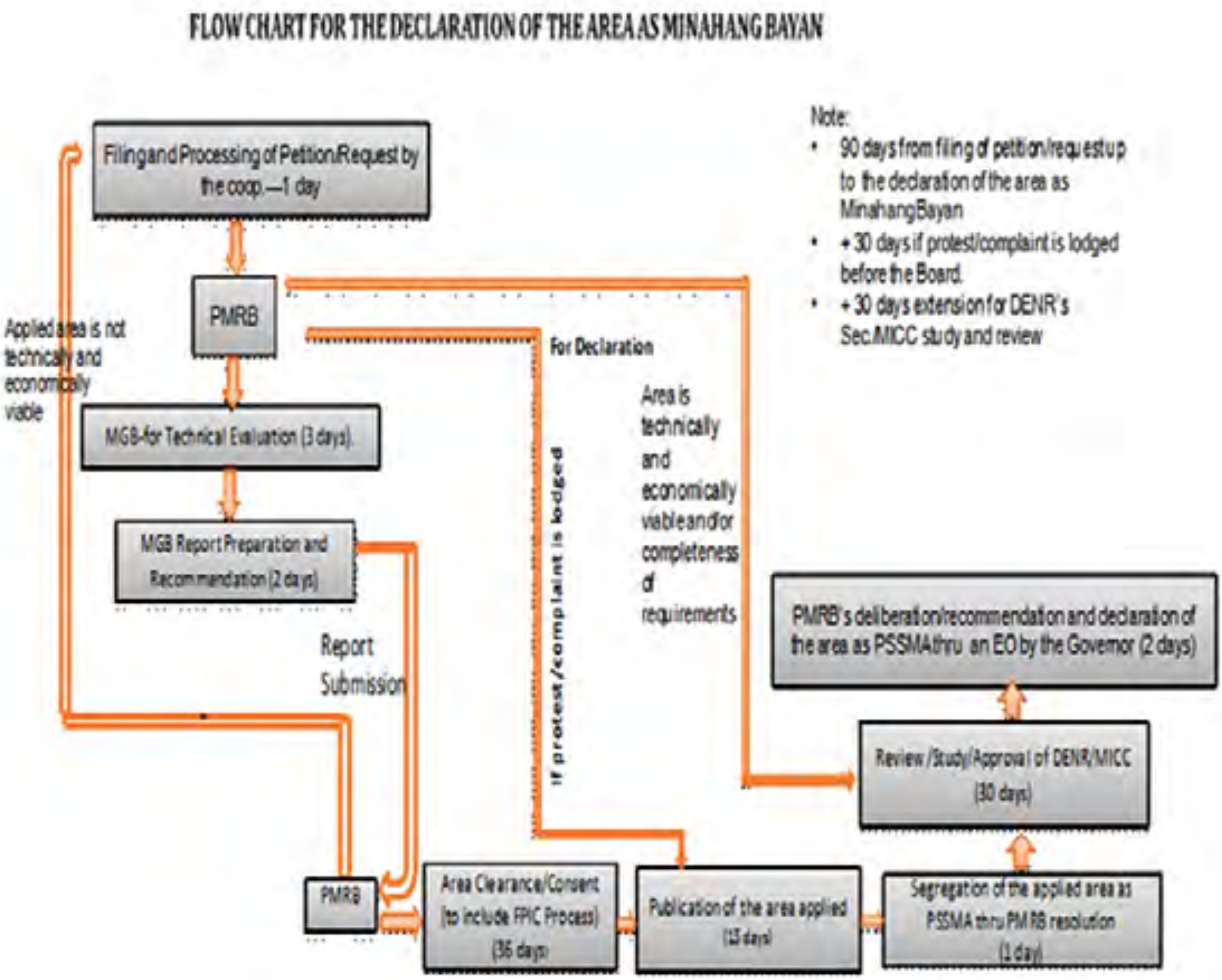
5. Present the Initial Environmental Examination report and Environmental Management Plan to DENR-EMB for advice.

6. Study the whole process in getting an Environmental Compliance Certificate (See Diagram below).



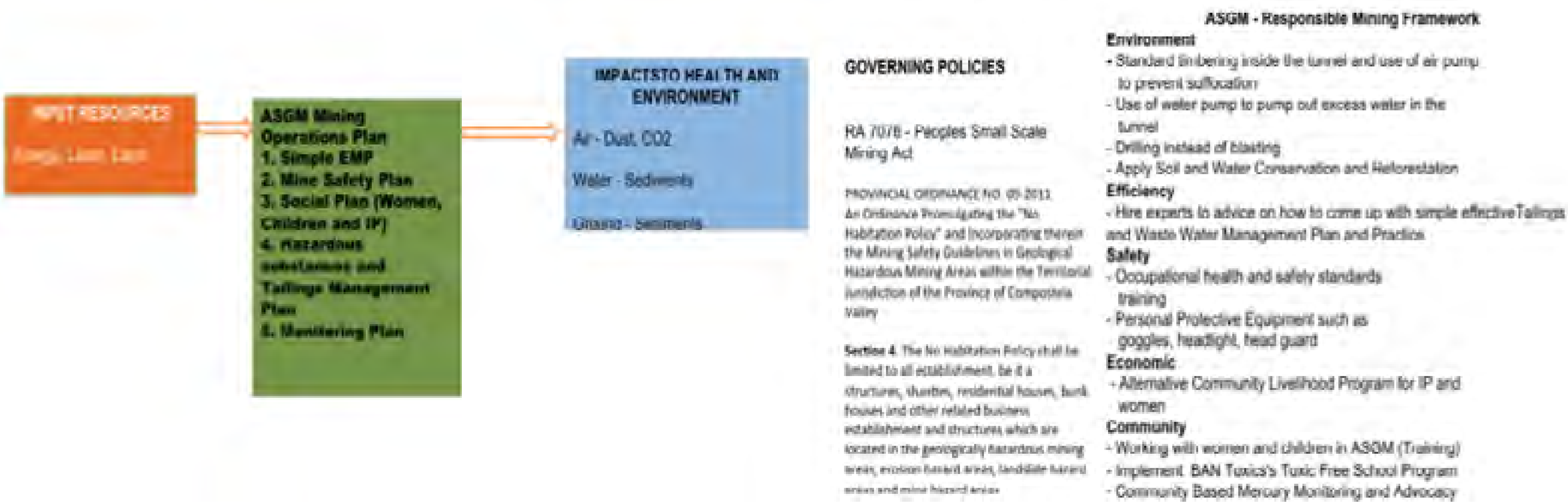
5.1.4. Declaration of Minahang Bayan

The diagram below illustrates the process flow and timelines of People's Small-scale Mining Area (PSSMA) Declaration in Compostela Valley Province.



45 www.industry.gov.au/resource/Documents/LPSDP/guideLPSD.pdf /A GUIDE TO LEADING PRACTICE SUSTAINABLE DEVELOPMENT IN MINING

5. 2 Mine Planning and Construction (Current ASGM Operations)



Planning and Construction (For Current ASGM Operations)

ASGM Mine Plan Components

Mine plan and design should take into account the mine closure issues, and integrate economic, environmental and social elements into the decision-making process. In the case of Compostela Valley Province, ASGM applicants are required to hire at least one (1) mining engineer to do the mine plan and design. Considering resource constraints and the need to make a good mine plan, ASGM groups would need to explore partnership with relevant NGOs, LGUs and DENR to get technical support from the experts and to guide them in drawing up a mine plan that fully meets the requirement of a responsible mining practice in ASGM. [45]

1. Simple EMP (Environment Management Plan)

ASGM Tips #3

1. ASGM miners can do an initial environmental examination (IEE) see Tip #1.

2. Get a map from the Municipal Planning and Development Office to determine the slope and elevation of the mine site and include in the plan Implementation of Soil and Water Conservation Measures (SWCM) and reforestation of denuded areas and steep slopes.

3. Link up with experts and get advice on how to come up with a simple effective Tailings and Waste Water Management Plan and Practice.

4. Visit any BAN Toxics ASGM Gravity Concentration Facility and observe method of mercury-free gold recovery, water storage, wastewater treatment and re-use (see Gravity Concentration manual and Facility 3D Design)

5. Include social and community development programs in the plan e.g. raising-awareness on mercury toxicity and ill effects (see Toxics Free School Program for added guidance)

Tips on how to organize into an association or cooperative:

1. Explore and decide on the type of organi zation and accreditation that best fit your group's goals and aspirations, e.g. association, cooperative[46], partnership, etc.

2. Decide the structure of your organization to determine your functions and operations.

3. Develop your VMGO (vision, mission, goals, objectives)

4. Register your organization to SEC (Securities and Exchange Commission) for corporations, limited partnerships profit organization or non-stock, non-profit organizations.

5. For cooperative organizations, you may register with CDA (Cooperative Development Authority.

6. Go to SEC or CDA to get the requirements for registration.

[45] ww.industry.gov.au/resource/Documents/LPSDP/guideLPSD.pdf /A GUIDE TO LEADING PRACTICE SUSTAINABLE DEVELOPMENT IN MINING

[46] Association is a formal organization of people or groups of people with a common purpose. Easy to organize and does not require a lot of effort and resources. Cooperative is an organization owned, controlled, and operated by a group of people for their own benefit. Each member contributes equity capital, and shares in the control of the organization on the basis of one-member, one-vote principle (and not in proportion to his or her equity contribution.

7. To register name and type of organization to SEC, you must register 3 names online for approval of your organization's name. Then go to SEC office and pay Php500 for the reservation of your organization's name for 3 months while you process the documentation required.

8. SEC and CDA have articles of incorporation prepared for sale.

2. Mine Safety Plan

ASGM Tip # 4

At the minimum, what to include in your mine safety plan.

1. Use standard timbering inside the tunnel and use air pump to prevent suffocation of workers.

2. Drilling instead of blasting inside the tunnel.

3. Use water pump to take out excess water in the tunnel.

4. Invite LGU/DENR-MGB/NGOs to conduct occupational health and safety standard training to mine workers.

5. Make a policy monitor and require all mine workers to put on personal protective equipment (PPE) such as goggles, headlight and head guard when entering the tunnel. (see annex for Personal Protective Equipment guidelines)

3. Social Plan: Engaging Women, Children and Indigenous People (IP)

Women play key roles in addressing development challenges in ASGM. The significant role that women play in decision-making in all aspects of community life should be tapped during mine planning.[47]

ASGM Tip # 5

1. Get the socio-economic profile from the barangay to have an idea of how many women and children will be included in the plan.

2. Look for competent partner/s, including government agencies, NGOs, etc. to conduct training on Gender, Women and Children's Rights.

3. Assess the role of women in the ASGM community, the issues and challenges encountered.

4. Identify strategic interventions and relevant policies in the mining areas that can help eliminate child abuse/labor in the mining process and strengthen gender equality.

5. Actively engage women and women's organizations in public information campaign and outreach program to increase awareness on mercury toxicity.

4. Hazardous Substances and Tailings Management Plan

The large volumes of waste produced at ASGM operations are expensive to manage, and are frequently cited as an obstacle in responsible mining. Mine waste should be managed to prevent the release of toxic substances into the environment.[48]

[47] www.industry.gov.au/resource/Documents/LPSDP/guideLPSD.pdf/ A GUIDE TO LEADING PRACTICE SUSTAINABLE DEVELOPMENT IN MINING
[48] www.industry.gov.au/resource/Documents/LPSDP/guideLPSD.pdf/ A GUIDE TO LEADING PRACTICE SUSTAIN-

ASGM Tip # 6:

Ban Toxics recommends mercury-free gravity concentration as an effective and efficient method of recovering gold for ASGM. Please refer to BT handbook on Gravity Concentration Method.

As cited by experts, mercury-free tailings produce greater yields in gold recovery and it can also be used for the following purposes:

- Waste rock can be reprocessed to extract minerals and metals, used as backfill, landscaping material, aggregate in road construction, or feedstock for cement and concrete.

- Slag is often used for road construction, and in concrete and cement.

- Mine water is used for dust suppression and mineral processing, industrial and agricultural uses, as a coolant, and as a source of drinking water

- Water treatment sludge from ARD treatment, which is high in iron, has been sold commercially for use in pigments.

5. Monitoring Plan

Elements of mining project monitoring programs can be broadly categorized into environmental, social, occupational health and safety (OHS), and routine operational monitoring. However, the incorporation of additional monitoring parameters and performance evaluation criteria is essential to the identification and proactive management of environmental, social and OHS issues during the mine life. Baseline monitoring should commence at the pre-feasibility stage for new ASGM applicants and include all relevant environmental, health, economic, and social issues. In most cases, the baseline monitoring system will need to be permanent so that repeat assessments can be made. This will provide essential data on several aspects related to impacts of the mining project.

ASGM Tip # 7: Monitoring Plan

1. Organize multi-stakeholder monitoring team at the planning stage that will gather the pertinent data on the ground.

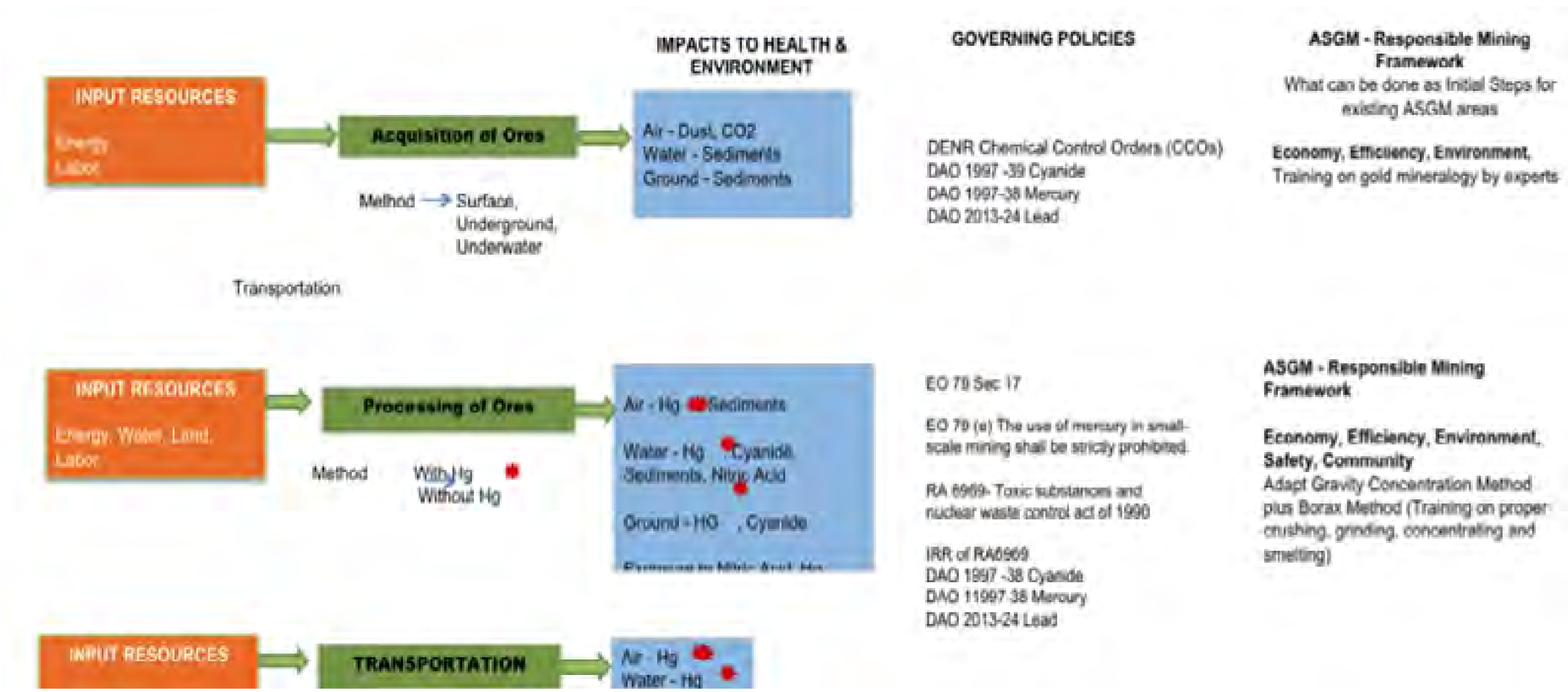
2. Collaborate with partners such as LGUs or NGOs for trainings on Community-Based Mercury Monitoring and advocacy and as well as ambient air monitoring using technical equipment (See BAN Toxics reference on Mercury monitoring for added guidance)

3. Design a community-based environment sampling protocols for air, fish, water and sediments. Link up with BAN Toxics and partners for technical support.

4. Contact Department of Health for biomonitoring support and training on health effects and management of Hg poisoning.

5. Coordinate with DOH and Philippine Society for Clinical and Occupational Toxicology (PSCOT) to conduct a bio-monitoring study on the effects of mercury.

5. 3 MINING OPERATIONS



5.3.1. ACQUISITION OF ORES

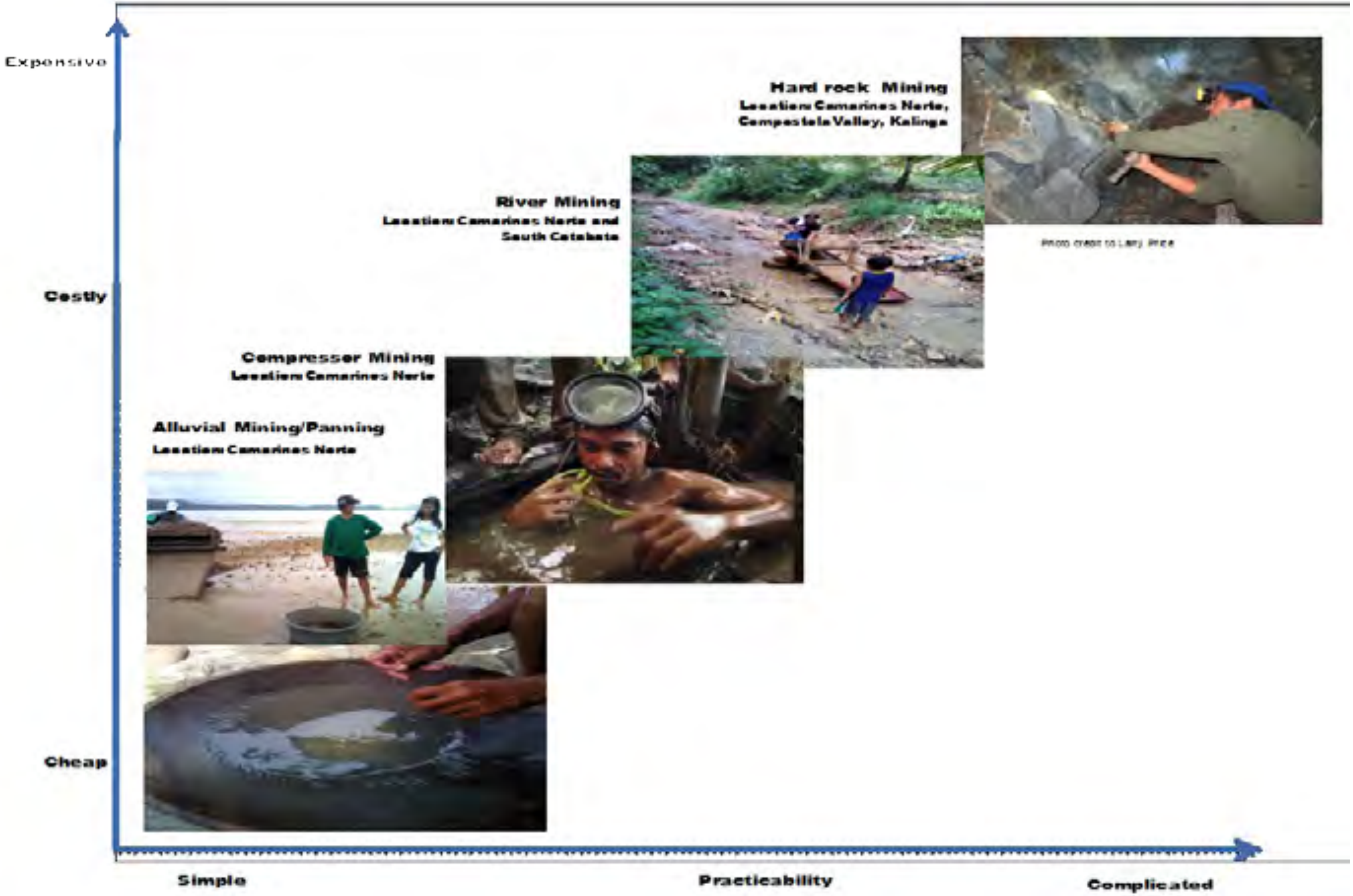


Photo credits: 1. Arlene Galvez 2. Larry Price 3. Arlene Galvez 4. Jimbea Lucino

5.3.2 Extraction and Gold Recovery in the Philippines

ASGM miners generally use simple tools and indigenous knowledge to assess types of minerals. Prospecting for gold is done by looking for and following exposed portion of gold-bearing veins, examination of stream sediments and/or prospecting upstream from an area where gold is present. Sampling methods used to assess the concentration of ores are mainly visual (Rey et al, 2005)

5.3.2 Extraction[49]

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5.3.2.1 Vein Deposits

Vein or lode deposits are mined underground through pocket-sized adits or tunnels or through shallow surface excavations (Baluda 13). Mines are developed by tunnels that directly follow the veins. If it is not possible, crosscuts are constructed where veins could be intercepted at short distances. Tunnels are kept small for economic reasons and to avoid timbering (Bautista 13). Sometimes, a stream may be used to remove overlying rocks for a vein. A dam is constructed along a stream to form a reservoir. When the reservoir is full, water is released to tear away the overburden from the vein (Padilla 36). Miners rely on the natural ventilation but sometimes hand or gas operated blowers are used. Tools are usually small and manually operated which include picks, shovels, miners lamps, sample picks, sample pans, water pumps and siphons (Bautista 12). Ores are manually hauled using sacks, trackless mine cars and/or wheel barrows.

5.3.2.2 Placer Deposits

Placer deposits are extracted from sediments within or downstream of known gold deposits, gold mines and tailings ponds by panning or sluicing. Place deposits are extracted from sediments within or downstream of known gold deposits, gold mines and tailings ponds or sluicing

[49]E. Rey et al 2005. Small Scale Mining in the Philippines, Towards Genuine National Development

5.3.2 Gold Recovery

5.3.2. 1 Crushing and Milling[50]

In order for gold to be concentrated it must be "liberated". Many alluvial gold deposits do not require liberation, because gold already occurs as free gold particles. In most other deposit types, however, gold occurs inside other minerals and must be separated from these before it can be concentrated. This is accomplished by crushing and milling rocks into powder. The technical term for this is "comminution". The table below shows a number of rock types and their relative crushability. As one can see, rocks with high amounts of quartz are harder than many other rock types, and thus require considerable effort to crush:

Photo Credit to Rasmus Rasmussen

Type of Rock	Hardness
Basalt	Very hard
Granite	↓
Quartz/quartzite	
Copper ore	
Iron ore	
Sandstone	
Limestone	Soft

There are four typical stages of comminution:

- Primary crushing is the crushing of large rocks fresh from the earth.
- Secondary crushing is the crushing of rocks after primary crushing.
- Tertiary crushing is the final sizing of rocks by crushing.
- Grinding is when crushed rocks are ground to fine powder form.

[50]Lifted from Manual for Training Artisanal and Small-Scale Gold Miners, Marcello M. Veiga, www.globalmercury.org/

5.3.2.2 Grinding

Grinding is undertaken on already crushed material to achieve adequately fine particle- size necessary to liberate the most gold possible. Grinding typically uses some sort of tumbling mill, a round metal barrel driven either manually or mechanically and filled with a grinding media such as steel balls, rods or hard pebbles. Grinding can be undertaken dry or wet. Dry grinding reduces the wear on mill shells, liners and balls, but requires up to 30% more power than wet grinding. [51]

Common types of grinding mills

Ball mills and rod mills

Ball, pebble and rod mills are all cylindrical rotating shells which are mounted on bearings and filled with up to 40% by volume of a grinding medium such as steel balls, rods or hard pebbles. Large models are usually lined with a wear-resistant lining. Mills are typically longer than their diameter, although some ball mills can be shorter in length than diameter. Feed rock size is typically 10-40 mm and discharge sizes can be 0.03 to 0.3 mm. Mills operate at an optimum speed, which is typically 70% of the critical speed of the mill, the speed at which the contents will stick to the shell of the mill. The critical speed N for a mill is calculated based on the diameter D (in meters) of the mill: N = 42.3/D0.5. For a small ball mill with internal diameter of 90 cm, the critical speed is around 44 rpm. The suggested speed is 70% of the critical speed or 31 rpm.

Photo Credit to Rasmus Rasmussen

Sledgehammer

A common method of pre-sizing rocks before grinding in a stamp mill or ball mill is to place oversize rocks (>2”) on a large flat rock, inside a Hessian or nylon ring which holds the rocks in place while they are hit with a hammer to produce typically 1 cm rocks. Some miners then use a piece of stone to grind the crushed rocks. In this process, the ground material is screened at 0.5 to 1 mm and the coarse material re-ground.

5.3.2.3 Sluicing[52]

For efficient sluice operation, consistent water supply is important. When buckets are used to deliver sediment and water onto sluices, surges in flow can lift gold particles off the carpets, reducing gold recovery. This can be avoided by filling a small reservoir like an oil barrel that delivers consistent flow to the sluice. Sluices work on the principle that heavy particles sink to the bottom of a stream of water while lighter particles tend to be carried downstream and discharged. A rough surface, typically carpets, can trap the gold and other heavy particles. Like a ball rolling down a hill, flow and momentum increase with distance, making the trapping mechanism less effective further down the sluice, particularly for fine gold. For this reason most gold is caught in the first meter of simple sluices.

[51] M. Veiga, www.globalmercury.org/
[52] Ibid

5.3.3 Mercury-Free Gravity Concentration Method[53]

Gravity methods are the most widely used method of concentrating gold in ASGM. Using gravity is effective because gold is heavy -- approximately 7 times heavier than an average rock of the same size. There are a wide variety of approaches to gravity concentration from basic such as panning and sluicing, to more complex such as centrifuges and shaker tables.

Gravity concentration is a process to concentrate the mineral of interest (in this case gold) using the difference of specific gravity of gold and gangue minerals. The specific gravity of gold is 19.5 and the specific gravity of quartz (the common gangue mineral associated with gold) is 2.65 (i.e., gravity concentration works because gold is heavy, and quartz is light). Often, gravity separation methods are confused with size classification because large particles of light minerals can behave like a small particle of a heavy mineral. The most effective gravity separation processes occur when applied to ore particles of about the same size. The most important factor for a successful gravity separation is liberation of the gold particles from the gangue minerals. It is not easy to establish the degree of liberation of low-grade minerals such as gold. Classical

The most recommended method to establish the optimum gold liberation size is grinding for different times (or grain size distributions) and applying gravity concentration to the ground products. This is a classical and important procedure to recommend any type of gravity concentration process. Because most artisanal miners do not classify (screen) the crushed/ground material (i.e. they work in open circuit), their chances to improve gold recovery are very limited.

The main advantages of gravity concentrators over gold cyanidation are:

- Relatively simple pieces of equipment (low capital and operating costs);
- Little or no reagent required;
- Works equally well with relatively coarse particles and fine grained materials.

[53] M. Veiga, www.globalmercury.org/

5.3.4 Calculating recovery and concentrate grade

There are two main variables of high importance in mineral processing -- recovery and concentrate grade. They are always "enemies", i.e. when you have high gold recovery, the gold grade of the concentrate is low. This is easy to understand. If you are concentrating an ore with 10 grams of gold per ton of ore and you have a concentrate with a large weight, the recovery is likely high, but probably the grade is close to 10 g Au/ton. In other words, you did not concentrate too much gold. In opposite, if you have almost pure gold in your concentrate, you lost lots of gold in the process and the recovery might be low. Then the trick is to find a process and a condition (time, equipment, etc.) in which the gold recovery is good and the grade of the concentrate is also acceptable.[54]

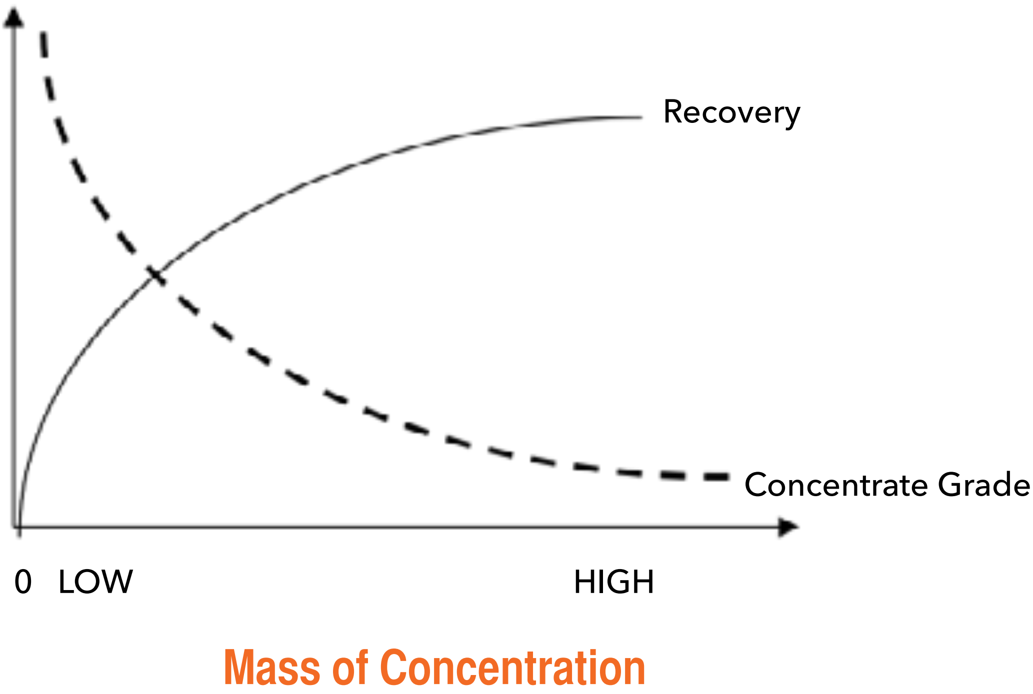


Fig. 4.1 – Gold recovery and concentrate grade (Veiga 2006)

Observe Fig. 4.1 which is a hypothetical example of a gold ore. When the mass of concentrate is high, the gold recovery is high but the concentrate grade is low. Miners want high recovery and a concentrate with almost pure gold. Of course this is the ideal situation, but hard to meet. Where is the best point in this curve? There is not a clear answer for this. Some miners prefer to discharge the concentrate from the sluice box or centrifuge more frequently to have high recovery but the grade of the concentrate is low and then they have to spend more time in panning and amalgamating a large amount of concentrate. Other miners prefer to run their sluice boxes for long time (e.g. 7 days) to have a very rich concentrate but their recovery is usually low.

[54] M. Veiga, www.globalmercury.org/

Gravity causes gold to settle in water faster than silica and other gangue minerals. The rate of settling depends on particle density, size and shape: large, dense, spherical grains settle quickly, whereas small, less dense and flatter particles settle much more slowly. Coarser grained low-density particles can settle at the same rates as finer high-density particles. In sluices where turbulence is low, the difference in settling rate between heavy and light particles tends to separate the slurry into loosely stratified zones. As the slurry stream flows down a sluice, the densest and largest particles accumulate in a zone close to the bottom where they can become trapped within the lining carpet's pile or weave and sheltered from the current, while the smaller, lighter

Panning[55]

Pans are widely used for concentration in many ASGM sites. Panning with water causes lighter particles to flow over the edge of the pan, while heavier particles, including gold, remain in the bottom. Gold is 19 times heavier than water, mercury is 13 times heavier, and an average rock is only 3 times heavier. Simple panning works best when the gold is coarse and well liberated.

ASGM Philippine Practice in Crushing and Grinding

Stage	Ore	Feed (inches)	Output (inches)	Types of Equipment
Primary Crushing (fresh ore extracted inside the tunnel)	Soft	Any sizes	Any sizes	Electric Drill with Pinch bar, Sledge hammer
	Hard	Any sizes	Any sizes	Electric Drill with pinch bar, Dymanite, Sledge Hammer
Secondary Crushing	Soft	Any bigger sizes	1 inch – 2 inches	Mechanical crusher, Sledge hammer
	Hard	Any Bigger sizes	½ inch – 1 inch	Mechanical crusher, Sledge hammer
Grinding	Soft	1 inch – 2 inches		Rod mills – 20 X 18 drum with 2.5” rods 2 pcs and 2” rods -8 to 10 pcs, grinding time is approximately 2 hours
	Hard	½ inch- 1 inch		Rod mills – 20 X 18 drum with 2.5” rods 2 pcs and 2” rods -8 to 10 pcs, grinding time is approximately 2 hours to 3 hours

[55] M. Veiga, www.globalmercury.org/

5. 4 REFINEMENT OF GOLD/AMALGAM

GOVERNING POLICIES

EO 79 Sec 17

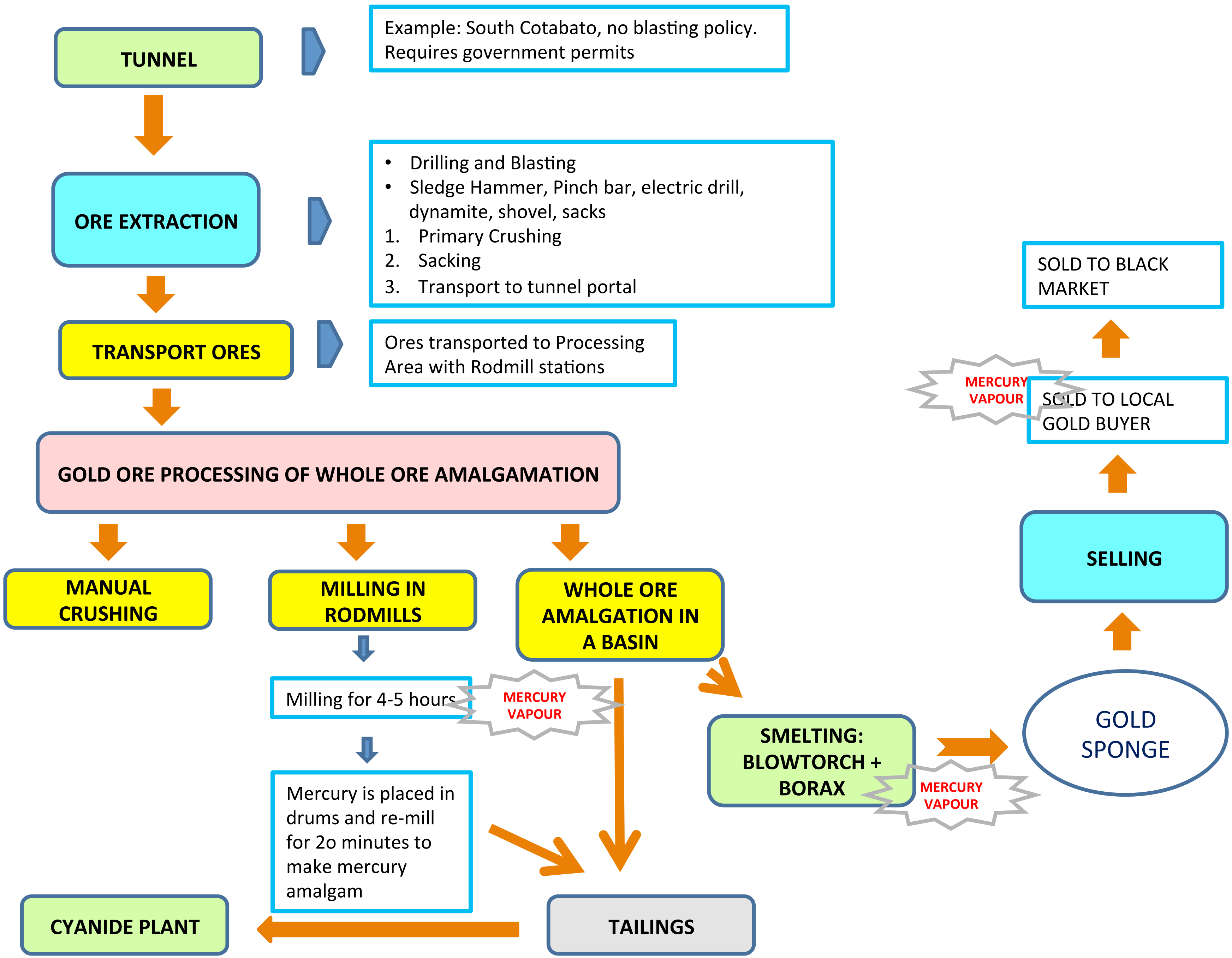
EO 79 (e) The use of mercury in small-scale mining shall be strictly prohibited.

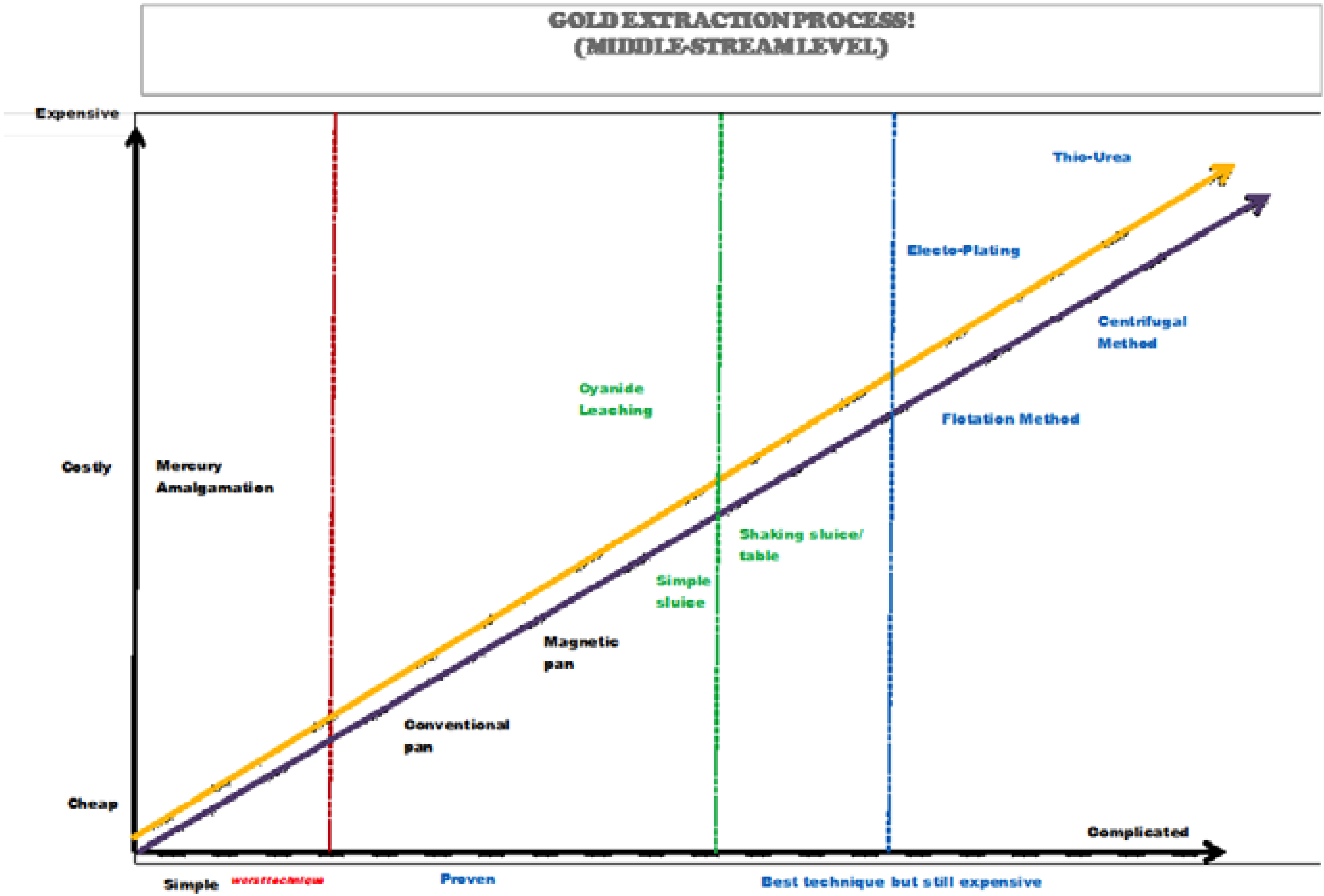
RA 6969- Toxic substances and nuclear waste control act of 1990

IRR of RA6969
DAO 1997 -38 Cyanide
DAO 11997-38 Mercury
DAO 2013-24 Lead

ASGM - Responsible Mining Framework

Efficiency, Economy, Environment, Community
- Apply Mercury-free method such as Gravity Concentration Method in smelting
- Advocate for Clean Gold trading


TUNNEL
Example: South Cotabato, no blasting policy. Requires government permits
ORE EXTRACTION
• Drilling and Blasting
• Sledge Hammer, Pinch bar, electric drill, dynamite, shovel, sacks
1. Primary Crushing
2. Sacking
3. Transport to tunnel portal
TRANSPORT ORES
Ores transported to Processing Area with Rodmill stations
GOLD ORE PROCESSING OF WHOLE ORE AMALGAMATION
MANUAL CRUSHING
MILLING IN RODMILLS
WHOLE ORE AMALGATION IN A BASIN
Milling for 4-5 hours
MERCURY VAPOUR
Mercury is placed in drums and re-mill for 2o minutes to make mercury amalgam
SMELTING: BLOWTORCH + BORAX
MERCURY VAPOUR
GOLD SPONGE
SELLING
SOLD TO LOCAL GOLD BUYER
MERCURY VAPOUR
SOLD TO BLACK MARKET
TAILINGS
CYANIDE PLANT



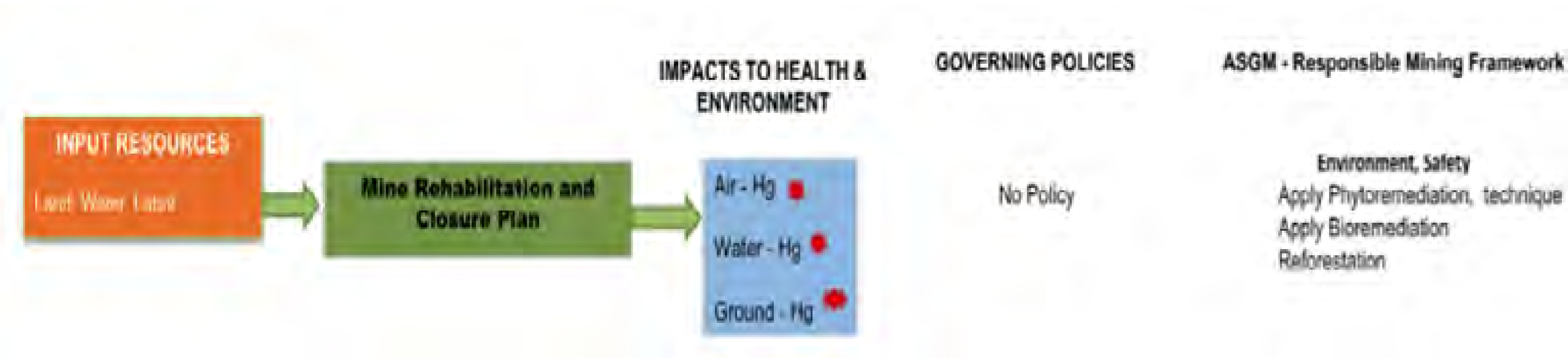
Adapted from Balifokus.asia presentation during raining to Identify Mercury and its Health Impacts
For Health Workers, Academe, and Civil Society from ASGM Hotspots Areas in Indonesia and the Philippines, Jakarta, 20-22 October 201

COSTS OF AND BARRIERS TO THE USE OF NON-MERCURY TECH-

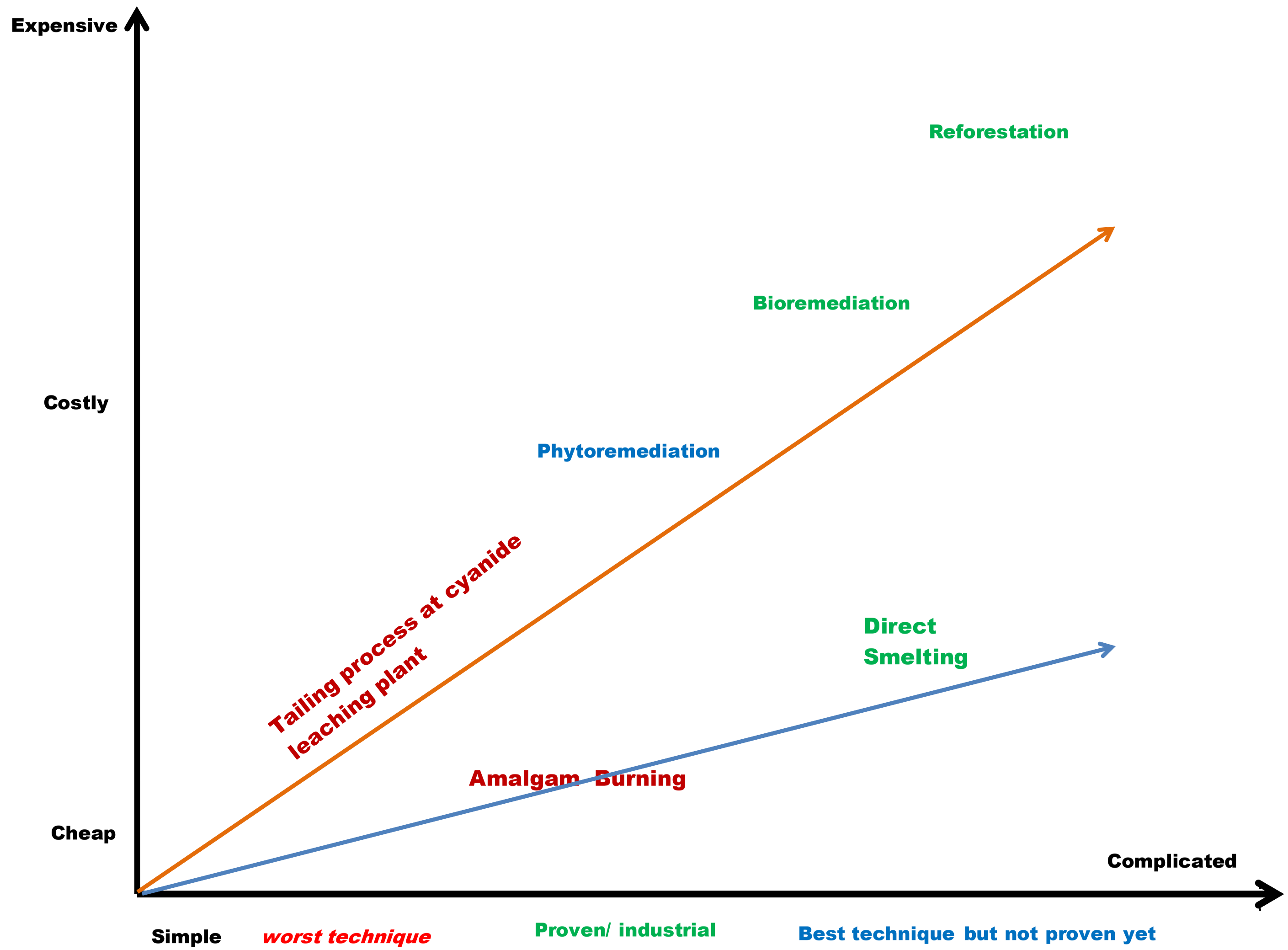
Alternatives	Remarks	Dollar Cost in United States dollars **	Obstacles/Barrier
Centrifuge	No mercury	$1,000 - $10,000. Average $4,000 for a good ASGM centrifuge	Initial cost, energy, water, technical know-how, legal status
Sluice can	No mercury	$50 – $1,000	Water (although also be dry), high cost, high energy use
Magnetic Carpet Clean Gold	No mercury	$50 – $500	Preferably for alluvial ore or fine crushed ore
Shaking-table	No mercury	$20,000	Relatively expensive, need preliminary treatment
Direct smelting kit	No mercury	$1,000	Cost, energy, technical knowhow, quantity of material that can be processed

Source: Global Forum on ASGM (2010) and UNEP Conclusion Workshop on National Strategic Planning for ASGM,
Siem Reap, 22-24 March 2011

5. 5 POST MINING-PLANNING FOR CLOSURE AND REHABILITATION



End Products, Tailing and Rehabilitation



Adapted from Balifokus.asia presentation during raining to Identify Mercury and its Health Impacts For Health Workers, Academe, and Civil Society from ASGM Hotspots Areas in Indonesia and the Philippines, Jakarta, 20-22 October 2001

Planning for Closure

Planning for mine closure should be undertaken progressively throughout an operation's life cycle. The amount of detail will vary and refocus on specific issues through the operations' life cycle. In order for mine closure planning to be successful, the ASGM operation needs to ensure it is integrated early into planning rather than being attended to at the end of mine life. The initial ground work, even at the exploration phase, can impact the effectiveness and success of closure planning.

ASGM Tip # 8

1. Ensure that mine rehabilitation plan is part of ASGM's environmental management agenda even at pre-mining stage;

2. Link up with BAN Toxics and ask about mercury waste management and storage options in the short and long term (See annex on mercury waste management and storage options);

3. For LGUs, ask the government about its National Strategic Plan guidelines to phase-out mercury; draw up your own local action plan. Link up with BAN Toxics for added briefing and collaboration.

4. Link with your nearest DENR Office in the area and ask for assistance on reforestation and rehabilitation guidelines.

5. For technical support, link with academes nearest you and with the Department of Science and Technology for possible collaboration on post mine closure and rehabilitation project

6. There are abandoned mining sites that has been developed into other uses and became a good source of community livelihood – get organized, discuss among your group and ask your local government council to help you assess and design a community development plan that will turn things around. For example, link up with your Department of Tourism and Industry for possible eco-tourism and livelihood potentials of the abandoned mine site.

The long-term objectives of rehabilitation can vary from simply converting an area to a safe and stable condition, to restoring the pre-mining conditions as closely as possible to support the future sustainability of the site. Rehabilitation normally comprises the following:

- Developing designs for appropriate landforms for the mine site.

- Creating landforms that will behave and evolve in a predictable manner, according to the design principles established.

- Establishing appropriate sustainable ecosystems.

Different Rehabilitation Technology

1. Phytoremediation

- Any plant-based system that is used to improve contaminated media (Pilon-Smiths, 2005).

- Uses the sun's energy to cleanse contaminated soil and is therefore inherently cheaper than other remediation technologies.

- Plants contain, sequester, remove, or degrade contaminants as part of their normal physiological processes such as water uptake, inorganic ion uptake, evapotranspiration, root exudation and turnover, and the photosynthetic production of phytochemicals. Rhizosphere microbes stimulated by plant roots can biodegrade organic contaminants (Tsao, 2003). The application of these plant-rhizosphere processes has been used to treat contaminated soils, sediments, surface and ground waters.

- Treatable contaminants: hydrocarbons, chlorinated compounds, and nitroaromatics in the organic contaminant class, as well as heavy metals, metalloids, radionuclide, and salts in the inorganic contaminant class.

Case: Pytoremediation were tried and tested in artisanal and small-scale gold mine (ASGM) area of West Lombok, Indonesia, where gold is recovered through a two-stage process of amalgamation and cyanidation. Tailing is discharged to land with no concern for contaminants in the tailings. Certain plants that grow in around the vicinity of the mine site were collected, potted and replanted with proper care and management and let it grow for some time. After the trial period, the plants were harvested and tested. The result showed that certain plant species have the ability to extract and accumulate mercury both from the atmospheric and soil.[56]

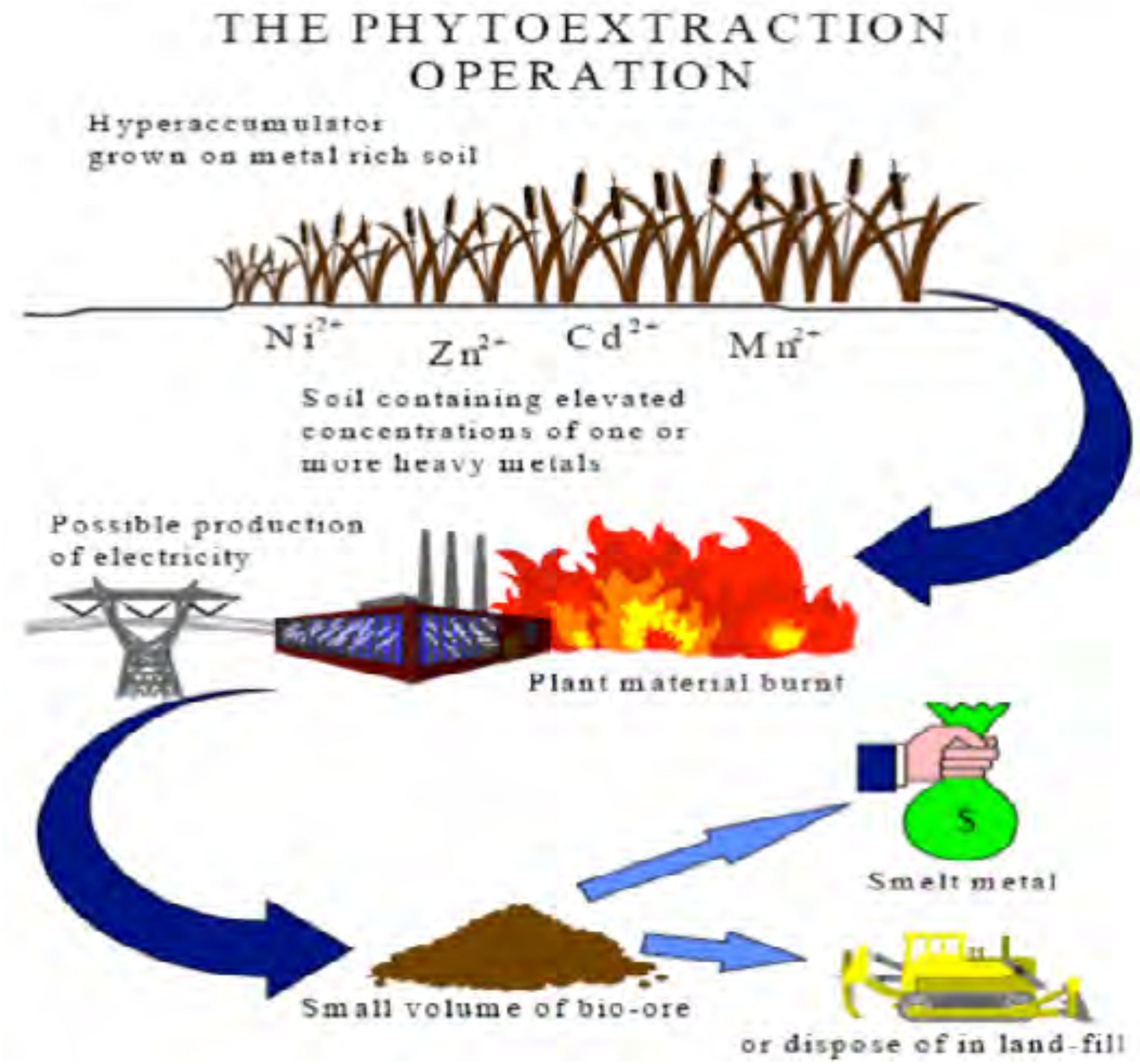
2. Phytoextraction

- Repeated cropping and safe storage of the harvested plant biomass following accumulation of metals in the plant aerial tissues.

- Incineration of the biomass can reduce up to 95% the material to be disposed of in landfills (Robinson et al., 1998) (Figure 2).

- Can be applied to the soil removal either of those elements that are essential (e.g., B, Cl, Co, Cu, Fe, Mn, Mo, Ni, Zn) or non-essential (e.g., Cd, Pb, Cr, Hg and As) to plants (McGrath, 1998).

[56] IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399. Volume 4, Issue 1 (May. - Jun. 2013), PP 15-19 The potential of wild plants for phytoremediation of soil contaminated with mercury of gold cyanidation tailings



Source: F.N. Moreno et.al., Phytoremediation of mercury-con-

3. Bioremediation

• Treatment of waste or pollutants by the use of microorganisms (as bacteria) that can break down the undesirable substances.

• Scavenging of organic contaminants (such as chemicals, heavy metals, oil) in the soil or water, by the action of cultured microorganisms selected for their ability to metabolize the specific contaminants.

4. Reforestation

• The process of restoring and recreating areas of woodlands or forests that may have existed long ago but were deforested or otherwise removed at some point in the past.

Conclusions and Recommendations:

In a situation where ASGM communities are linked to numerous social and environmental problems, LCA provides ASGM with relevant framework in assessing environmental impacts of mining in all stages in the life cycle of a product. The discussion at length assessed resources used in ASGM for a product, from the point of raw material acquisition, through production of product parts and the product itself and the use of the product, to ultimate disposal of product and its waste management.

Currently, the experience of BAN Toxics in working with a number of ASGM communities in the country has shown that mining can contribute to sustainable development by focusing on mercury-free options for gold recovery, economic, health and safety and environmentally sound outcomes.

However, the application of LCA in the ASGM context is still limited to an extent as it fails to completely map and integrate socially inclusive dimensions in its life cycle. BAN Toxics fully believes that investing fully in improving the welfare and rights of women in ASGM is key to transforming ASGM communities into a viable and sustainable communities.

The prevailing lack of studies in LCA focusing on ASGM is a recurring challenge. This springs from the lack of capacity and resources by ASGM to map out all aspects of activities using LCA and use it effectively. However, BAN Toxics sees a lot of potential in fully bridging these gaps under limited resources and budget by mobilizing community-based resources and tools. This is outlined in the LCA can be applied to ASGM and will ensure environmentally sound options in all stages:

Product Development and Improvement. ASGM is poverty-driven and mostly conducted as a backyard activity in many areas. Effective steps must be explored to improve extraction of gold that is mercury-free and environmentally sustainable. BAN Toxics training on mercury gravity concentration method can be applied in this case.

Strategic Planning. LCA results can be used by ASGM groups to prioritize and decide on most effective strategies such as pollution prevention, resource conservation and waste minimization. It can be used to lobby for government support. For example, BAN Toxics community-based mercury-monitoring can complement in this aspect and help ASGM gather relevant data and information at the community level.

Policymaking. LCA can provide ASGM an insight into envir onmental problem areas and improve and guide internal environmental policy formulation. LCA can even help examine various social environmental issues considered or not considered in the current regulations governing ASGM in the country – in this case the welfare of women and children in ASGM, child labor and serious health impacts of mercury pollution in ASGM.

Marketing. LCA can also be used to support and inform customers about options for buying toxics-free and fairly traded gold. The process can be used to support and encourage ASGM to use toxics/mercury-free gold recovery in the process. LCA can also address the economic aspects and viability of mercury-free gold recovery in ASGM such as access to credit and investment.

Enhancement of Environmental Management Systems. LCA can be used to enhance environmental management systems in ASGM and minimize environmental resource use conflicts in the process. This can also be used as a tool to harmonize and integrate various aspects of resource use in all ecosystem level – upstream, midstream and downstream.

6. Learning. LCAs that focus on artisanal small-scale gold mining could generate in-depth understanding on the impacts of different mining processes and provide governments and communities with important information for informed decision-making. Many ASGM communities venture into mining without enough knowledge and know-how, resulting in serious environmental degradation. This resource guide can be used to design environmentally sound options for ASGM and as well as information on other economically viable alternatives

For ASGM communities to apply LCA fully, we see further work in the following areas:

- Favorable legal environment for ASGM development in the country;
- Projects and initiatives that support women and children's right and empowerment in ASGM;
- Options for short and long-term management of mercury waste;
- Development of relevant government policies and researches addressing effective and environmentally sound rehabilitation and remediation of toxics waste in post mining phase;
- Technical support for ASGM miners in the aspect of exploration, mining and construction and post rehabilitation;
- Scaled up LGU support in eliminating mercury in the gold recovery process in ASGM; and
- Scale up efforts to encourage participation of ASGM community such as women, children and youth in the aspect of aware ness raising and decision-making.

For LCA to be fully utilized in ASGM processes and effectively help guide decisions that minimize the environmental impacts of products and services, better data needs to be derived from ASGM sector.

Further research is required to evaluate other life cycle impact categories to address more resource inputs and emissions to air, water and ground. The incorporation of other impact categories such as women, children, indigenous peoples, etc. would provide a complete evaluation of the potential environmental and social impacts of ASGM.

To facilitate efficient and accurate data gathering, ASGM communities and governments will need to be engaged and support technical and non-technical community based monitoring system work of organized ASGM communities.

SECTION 6. TOOLS AND RESOURCES

BAN Toxics tools and resources listed can be downloaded at www.bantoxics.org.

- BAN Toxics, Deciphering Benguet Method: A gravity concentration method being practiced in ASGM communities in the northern provinces of the Philippines.
- BAN Toxics (2015), ASGM Community Based Mercury Monitoring Handbook
- BAN Toxics (2015), Technical Monitoring Guide to Monitoring Mercury Vapor Levels, BAN Toxics
- BAN Toxics, Chasing Mercury
- BAN Toxics (2015), Handbook on Women and Children's Rights
- BAN Toxics, Toxics Free School Handbook for Elementary and High School
- BAN Toxics, Options for Terminal Storage of Mercury in the Philippines, BAN Toxics
- National Strategic Plan for the Phaseout of Mercury in the Philippines
- Minamata Convention on Mercury Ratification and Implementation Manual

The following tools and resources can be accessed in the CD accompanying this manual.

- EIA Revised Procedural Manual Main Document
- Community Mapping Tool Kit
- Environmental Monitoring Form
- Environmental checklist form
- IEE report sample
- Phytoremediation of mercury mine waste
- Rehabilitation Plans and other environ

REFERENCES

A Guide to Leading Practice in Sustainable Development, www.industry.gov.au/resource/Documents/LPSDP/guideLPSD.

Alternate Forum for Research in Mindanao Inc. (AFRIM). 2012. A Background Study on the Small-Scale Mining Operations in Benguet and South Cotabato and their Impact on the Economy, the Environment, and the Community. Bantay Kita.

http://www.miningfacts.org/communities/what-is-artisanal-and-small-scale-mining/

Alliance for Responsible Mining, http://www.communitymining.org/

Mining Policiy Brief, Arangkada-Mining-Policy-Brief-2014.09.06.compressed.pdf, http://www.investphilippines.info/arangkada/wp-content/uploads/2014/09/1

Definition of Mining, www.prrm.org/publications/gmo2/table.htm

Ditsele, Ofentse, " Application of life cycle assessment to estimate environmental impacts of surface coal mining" (2010). Masters Theses, www.envirogeremi.polymtl.ca/pdf/articles/G3-P_Lesage-paper_(II).pd

E. Rey et al 2005. Small Scale Mining in the Philippines, Towards Genuine National Development, http://www.slideshare.net/AGHAM/small-scale-mining-in-the-philippines-towards-genuine-national-development

J. R. Henry, National Network of Environmental Management Studies (NNEMS) fellow
"An Overview of Phytoremediation of Lead and Mercury"

IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399. Volume 4, Issue 1 (May. - Jun. 2013), PP 15-19 The potential of wild plants for phytoremediation of soil contaminated with mercury of gold cyanidation tailings

ISO 14040 (2006). Environmental Management – LifeCycle Assessment– Principles and Framework.

M. Veiga (2006), Manual for Training Artisanal and Small-Scale Gold Miners, www.globalmercury.org/
Mines and Geosciences Bureau. (2008). Quick facts on mining.
https://restaurantsustainability.wordpress.com/.../pillars-of-sustainability-a.

National Statistical Coordination Board(2011), http://www.mgb.gov.ph/linf.aspx.

Sustainability and sustainable development. www.circularecology.com/sustainability-and-sustainable-development.html

Rovillos, R.D., Ramos S.B., & Corpuz Jr., C. (2003, April 15). When the 'isles of gold' turn into isles of dissent: A case study of the Philippine Mining Act of 1995.
www: ilsdole.gov.ph/wp content/uploads/2012/12/artajo-with-edits.pdf

Small-scale-mining, www.mgb10.com/news/clarificatory.html

Surface_mining, http://en.wikipedia.org/wiki/

The Intergovernmental Forum on Mining, Minerals and Sustainable Development
A Policy Framework, Mining and Sustainable Development-Managing one to sustain the other abourassa@nrcan_rucanu.gc.ca

BAN Toxics, The Price ofGold. Retrieved from http://bantoxics.org/download
UNEP. Mercury Use in Artisanal and Small Scale Gold Mining.
http://www.unep.org/chemicalsandwaste/Mercury/MercuryPublications/ReportsPublications/AwarenessRaisingPackage/tabid/4022/language/en-US/Default.aspx

Pascal Lesage et.al, Use of LCA in the Mining Industry and Research Challenges,
www.enviro-geremi.polymtl.ca/pdf/articles/G3-P_Lesage-paper_(II).pdf

UNEP Global Mercury Partnership document produced in conjunction with Artisanal Gold Council. A Practical guide in reducing mercury use in ASGM, www.artisanalgoldcouncil.org
UNEP. Mercury Use in Artisanal and Small Scale Gold Mining. Retrieved March 2015. http://www.unep.org/chemicalsandwaste/Mercury/GlobalMercuryPartnership/ArtisanalandSmallScaleGoldMining/tabid/3526/language/en-US/Default.aspx

UNEP, Towards A Life Cycle Sustainability Assessment: Making Informed Choices on Products.
T. E. Norgate and W. J. Rankin (2000), Life Cycle Assessment of Copper and Nicke, http://www.minerals.csiro
V. J. Soriano, A Simplified Sustainable Manufacturing for Small-Scale Gold Production System, Department of Industrial Engineering Research, College of Engineering
University of the Philippines, www.seed-net.org

What-is-artisanal-and-small-scale-mining, www.miningfacts.org

What-is-the-role-of-cyanide-in-mining, http://www.miningfacts.org/environment

www.bantoxics.org

26 Matalino St., Suite 332
Eagle Court Diliman,
Quezon City 1101 PHILIPPINES

Tele Fax: + 63 2 355 7640
Email: info@bantoxics.org

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